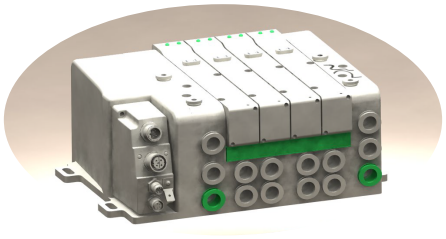
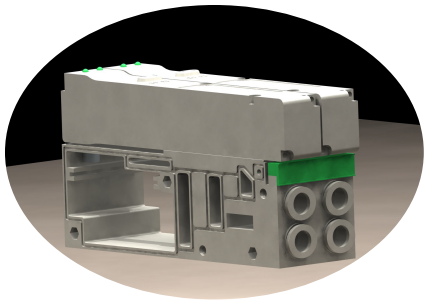
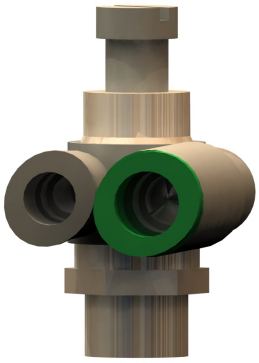
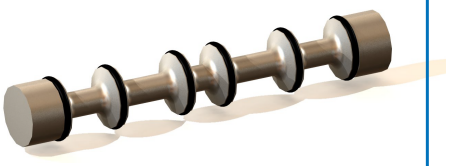
Optimizing Pneumatics

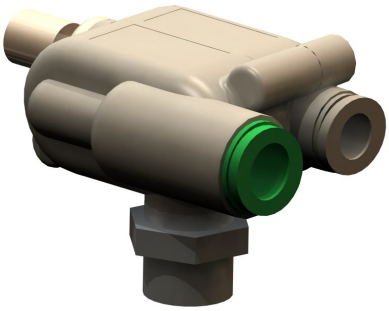
The design and introduction of a new energy saving system











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Introduction

This report explains the creative journey made by a strategic product designer developing a new energy saving system and its market introduction. In short, the assignment was to design and optimize the components needed in a new energy saving concept, already partly conceptualised by the company Q Plus. Starting with only a raw first idea, my goal was to improve the idea into a solid design that it would be profitable to get implemented. After that, I had to develop a method for introducing this new product in the market.

This report starts with an overview of the graduation assignment, followed by a short research of the company Q Plus. It was important to get a good overview of the wishes and views of Q Plus regarding their own portfolio and their place within the pneumatic market.

The next part discusses the design of the pneumatic innovation done for Q Plus. During my graduation project, most of my time has been spent on re-designing and improving the new products. Various design stages have been gone through, before eventually creating an end product answering all Q Plus' demands.

After the design stage, a complete analysis of the product was executed. First, the pneumatics' market was researched, to see in what ways this new concept could be implemented. Secondly, a more in-depth analysis of the European market was conducted, resulting in an extensive overview of potential buyers and other market opportunities.

The analysis of the market was followed by another in-depth look at the product itself. A SWOT was conducted, which lead to a clear overview of the strategic possibilities of this new concept. These strategic possibilities lead to an product-tailored advice to Q Plus how they should implement this new product in their own business portfolio and in the market

I would like to thank S.C. Santema and R. Mugge for their insights and input in the project. Also I would like to thank R.J. Van Dongen for facilitating and supporting me in my graduation project at Q Plus.

Wouter Schrandt

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1. Graduation Description

The Innovation

Q Plus has created a new way of saving compressed air in pneumatic systems (controlled movements with air). Its main principle is based on the re-usage of compressed air at a lower pressure level as opposed to the use and exhaust technology which is applied in pneumatics today. The system Q Plus has developed can save customers a large percentage, probably somewhere between 40 and 55%, of their compressed air usage. The production of compressed air is highly energy inefficient and the concept has therefore an annual energy saving potential of (roughly calculated) € 250 million if used in all Dutch factories. This innovation is, at the moment of writing, patent pending. Due to this course of receiving patents, Q Plus would like to keep this solution confidential until the product gets to the market or until the patents have been granted.

Problem Definition

Because the solution requires a new pneumatic lay-out , no standard valves or manifolds can be used. To make the energy saving system work, new pneumatic parts have to be developed due to the different layout and function of these parts within the pneumatic system.

Because potential customers do not have a clear awareness about the costs of compressed air and do not see the potential of energy saving with pneumatics straight away, an information gap is a problem. Having such a high energy saving potential, this concept needs a different approach for Q Plus compared to their current products, more defined as me-too products in a highly competitive market.

Q Plus is an importer for several brands, re-selling those to different customers. After designing the energy saving concept components Q Plus is no longer exclusively a reseller but becoming more of a manufacturer. Both this identity shift and the creation of energy saving awareness within the customer need a good support plan.

The challenges for Q Plus are:

- Convince its customers they can save up a large percentage of their current energy usage with pneumatics when they switch to use this innovation.
- Explain the technical function of the designed system.
- Quantify energy savings for the potential customers.
- Branding strategy. Find a suitable branding strategy for Q Plus.
- Market introduction strategy. Find the most suitable market introduction strategy for this new innovation by Q Plus.
- Address the potential customer. Selling an energy saving valve system in a business to business market, is challenging. Not only the final user is a potential customer, also the machine building industry and even technical trading companies and competitors are potential buyers of this new product set, all needing a different approach.
- Quality. The customer wants high quality products. Therefore, customers have to be convinced that the quality is equally high or even better as the competitors products in the market.

Assignment

Design and optimization of the components needed in the new energy saving concept and design a market introduction strategy for Q Plus for introducing this new energy saving pneumatic valve product set.

No existing products can be used for the concept so new products have to be designed. Q Plus needs clear 3D drawings to show manufacturers the different parts. Design must respect patents as put down by competitors and it will be prototyped before putting into production. Iterations will be needed to obtain the optimal form between the different functionalities of the pneumatic components. The product must be easy to manufacture on industrial scale and must have appeal for good acceptance of the market.

Parallel to the designing and prototyping of the products, a marketing strategy has to be designed containing the following points:

- Show a good overview of the current energy saving products to be able to create a total picture of energy savings within the field of pneumatics for the customer.
- Identify both the unique selling points and the problem areas.
- Investigate the decision making units within companies regarding pneumatics.
- Investigate branding strategy, pricing strategy and communication tools.
- Estimate a commercial value of the energy saving concept.

2. Method

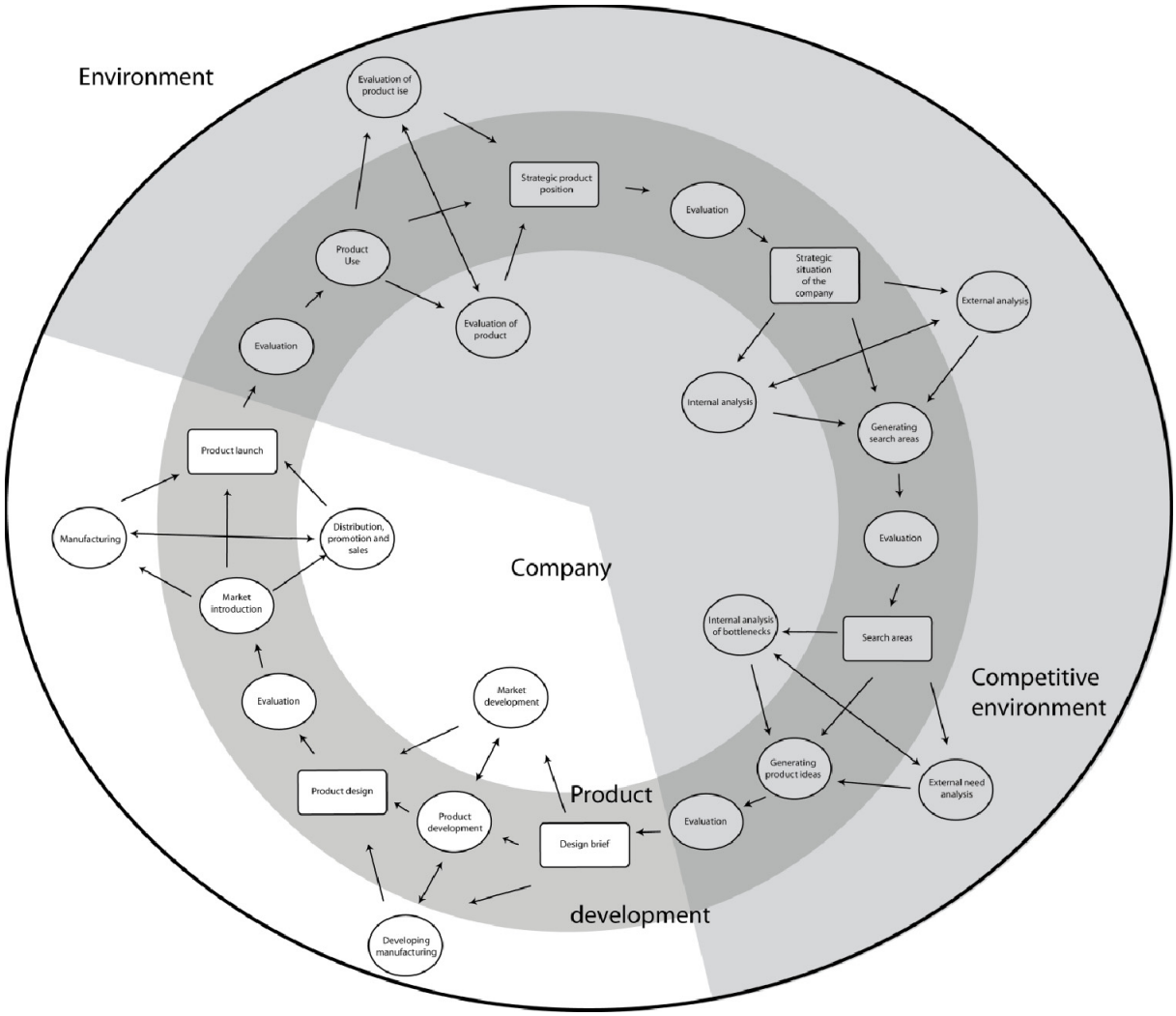

Fig. 1: Buijs innovation model (2003)

The model of Buijs is used to show which steps are taken in the innovation process during the graduation project. The project started with a design brief and developed towards the product launch. For my report structure, there are two main parts, a design/product development part and a marketing part.

Within the design part, the focus is on designing pneumatic products fitting the concept. The marketing part has as a focus the pneumatic market in general, market division, decision making units and a product swot analysis.

Basically the graduation project started with the design brief phase in the Buijs innovation model and product development of the products needed for the energy saving pneumatic system. Parallel to this, both market development as developing manufacturing have been researched. The design phase is the first phase of the project, the next step is the market introduction. The market introduction plan will contain a strategy suited with both the company as the designed product. Such a plan will aligning the strengths of both the product as the company strengths.

The product design has to be evaluated, preferably by either the manufacturer or an external engineering's office to guarantee the products can withstand the pressures of over 10 bar and have the flow/pressure drop calculated. The next step is to take the product into production. Preferences for materials and production technologies will be elaborated on.

In the project, the introduction strategy is key for making the energy saving concept a success in the pneumatic market. Dividing the assignment into smaller parts shows clearly which steps are to be taken for the projects execution.

- Introduction of the company Q Plus to show the context where the assignment takes place.
- Pneumatics and the innovation made, to introduce the technical background of pneumatics and the difference between different motion controls. Followed by an explanation of the difference between current pneumatics and the innovation.
- The design brief shows the demands and wishes for the products which are needed to make the concept work.
- The design process of each product.
- Market analysis, to investigate current energy saving solutions, energy saving potential, investigate customer profiles and their DMU. Closing off with a product SWOT.
- Investigate strategic possibilities, evaluating multiple options.
- Propose strategic direction to show the direction Q Plus should aim for.
- Plan of approach, providing guidance for Q Plus for communication objectives, tools and a description of the intended audience.

3. Q Plus BV

This graduation project is executed at the company Q Plus BV. Q Plus has been founded 20 years ago as a one-man company selling quick-release couplings. In 1994 Q Plus started with the sales of rotating units as a second product line. From 1996 onwards, Q Plus has been supplying pneumatic products to machine builders, technical trading companies and end users. Next to supplying the standard products, customers with special wishes and demands are also served. By designing or re-designing products, Q Plus can serve customers with specialized, technical and personal solutions.

Today Q Plus is a company with 20 employees and a turnover of about € 6 million. The office and warehouse of Q Plus are shown in Fig.2. The company regards itself as a technical company. Due to its size, this medium size trading company is not known in the entire market. The presentation in website and leaflets is consistent in house style and offers a pleasant and professional appearance. In case of new contacts, this is helpful to overcome the fact they are not market wide known. Presentation on the website is very professional, but webshop oriented which keeps the visitor a bit disconnected from other Q Plus qualities.

The product range is wide and oriented around compressed air applications of various sorts. It consists of three product lines: quick release couplings, rotating unions and pneumatics. All product lines are imported by Q Plus as the official representative of the manufacturer (importer/distributor).

About 35% of the turnover is sold to technical trading companies, which is off course part of the company's function as an importer. About 15% of the turnover is sold to the end user, using the goods in their primary production process. The other 50% is sold to OEMs (Original Equipment Manufacturers), companies that use these parts to complete the machines they build. Q Plus sells most of its products in the Netherlands and only a small percentage of its sales goes to Belgium and Germany.

The vision of Q Plus

The vision of Q Plus is to continue its growth by pursuing a product sales increase in the Benelux. To increase sales at the end users, Q Plus wants to support the customer technically and offer fair priced quality components, quick deliveries from stock and technical support. The advantage of having the end user as a customer is the continuous request for replacement products. This way Q Plus stabilizes its position in the market, decreasing dependency on the sales of other companies like technical trading companies and OEMs.

Fig. 2: Building Q Plus

Q Plus wants to grow in the Benelux. They support the customer to create better and longer lasting relationships. They prefer to be a technical specialist above mere trading of products. Q Plus wants to stay a reseller/importer and does not want to move into R&D or production.

4. Pneumatics and the innovation

Motion Control

Motion is everywhere in industry, to support the processes in transportation, production, packing and many others. There are three important principles to realise the desired motion: hydraulic, electric and pneumatic. A short comparison between these three technologies will improve the understanding of the different techniques and their advantages and disadvantages.

In all cases, there are three important parts in motion control systems:

- Generating the energy carrier
- Transporting the energy carrier
- Controls to release the energy where desired

Electric

The energy carrier is readily available : electric current is everywhere. Transported by electrical wires it comes to a wide range of electric and electronic controls. The energy losses are extremely low because the energy is not converted into a different energy carrier.

The controls are mostly electronics controlling some type of electrical motor making linear or rotating movement. Features are: quick, energy efficient, compact, complex movements, precise movements, high technological products and overall low energy costs. Due to this, electric is usually the best solution. The main disadvantage of electric actuators are the high purchase costs of the components. Other disadvantages can be the use of electricity (danger of explosions) and possible damage at jams.

Hydraulic

The energy carrier is hydraulic oil which is brought to pressure by a pump. The pump is driven by an electro motor. The efficiency is high: 70% of the electric energy is converted to hydraulic energy (pressure x flow). Transportation takes place via steel pipes, high pressure hoses and the hydraulic oil is controlled by various kind of valves which control the flow to cylinders, motors and other applications. Once used, the oil is returned to the pump (oil reservoir) by other pipes and flexible tubing.

Due to the high pressure hydraulic parts are robust and quite expensive, the amount of energy which is transported this way is very large. Because oil cannot be compressed, the motion control with modern proportional valves (integrated electronics) can be done very precisely with big energy content. For every application which is demanding big forces or torques, hydraulics are the obvious choice.

Pneumatics

The energy carrier for pneumatics is compressed air. To compress air, compressors are used. As the compressors are usually about 10% efficient, the conversion from electric energy to compressed air is a highly inefficient process. Heat is the largest by product of compressing air.

As a result, compressed air is 10 times more expensive as its energy in electricity making it one of the most expensive energy carriers in the market today. After leaving the compressor, the air is usually

cooled to improve its quality by condensing water vapour, making the air dry to minimize flow losses and prevent corrosion. A buffer tank is used in the pneumatic system in order to supply an as constant pressure as possible to the pneumatic system. The compressed air is distributed by means of a piping system to the points of use. Here actuators like pneumatic cylinders are operated by pneumatic valves. Other compressed air applications like hand tools, or cooling with air flow are not discussed here.

The advantages of compressed air are: cheap components, simple piping system, safe use due relatively low forces and no risks of explosions. Pneumatics are very useful for simple movements. There is a high level of standardisation so simple replacements are possible. The downside of pneumatics is the relatively high energy cost.

Current pneumatics

As concluded that the expensive air was led by a piping system to its application, actuators like cylinders are controlled by pneumatic valves have to be operated and switched.

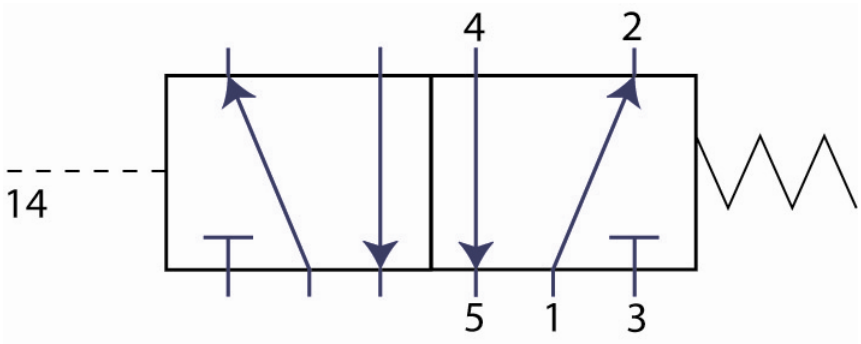

Fig. 3: Pneumatic 5/2 valve

The most used valve is a 5/2 valve (see Fig.3), having 5 ports and 2 positions. The system pressure is on port 1. When the valve is in its first position, the cylinder gets filled via port 2 with pressure while the other side of the cylinder is exhausted via port 4 and 5 (see Fig. 4). This makes the piston move outwards to perform it function.

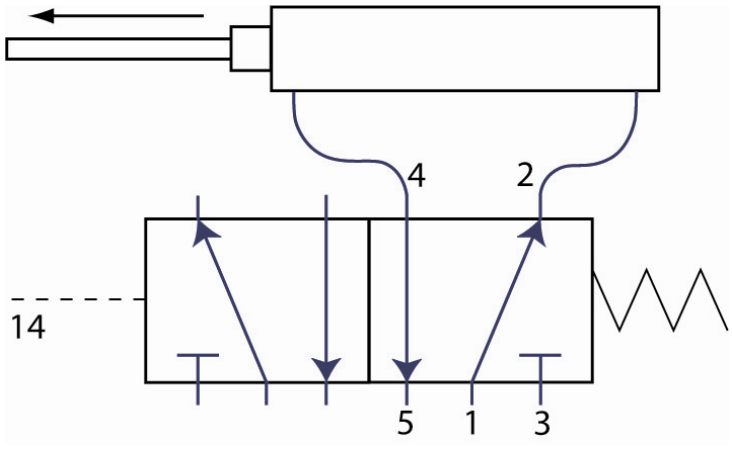

Fig. 4: 5/2 valve with acting cylinder expanding stroke

When the valve switches, the cylinder gets filled from port 1 to port 4 and exhausts the before filled cylinder chamber via port 2 and 3 (see Fig. 5) making the cylinder move inwards. When the cylinder empties via port 3 or 5 on either one of the strokes, the compressed air is exhausted into the air. The energy it contains (pressure x cylinder volume) is completely wasted this way.

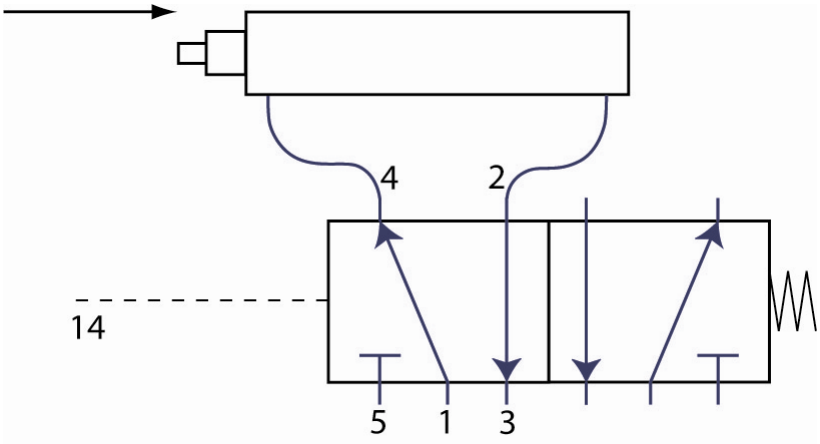

Fig. 5: Pneumatic 5/2 valve with acting cylinder return stroke

Working principle pneumatic innovation

What could be done with the wasted air? Here the innovation comes into the picture. Where most cylinders have one working stroke where high pressure is needed to move the cylinder for instance in which products or parts have to be moved. The return stroke is only needed to move the cylinder back into the standard position again a return stroke can be done using only low air pressure. Generating this lower pressure compressed air can be done by recovering the exhaust air from the working stroke of the cylinder. This way the return stroke can be achieved by compressed air that was normally thrown away. This way 50% reduction of air consumption can be achieved. Energy saving pneumatics have a slightly different port configuration.

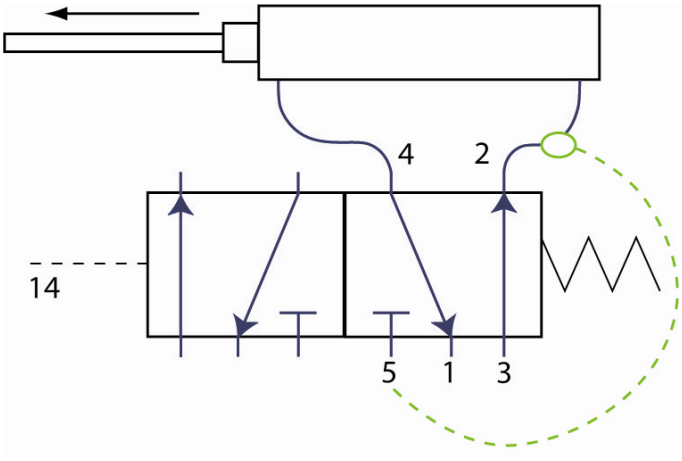

Fig. 6 Pneumatic 5/2 valve cylinder expanding stroke high pressure

In Fig. 6, the cylinder is filled with a high pressure from port 3 to port 2, while the air is released from port 4 to port 1. For the return stroke, see Fig. 7, the air at port 2 is saved and redirected to the low pressure network(green). Meanwhile, the cylinder returns on this low pressure network because port 5 is connected to the low pressure network. Air that can't be saved (the last bit) will be released via port 1.

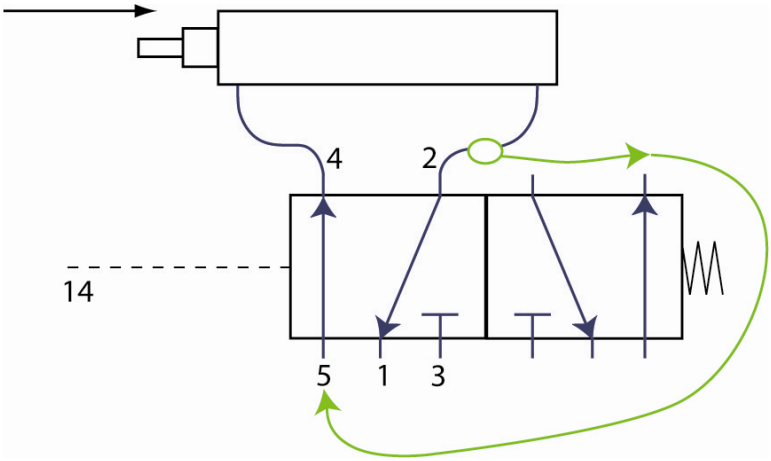

Fig. 7 Pneumatic 5/2 valve cylinder return stroke on low pressure

Taking it one step further, this recovered air cannot only be used for the cylinder return stroke but also in other low pressure air applications like: cooling, blowing and moving. The usage of this air pressure which would otherwise been lost can be seen as pure savings. When there are none of these low pressure applications available this low air pressure can also be used to boost itself again to the system pressure or to be re-used by giving the remaining pressure back to the compressor.

Conclusion

Basically, cylinders deliver labour into one or two directions. After a stroke, the remaining air pressure, is usually exhausted. If the air is not exhausted into the open, but collected and stored into a lower pressure system, it can be used in several applications. These applications can be diverse and have a broad range of applications: the non labour return stroke of the cylinders, blowing applications and boosting it up again to its original pressure. Cylinders that have two labour strokes and therefore cannot be sent back on a lower pressure are able to dump their air twice into the low pressure system.

The innovation can realise substantial energy saving with no technical downsides and hardly any extra investments. The return on investment will be quite quickly when the system is integrated in new build machines. Due to extensive rebuilding, existing machines have longer ROI because of the increased labour costs.

5. Design Brief

To make the energy saving concept work, a new valve manifold (manifold or bottom plate and valve)has to be designed, which will control the cylinder. Also, two new products (dump valve and speed controller) have to be designed, which have to be mounted on the cylinder. The demands and wishes have been listed below, specified per product:

Valve:

Demands

- Lifetime of 200 million cycles
- It should be easy and quick to replace a malfunctioning pneumatic valve
- Emergency manual override
- Water and dust tight
- One single connector to connect all valves (multipole)
- Multipole has to be sealed from water and dust and it has to be easy to connect directly, so it has to be integrated within both the valve, the ground plates and the side ground plates
- Appealing design

Wishes

- Optimal flow, thus minimal pressure loss in a most compact design
- Use as many standard components as possible to minimize mould costs
- Be able to support all known valve configurations (5/2, 5/3, 3/2 and its options)

Valve Manifold:

Demands

- Modular, free choice of valve number per manifold
- Facilitate easy valve replacement
- To be connected to multipole connector as well as to a field BUS system (The protocol used very often for communication between different machines, its components and their controlling computer/plc. This communication is standardised as IEC 61158)
- Dust and water tight IP65 (meaning fully dust tight and protection against jetting water, from any direction) isolation of the electronics
- Cheap industrial production and appealing design

wishes

- Compact design while maximising the flow, not wasting any available space. The flow in the ground plates and its connection with the valve has to be as optimal as possible, resulting in the lowest pressure loss throughout the valve manifold.
- Multiple use of injection moulding moulds

Dump valve:

Demands

- Adjustable control of exhaust air, to influence the cylinder speed according to the wish of the customer
- The cylinder has to be emptied as quickly as possible to regain most of the re-usable air
- When the cylinder is almost empty, the low pressure side has to be closed off again to prevent flow back of air, so a non-return valve has to be included.
- Needs to have room for standard push-in fittings

wishes

- Low pressure losses, the cylinder has to be filled with as little resistance as possible
- Integrated non-return valve should have optimal flow characteristics
- Compact design, optimal use of available space

Speed controller:

Demands

- Combination of non-return valve and a speed controller
- Compact to fit the cylinder with minimal obstruction
- Have room for standard push-in fittings

Wishes

- Optimised air flow

General design guidance:

Demands

- Not in conflict with any existing patents or design features of the competitors, it needs to have its own charisma and form language

Wishes

- Industrial high quality products, has to be and look solid, rigid, strong and professional
- Industrial production in big quantities, modular assembly
- Optimal product look and feel, has to be attractive and modern
- Economical production, acceptable investment costs by keeping the number of different products as low as possible

6. Product design

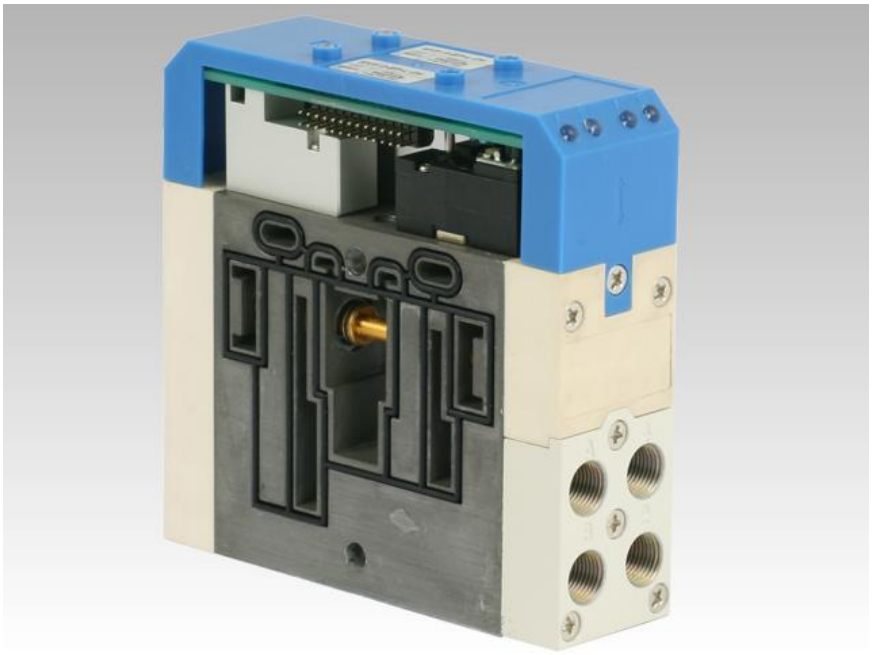

Fig. 8: Current product example: part of YPC valve manifold

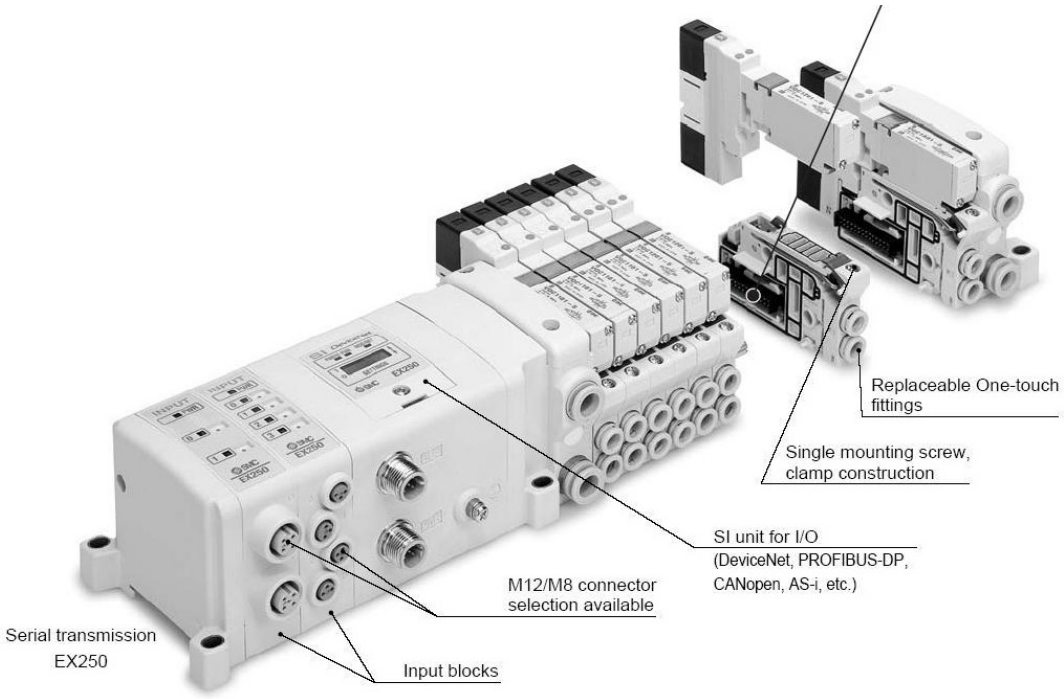

Fig. 9: Current product example: SMC pneumatic valve manifold

As starting point for our design, drawings and many current valves were studied and analysed as a help to design the different parts. Some of the studied models are shown above (Fig. 8 and 9), illustrating different manufacturing solutions in making valves and their manifolds. Many times the

design was blocked by patents of competitors. They have acquired patents on many details, some of which are about small and almost unimportant details.

Designing the products in order to make optimal use of the available space and realising modern and reliable design was a big challenge. Finding the most optimal form and shape for giving the components the best flow characteristic, designing new parts never made before and avoiding many design challenges was very intensive but also very interesting.

The valve manifold

During the design process, iterations are used to work towards a good end product. From the start, the technical optimization of the flow and the minimization of the needed space have been the key drivers in the design process. During the design process of this manifold, an immense amount of design decisions had to be made. Below several impressions from the first step in the design process (Fig. 10).

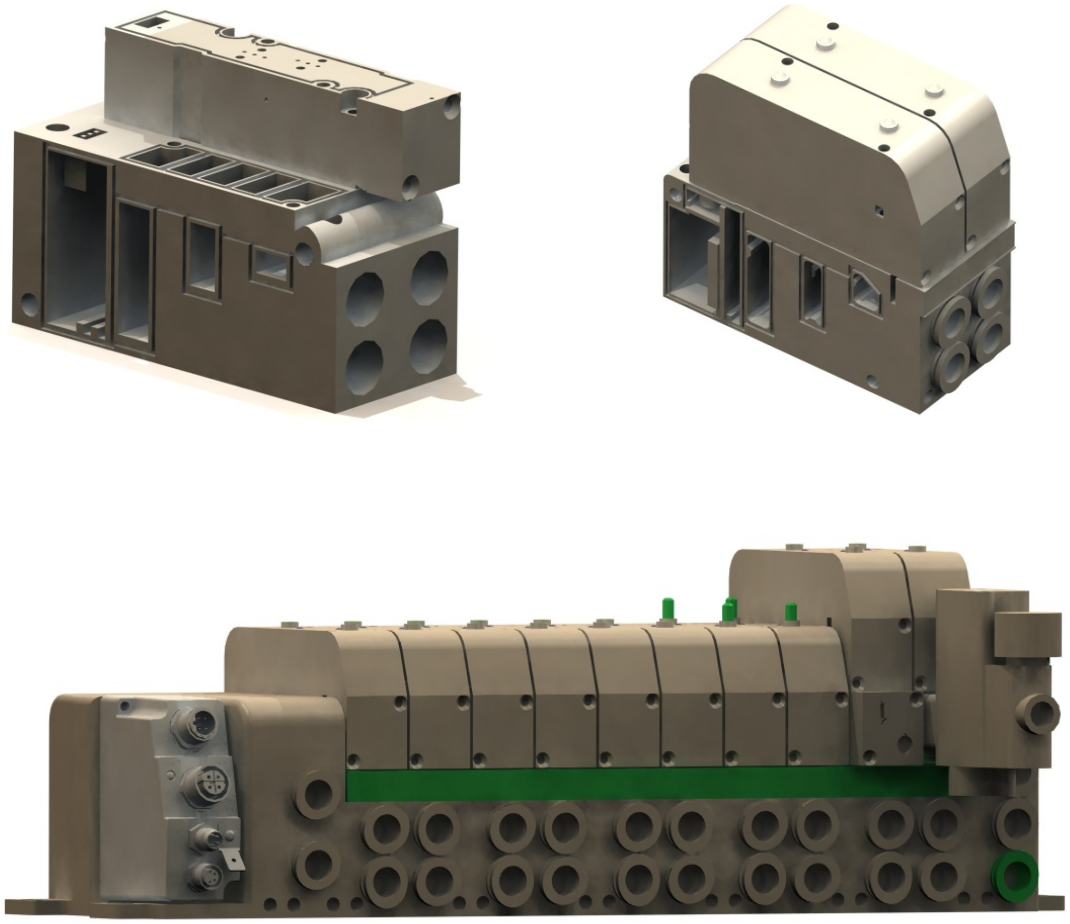

Fig. 10: First version of the valve manifold

In this first concept, the ground plates are connected via pins that can be tightened via screw holes in the front and on the back of the ground plate. The pilot valve which controls the main valve is a rectangular shaped block that is placed on top of the valve under a cover. This way they are sealed off from outside influences like water, dust and other filth. This construction was easy to design but increased the height of the valve however, which was a big disadvantage.

In the next iteration, the decision was made to go from these rectangular shaped pilots to cylinder shaped 13mm pilots integrated in the valve body above the main valve (Fig. 11). The advantage of these pilots is their reduced number of parts, the disadvantage is their complex manual override which is made for switching the valve without electrical current. This manual override, situated above the pilots is quite complicated due to the need for a minimal stroke length of 5mm for activation of the override. When the stroke length gets combined with a minimal spring length and the possibility to lock it in the override position (bi-stable override), its length increases quite dramatically. This length is added to the height of the valve and this is not wanted.

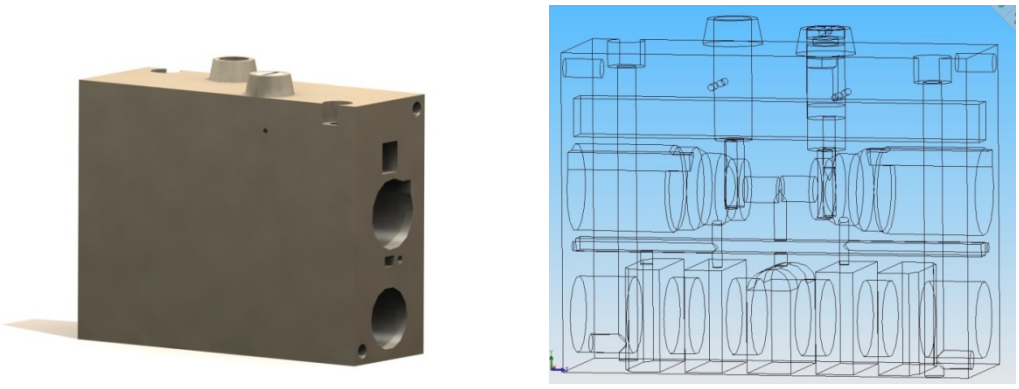

Fig. 11: Second version of the valve

The next logical step was to place these pilots behind the valve and create a new method for the manual override. This decision increases the length of the valve but minimizes its height. This will be appreciated by the machine builders, who can build the valve manifold into low spaces without any trouble now.

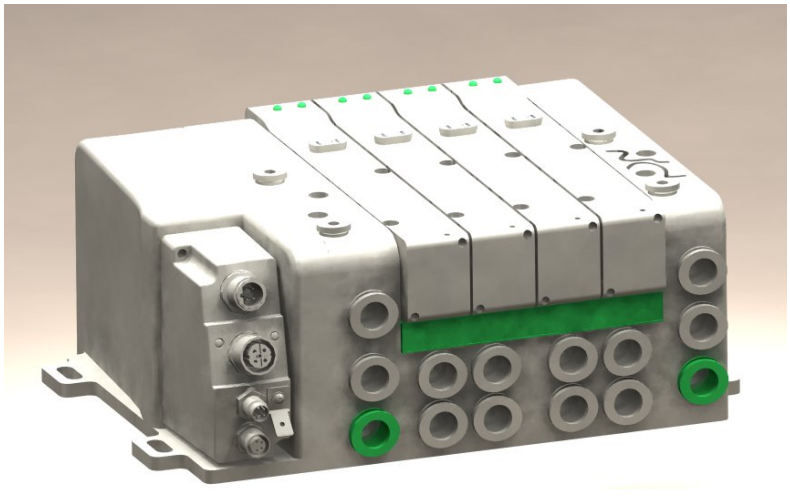

Fig. 12: Third design of the valve manifold

To understand the size of the shown manifold of the next iteration, push-in fittings in the front of the valve manifold are 10mm. The length of a valve is 154mm and the width is 23mm. Of the large amount of technical decisions which had to be taken, ranging from the way the ground plates are connected to the choices on the PCB and the electronics, some of the more interesting ones will here be explained and discussed.

For example, to connect ground plates of the valve manifold, multiple solutions are currently used:

- Direct screw connections
- Connection rings that centre and connect two ground plates
- Pins combined with two screws
- Threaded rods

In the design there has been chosen, after studying the various options, for the usage of threaded rods to connect the ground plates. This is most efficient for various reasons. First of all, the assembly of a whole manifold is most efficient when three parallel threaded rods are used. The ground plates can be assembled and fastened with one bolt per threaded rod. Secondly, the space needed in the ground plates is as minimal as possible, resulting in an optimal sized ground plate, needing only a minimal amount of space.

The only disadvantage is the amount of different threaded rods needed for different sizes of valve manifolds. Because valve manifolds ,with a 25 pole connector, can only have a maximum of 24 valves, this due to the limitation in electronics, the amount of threaded rods of different length needed is 12 (each ground plate contains two valve spots). Due to the modular design, expansion with one or multiple ground plates can be done easily with extension rods. These rods fit into the same bolt which makes extension of these plates easy.

To decrease the height needed to operate the emergency manual override, a new emergency override bypass system was designed and implemented in the valve between the back plate and the pilots. This bypass is an easier solution because the height needed at the pilots for the emergency override can be relocated. In between the back plate and the pilots, full height is available for creating both a bi-stable override and still have enough space for placing a spring. Therefore, this place is most convenient for this emergency override.

Conclusions valve and valve manifold

Evaluating the valve manifold in the present design stage, it can be concluded that most wishes and demands are integrated into the design. Both the demands and wishes are discussed step by step to examine if and how successful they are integrated into the designed product. After presenting the design to several colleagues their comments on the design were very positive.

Evaluation design demands valve

200 million cycles can be reached by using the right PU seals (thermoplastic polyurethane elastomer, e.g. Elastogran by BASF). These seals have a life expectancy of about 10 times higher compared with the NBR seals which are used currently in valves. (These seals are a bit more expensive compared to

normal ones, and due to the longer life span, the total amount of valves sold will decrease, due to the new market it is for Q Plus it cannot cannibalize on present turnover)

- The valve is easy to replace using two screws only, due to the ability to disconnect electronics easily using an electric plug. The valve is not connected to any hoses which have to be connected or disconnected.
- At the moment the emergency manual override has a difficult type of seal(Fig. 13). After enquiry at seal producers, this designed seal seemed too difficult to produce. Different solutions are available: a different kind of seal, a different override setup or having the whole back plate produced by a partner.
- The valve is dust and water tight. Due to the integrated seals in between the separated parts of the product the system keeps both dust and water outside.
- Electronics to connect the valves to the control system are sealed from water by a seal on the valve connector and easy to connect directly.

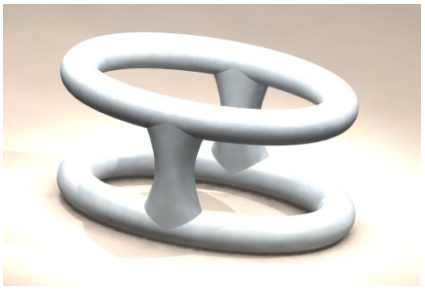

Fig. 13 Seal emergency override

Valve Wishes

- The flow within the valve and its pathway throughout the valve manifold is designed to be as optimal as possible, having rounded pathways with sufficiently large diameters for an optimal flow. A production technology is used which allows for much free space by putting the seals in the spool. This technology can only be used in combination with Zinc diecasted valve bodies which will be produced in Korea.
- Many standard components are used as possible to minimize mould costs.
- Compact design is maximising the flow, not wasting any available space. The flow in the valve and the ground plates and its connection is as optimal as possible, resulting in the lowest pressure loss in the valve manifold compared to other technologies.
- Creating one valve which is directly suitable for all valve configurations is impossible. Therefore the choice was made to make minor adaptations in a standardised valve body thus realising all configurations.

Valve Manifold Demands

- Modularity for the ground plates is large due to the possibility to select the number of ground plates needed to mount the valves and extend them freely with an extension rod. The decision has been made to work with ground plates that have space for two valves. When an uneven number of valves is requested by a customer, one valve spot will be closed off by a seal off plate(blind plate), which is common in the industry and lowers the cost price and simplifies the logistics.
- The valve manifold facilitates easy valve replacement. There is enough space to remove the screws and (dis-)connect the valve.
- The side plate facilitates space for: a multipoleconnection (DIN Sub-D 25 pole standard connector) which optionally be combined with a readily available FieldBus adaptor for connecting the valves with a computer/PLC. These adaptors support many different Fieldbus

protocols (versatile) to be integrated in many different machine types and are relatively cheap.
- Due to the used seals between the parts it is expected that the system is both dust tight and jet water proof from any angle.

Valve manifold wishes

- The final design of the valve and the manifold is making optimal use of the available space and has large diameters, allowing a large flow. Panels indicate the design is both industrial, and modern.
- To minimize costs, screws, threaded rods, some seals and the push-in fittings are standard products which will be integrated into the valve manifold. The manual override, the pilots, the electronics and the electronic connection, could all be purchased from manufacturing partners.

In the next stage of the design process, several parts might be improvement. For example the moving spool inside the valve needs extra attention. This part can have a final optimising step making the product more simple to produce and create optimal flow characteristics. The stroke can be slightly increased to decrease pressure drop. The result is that no standard spool can be used anymore, but the increase in flow is well worth the extra effort and investment due to the technical and marketing value.

The dump valve

The dump valve part (quick exhaust valve) is placed on the cylinder to be able to let the air flow in, and take the used air directly from the cylinder into the low pressure side of the valve system.

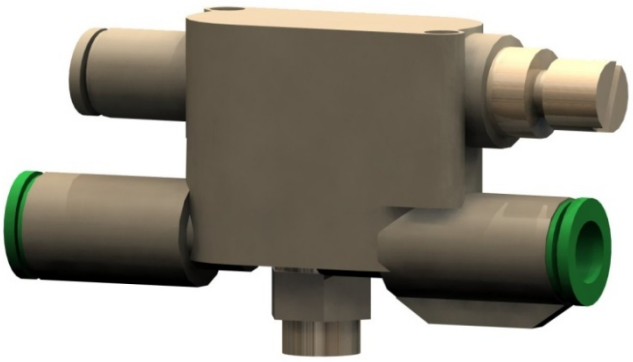

Fig. 14: First design dump valve

As a design process has many steps, this part also had its own iterations. In the process, the major challenge for this part is to minimize its size and optimize its flow characteristics. Because this dumpvalve (Fig. 14) has to be placed on a cylinder and cylinders are placed inside machines, the smaller this element is, the easier it can be placed inside the machines. When it is not possible to mount this dump valve directly on the cylinder, this part can also be placed near the cylinder connected through a short piece of tubing. Normal quick exhaust components are quite simple

(Fig. 15) but miss a few features which are needed for the energy saving function. Air enters via one side in the direction of the arrow and enters the cylinder via the top opening while the air pressure closes the exit off by pressing to the membrane at the end of the arrow. When the pressure gets switched around because the control valve is switched, the air comes back from the cylinder and follows the arrow to the exit. When this happens the membrane closes the entrance off.

Fig. 15: Example of a normal quick exhaust

The size of this minimized product which can be seen in Fig. 16 is about 45mm high 36mm wide and about 70mm long. The push-in fittings (two 10mm green ones and one 8mm grey one), O-rings and the cylinder connection nut are chosen standard components that will be bought and not designed/manufactured by Q Plus.

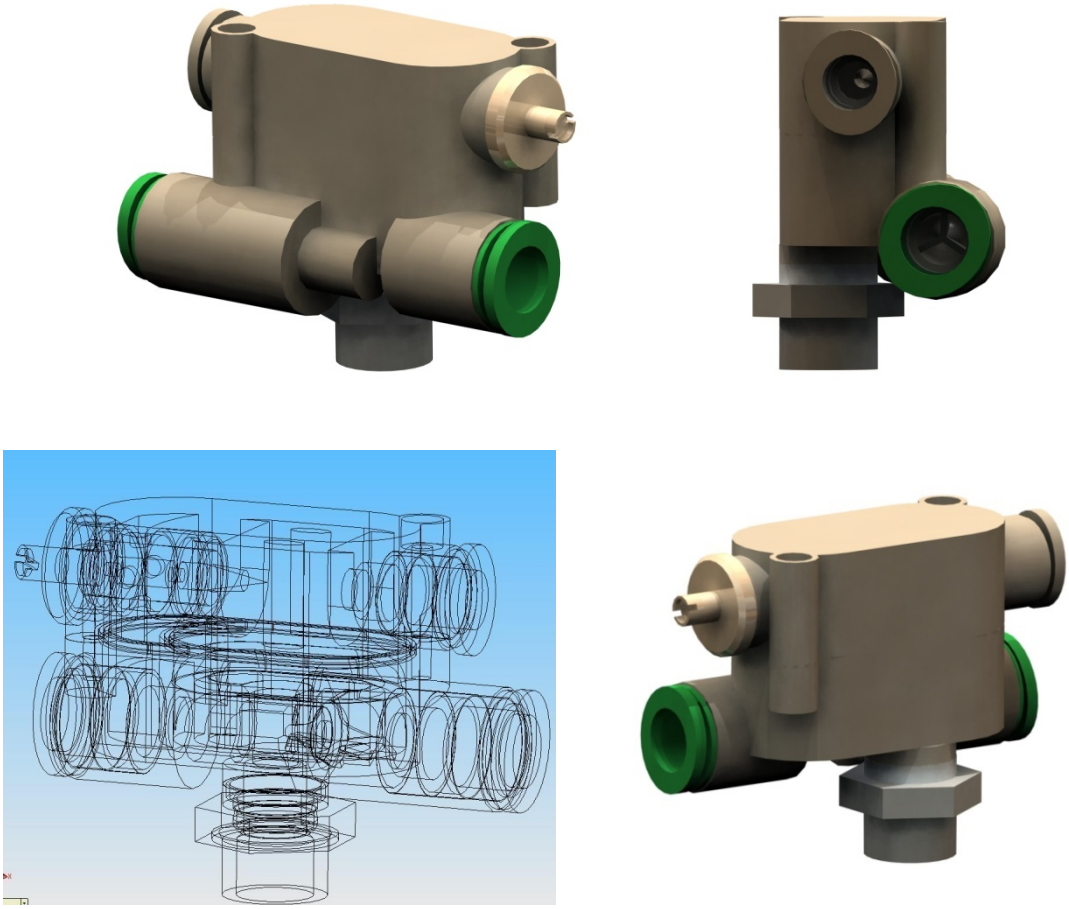

Fig. 16: Second design dump valve

The non-return valve, see Fig. 17, is the part that takes care of the air not flowing back from the low pressure air circuit. This non-return valve needs to have an optimal flow and should seal off solidly. Normally these non-return valves look like a tube with some holes inside and an O-ring to seal the tube. Due to limited flow capabilities of this part, a new design was needed. It has to be able to work with a normal standard O-ring and has to be most optimal for the flow, without losing any flow capabilities. The result can be seen as the right figure in Fig. 17.

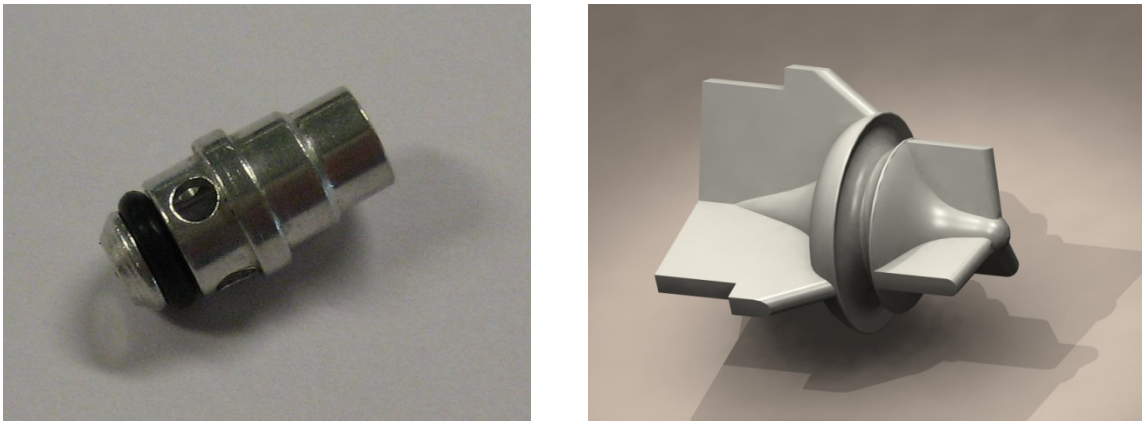

Fig. 17: Left, current design of non-return valve. Right, our design of a non-return valve

As soon as all the technical aspects of the dump valve were correct, rounding the edges made this part look more friendly. Rapid prototyping made it possible to have the drawn model real easily. Fig. 18 shows the first 3D printed prototype made.

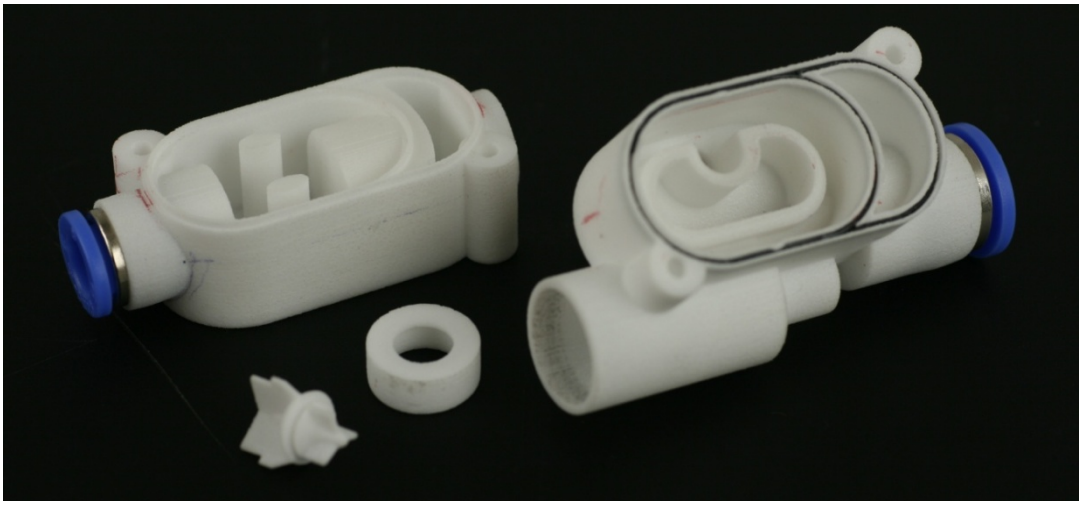

Fig. 18: Third design of the dump valve and the printed version

The next iteration of this dump valve was to turn the whole valve 90 degrees, decreasing its height creating more space above and below the dump valve. The extra space above the dump valve increases the build-in possibilities. The extra space below the dump valve increases assembly room and space for the socket wrench. The cylinder connection has also been moved closer to the front side, thereby making the crossing the edge of the cylinder as minimal as possible, increasing the cylinders' freedom of movement. The 3D printed prototypes have proven to be very useful in the process of improvements. A physical product is more accessible than a 3D drawing on a 2D flat-screen to judge the design.

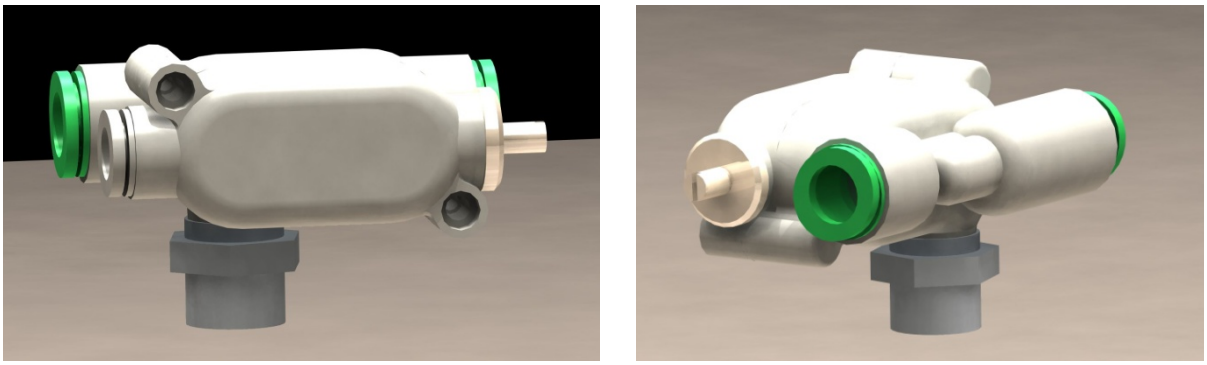

Fig. 19: Final design dump valve (front and side view)

Conclusions dump valve

The dump valve has gone through many design steps as well. Finding its optimal form while balancing all needed components and the most optimal flow characteristics has been a continuous challenge. Below a step by step evaluation of the design of the dump valve is shown, explaining the demands and wishes from the design brief.

Demands

- The customer will be able to adjust the last bit of air that is released from the cylinder via the speed controller. This way, the speed of the cylinder can be adjusted.
- By insuring the flow space around the non-return valve is larger than the connection with the cylinder, optimal room for flow is created. This results in regaining as much re-usable air as possible.
- When the cylinder is almost empty, the low pressure side is closed off again to prevent flow back of air. The non-return valve is pushed into place by a spring to ensure no flow back occurs in the product allowing the compressed air energy to be dumped.
- Standard push-in fittings can be placed in the product to have easy tubing connections with other pneumatic products to keep the design affordable.

Wishes

- Optimal flow characteristics have been reached due to keeping all openings inside the product and the flow space when passing the membrane equal or larger than the connection with the cylinder.
- The shape of the non-return valve is created to have the most optimal flow characteristics for the passing air as possible.
- In the design of this component, all different functions are integrated as compact as possible without compromising on flow characteristics thus succeeding the demand for small design.

Due to the specific measurements of, for example, the connection between the product and the cylinder and the product and the push-in fitting, production tolerances and final production responsibilities have to be given to a manufacturing company, which has the technical knowledge producing products like this one.

Speed controller

This part is placed on the other side of the cylinder being a speed controller and a non-return valve to be able to fill that side of the cylinder with the already used (recycled) air at a lower pressure level. Technically, this product is the most simple of the designed products. It is a combination of a duo in-outlet, of which one contains a non-return valve and a speed regulator. The combination of these features did not exist yet in one product. To give a feeling about the dimensions of this product: it is about 45mm high, 35mm wide and 60mm long (see fig. 20). Just like the dump valve part, this part has two push-in fittings (one of 10mm and one of 8mm). The functions are already available in two easy to combine other products. So this speed controller is not needed immediately as a finished product.

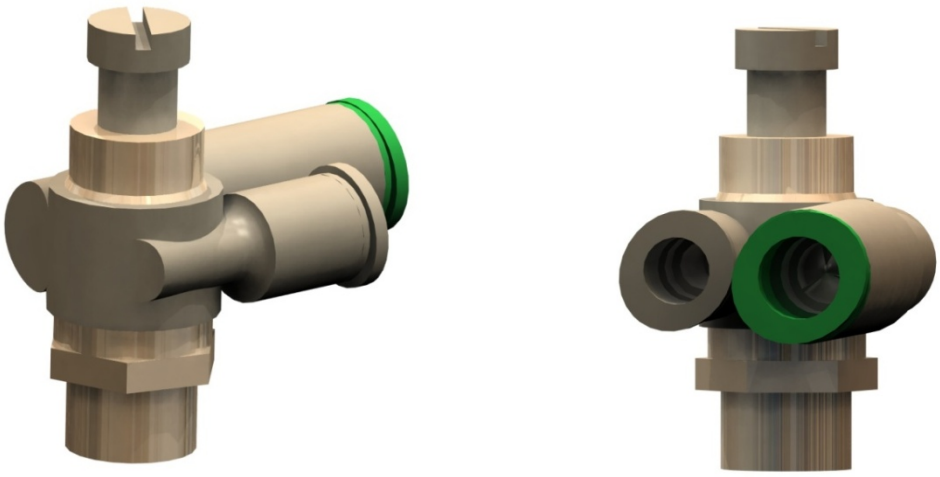

Fig. 20: Speed controller (side and front view)

Conclusions speed controller

Due to the simplicity of this product, the demands and wishes for this product are quite straight forward and met easily. The optimisation of the flow with the carefully designed non-return valve and integration of functions is basically the only added design value in this product.

Demands

- The combination of the functions of non-return valve and a speed controller within one product has succeeded.
- The product can fit the cylinder with minimal obstruction.
- Standard push-in fittings can be used.

Wishes

- The airflow within the product is as optimal as possible.

Q Plus might want to start producing this product only when sales take off for the dump valve and the valves. Meanwhile, current products can be used to fulfil the functions of this product. As this function can also be reached by combining two standard products, this product could stay in a

concept phase and not be produced yet to save costs. As soon product sales of the other two products is high, adding this product could be considered.

The form language of this product has not reached the same level as the other components and does not fit with the other products yet. This needs extra attention in a later phase, when taken into production.

Production process and material selection

Zinc die casting (ZnDC), injection moulding and 3D printing would be the most promising production possibilities for these products. Some parts need low tolerances, high durability and a long lifespan. Other parts only contain electronics and have no moving parts and no compressed air pressure to withstand. To improve the understanding on 3D printing a visit to Freedom of Creation[1] was made.

The materials should form strong, durable and good looking products. The products are going to be implemented in factories and have a rough life ahead of them. The maintenance staff buys these products or advises in the buying process. Because the maintenance staff uses these products in the factory, they want to have products they can trust upon. Therefore the look and feel of these products has to be strong and solid to influence their choice. Historically most of these products have been made out of metals. Because modern plastics and especially the ones which are strengthened with glass fibres, form a high quality alternative for metal, the large pneumatic companies are shifting from metal towards these plastics for cost reasons. Because of the modular way a valve manifold is build with a minimal number of parts there is no need for flexibility as offered in 3D printing because the investment is easily repaid by the lower parts price.

Injection moulding production is a very suitable production method for pneumatic parts. This production method has high initial costs (an injection mould is needed, easily costing €10.000,- for a small part) but a very low price per product. 3D printing would possibly be an option for the simple but its strength is not convincing, non-moving and low-pressure parts having virtually no initial costs, but a higher price per product. Therefore print production would be interesting for the first series being able to make easy adjustments and have production on demand. As soon as sales take off, this way of production will not be commercially attractive.

General design and manufacturing conclusions

Design considerations

Both the valve manifold as the dump valve are considered by most of the employees of Q Plus as nice, high quality and professional looking designs. The questioned employees think this product has its own charisma and form language that distinguishes these products from those of the competitors. The design of these products is not in conflict with the patents of competitors. All products can be produced at low costs in large quantities and the valve manifold can be assembled with modular components

For both the dump valve as well as the speed controller, economical production can be reached. The production of the speed controller is similar to current speed controllers. It does need a new mould

to be produced, but that is to be expected for a new product. Because the speed controller is a product combination of two existing products, my advice is to not produce this product yet and use the combined products until the sales of the other products takes off.

The dump valve needs multiple moulds for the new components. The base mould will be more complex and needs to be suitable for fitting multiple components, so the tolerances need to be monitored well. Having a partnership with a company that produces such kind of products already for a long time, these problems are sure to be solved.

The valve manifold is a product that is produced with multiple larger moulds compared to the dump valve. Due to the high investment this product will be much more expensive. Testing the concept thoroughly can be done with the dump valve and a normal valve. These results can return a savings percentage, showing the value of the products compared with the normal use of pneumatics. The valve manifold is expected to have better flow characteristics compared with competitors manifolds and will therefore increase the saving percentage.

The design realised however is more than a energy saving valve. It can also be used as a high flow, compact valve manifold fit for present technology pneumatic applications. With the modular build (up) with a bus controller this is the most versatile design in the market place. Due to the modularity of the valve manifold, the product can also be used as a normal valve manifold with a bus controller. This makes investments in this valve manifold safer, and leaves the possibility to test the manifold as a normal manifold.

Quickly replaceable valves, long life due to PU seals makes the concept very appealing to maintenance staff.

Future design steps needed

The design of the dump valve is in the stadium where manufacturers can add the information needed to make the products ready for production. No large changes are expected due to the large amount of iterations this product already went through. Improvements will be incremental and will mainly consist of changes in wall thicknesses.

The design of the manifold still has iterations to go through. The back plates of the valve do need extra iterations to improve the seal, the way the emergency override is connected and material has to be saved.

Improvements are also to be expected, in my opinion the ground plate has to be changed from a duo ground plate to a single ground plate. This will not only benefit the cost of the mould, but also the amount of material needed is much smaller compared with a duo ground plate.

All seals have to be assessed to validate their effectiveness. Finally also labelling and colours still have to be decided upon, which can increase the look and feel of the product. Concluding I can say that the design phase, though not finished yet was quite successful and will bring an above standard design to the market.

7. Market analysis

Current energy saving solutions

There are multiple ways of saving energy with compressed air systems. Below, a list of different kinds of savings is shown each with their own applicability, gain and potential energy saving contribution.

Every compressed air user has a different level of implementation of energy saving solutions due to the differences in energy awareness and level of knowledge. Of course, there is a big difference depending on a company's core business. Packaging is totally different from a car repair shop, however they both use compressed air. For different industries, different solutions are applicable.

Secondly, larger companies are usually implementing more solutions and on a more structural basis than smaller companies. The knowledge and understanding about energy saving solutions is usually greater and more in-depth. Management specifies energy saving goals. Often this is done by dedicating employees specifically with this task. Smaller companies are more dependent on their suppliers for support in both knowledge and service. The solutions are summarised in a list below, having the most important and implemented ones on top of each individual list. For the full list with details see appendix 4.

General:

- Reduce air consumption where possible, by using other energy sources like electricity
- Avoid water in the system
- Use pressure boosters where required to keep main air pressure low
- Have a good alignment between supply and demand
- Correctly size air preparation units
- Use easy to read pressure gauges, to support lower pressure settings

At the compressor:

- Use VSD (Variable Speed Drive) with large and multiple compressors
- Minimize system pressure
- Use the rest heat from the compressor

With the distribution:

- Detect and seal leaks, minimally once a year
- Install flow meters for better consumption understanding
- Regular filter replacement and monitoring to minimise pressure losses
- Avoid rough piping due to corrosion to minimize losses
- Minimize pressure drops in the distribution system by using right diameters

At the usage:

- Fit nozzles with correctly sized nozzles to prevent overconsumption
- Consider using differentiated actuating pressures or single acting cylinders
- Lower the standard system air pressure as low as possible
- Re-use the air from the tools

Indication of European air volume usages

To create insight into the market for compressed air, the European Union has issued for a report on energy usage in industry with the focus on compressed air systems. [2] (Peter Radgen, Edgar Blaustein, Compressed Air Systems in the European Union) Although this report is from 2001, the general figures are still applicable enough to gain an insight into the market of compressed air systems in Europe. In the European union, compressed air production accounts for about 10% of the industrial energy consumption and is over 80 TWh a year. For calculations made in this report, this percentage will be used on the assumption this percentage has not changed significantly.

In this report on the saving potentials of compressed air in the European Union, a clear table shows for each savings measure its applicability, its gain and its potential contribution. Please bear in mind this report is from October 2000, thus some of the savings have hopefully already been applied. Table 1, shows that reducing air leaks has the highest contribution (16%) among all the different energy saving solutions. Quick note, there is much doubt about adding up the potential contributions into one total figure, so this figure is ignored.

Energy savings measure	% applicability (1)	% gains (2)	potential contribution (3)
System installation or renewal			
Improvement of drives (high efficiency motors, HEM)	25 %	2 %	0.5 %
Improvement of drives: (Adjustable speed drives, ASD)	25 %	15 %	3.8 %
Upgrading of compressor	30 %	7 %	2.1 %
Use of sophisticated control systems	20 %	12 %	2.4 %
Recovering waste heat for use in other functions	20 %	20 %	4.0 %
Improved cooling, drying and filtering	10 %	5 %	0.5 %
Overall system design, including multi-pressure systems	50 %	9 %	4.5 %
Reducing frictional pressure losses	50 %	3 %	1.5 %
Optimising certain end use devices	5 %	40 %	2.0 %
System operation and maintenance			
Reducing air leaks	80 %	20 %	16.0 %
More frequent filter replacement	40 %	2 %	0.8 %
		TOTAL	**32.9 %**
Table legend: (1) % of CAS where this measure is applicable and cost effective (2) % reduction in annual energy consumption (3) Potential contribution = Applicability * Reduction			

Table 1: Energy saving potential in the European Union [2] (CAS = Compressed Air Systems)

Estimation energy saving potential

When the innovation of Q Plus would be added in this list of potential energy saving possibilities, applicability is estimated around the 15.2% and the gain is estimated to be around 40% leaving a potential contribution in energy saving of 15.2% x 40% = 6% in the European Union.

The applicability of the energy recovery system is estimated to be around 95% of the pneumatic cylinders. From these cylinders the energy savings are thought to be around 40% of the compressed air (minimally). Financially and practically, we estimate minimally 40% of the cylinders could be used to implement the energy saving as a retrofit(some cylinders will be too small, inaccessible or not used regularly and are left out with this estimation of 40%). This would result in a applicability of 40%*40%*95% = 15.2%. This system would benefit most to be build in new machinery. When its directly integrated in the machinery, there is no need to refit and reprogram machines, saving time and money. In that case the applicability should be estimated much higher going close to 20%

6% energy saving in the EU would account for 4.8 TWh in energy. Calculating the energy value of this 4.800.000.000 KWh it would be around € 240 million, as possible European Union saving potential, calculation with a € 0,05 per kWh.[3]

According to CBS, the amount of electricity used by the industry in the Netherlands in 2008 is 36.626 GWh. Estimated that also for the Netherlands, 10% is used for creating compressed air would result in 3662,6 GWh of electricity. Calculating with a similar percentage of 6% energy savings would result in 219.756.000 KWh or € 10.987.800,- savings potential.

In the compressed air systems in the European Union report, two programmes are proposed to decrease the energy usage of pneumatics.

The first one is the Awareness Raising Programme(ARP), possibly stimulating 16,5% of the compressed air savings electricity consumption. This programme would include information and decision aid measures.

Secondly, an Economic and Regulatory Programme(ERP) could in combination with the Awareness Raising Programme, stimulate savings of 24,7%. (The study team believes that the ERP would be useless without the ARP)

If Q Plus would be able to be part in these programs, it would benefit the innovation greatly.

Valve market potential

The total pneumatic market (Europe, America and Japan) is estimated on € 10 billion a year. This figure is estimated by adding up parts the sales figures from the biggest companies (SMC $ 3.1billion, Festo € 1,7 billion, Parker 5-10% of $ 12 billion group turnover, Bosch Rexroth Group 10% of € 5.8 billion group turnover, Norgren € 666 million, Metalwork € 125 million) and an estimation of the sales figures of the many smaller companies.

Within pneumatics, a rule of thumb created from the turn-over is that in the sales of pneumatic products: 15% is for air treatment, tubing and fittings, 30-35% is for valves, 50-55% is for cylinders. Therefore roughly the statement could be made that the pneumatic world market for valves would be around € 3 billion a year. Obviously, having a share of this valve market would increase the chance to sell more other pneumatic products as well (cross selling). However, the home market of Q Plus is the Benelux. The full market of the Benelux is estimated on € 170 million a year, which makes the market for valves to be around € 56 million a year.

Competitors

The largest competitors are big international pneumatic companies. These companies are globally oriented and generally have extreme strong marketing. These companies have large R&D departments and develop many new products. European market leader Festo for example has its main focus on creating special products for customers and integrating mechanics and controls. One of the focus areas of Festo is its bionic learning projects. In these projects nature is used to find the best solution for industrial processes and needed movement, while learning from natures solutions.

These big international pneumatic companies have clear sales strategies where it is their goal to sell to key markets themselves and create a strong pull of the market as a result from their marketing. World market leader is SMC very strong in Asia. In Europe however, Festo is dominant. In Europe Festo has strong entrance to all markets, and also has a large network of technical trading companies. This network is important for the end users, who create a pull by specifying the Festo product when they order new machines. They do this because they rely on local service afterwards. Technical trading companies are also used for supplying smaller machine builders for economic reasons.

Runners up in Europe are SMC, Bosch Rexroth, Norgren and Parker, followed by companies like Metalwork, Cammozi, and others. All these companies aim mainly for machine building industries and try to pay as much attention to the machine builder as possible. This is mostly less economic because the turnover is lower but the end user costs more time to service too: this results in lower margins. Although when end users become regular customers and order their own products, the service goes down and the margin up. Supplying the machine builder results in lower margins when the products are sold, however the volume is very large with generally easy distribution and therefore brings important sales volume. For this reason, the machine builder is the key customer in the market for the pneumatic manufacturers.

Customer profiles

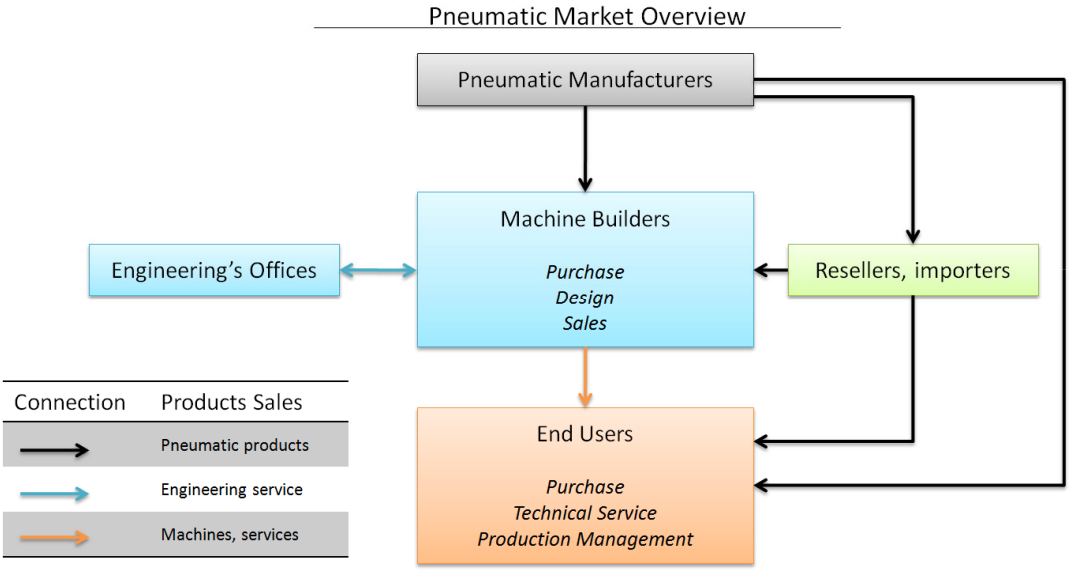

Fig. 21 Pneumatic market overview

Profile of users of pneumatic components

Technical trading companies and small importers

Technical trading companies are usually reselling a wide range of products to supply to their customers. This ranges from toilet paper to pneumatics. Due to this wide range of products, the knowledge about specific products is quite limited. On the other hand there are also technical trading companies and importers who only supply a small set of specialised products. These companies usually do have the knowledge about the products they resell or import.

The key motives for customers of technical trading companies are:

- Local, one-stop-shopping, customer buys all needed supplies at one supplier
- Getting a high service level, supplier of many different brands and products
- Speedy delivery, very strong logistic service
- A disadvantage is higher prices and limited knowledge of specific products, this is compensated by lower company costs on procurement
- When specialised products are needed or budgets are getting bigger, local suppliers are surpassed to benefit from lower prices and higher expertise of specialised technical trading companies or importers

Engineering's offices

Engineering's offices are sometimes hired by the machine builders, or are a department of the machine builder company. The design service delivered can be from the design of a new print board to the design of a whole new factory including all necessary machines needed in the factory.

The key motives for customers to use an engineering office are:

- Buy the required knowledge when needed at relatively low overall costs, only when needed
- Deliver good design solutions with sate of the art technology

Machine builders

Machine builders select, configure and setup components to support the process on a part or the whole product line. Usually, the products used in these machines are selected by the machine builders. The machine builder is usually a company specialized in one small part of the process line (eg. palletizing, filling) or in the whole process line (eg. production of tires). The machine builders compete with other machine builders on that part of the production line in which they are specialised. Competition is done on price and machine output.

The key motives for their customers are:

- High quality, reliability, continuity in production
- Long product lifespan
- Acceptable price level
- High output
- Easy maintenance, standardised parts
- Trustworthy supplier with continuity and quick responses when needed
- Increasing interest in durability, energy efficiency and environmentally friendly parts

The end user

The end user is a company that buys the machine and uses it for its production process. The end user pays for the energy bill, pays for service(maintenance) and makes the initial investments. For the end user Return On Investment(ROI) or the Total Cost of Ownership(TCO) should be the key factor for making decisions between different product offers. Usually, this ROI is based upon the initial purchase combined with its expected company added value. When this ROI would also include lifetime energy usage and service, a complete overview emerges showing the TCO of a product. Currently reliability, output and price are the main motives for the end user. Within companies, the chief of the technical maintenance usually influences the buying process. Because he is responsible for keeping the factory up and running mechanically, he usually decides which kind of products are bought. Therefore, the chief is usually an influencer or sometimes even the decision maker within the buying process.

The key motives for an end user are:

- Having influence on used parts which fit in their maintenance programme
- Return on investment (machine instead of human labour or as supporting labour)
- Reliable machines, reliable supplier
- Output of machines
- Price/quality ratio
- Total cost per product output

Interview goals

To gain information on the three important areas of: innovation, energy and Decision Making Units (DMU), I have conducted interviews of several machine builders' and end users' companies. This division has been made to gain insight into these three key areas which are very important to give a direction for developing a marketing and market introduction strategy of the energy saving concept.

Expected Results

Innovation

I want to find out what barriers and benefits are at hand for both machine builders as end users regarding new pneumatic products. How is information about new innovations acquired, understood, and chosen for implementation?
If a new energy saving product enters the market, what amount of effort is there available for implementation, what would they consider to be a realistic and attractive ROI?

Energy

I want to learn how much knowledge is available at both machine builders as end users about pneumatics and its energy losses.

DMU

I expect to gain a clear insight into the processes at hand within the buying process and designing/selecting process of pneumatics. This to get a clear overview of the DMU and its processes for both machine builders as end users.

Which selling points can be used to convince customers in the decision making process(Unique Selling Points)? Is it: ROI, TCO, production continuity/reliably, efficiency, capacity, effectiveness, a combination of these points or are there other factors having a role?

Interview conclusions

To improve insight into both the machine builder and the end user, interviews have been conducted. The setup of these interviews can be found in appendix 3 and was set up and conducted in Dutch. Its key research areas were innovation, energy and DMU. To create good insight of the market, four machine builders and five end users were interviewed and analyzed. To get a clear insight of the market, the companies chosen for the interviews were very different in size. The reason to choose for different sizes was to get a diverse group in which especially the DMU and energy awareness were expected to be very different.

Conclusions machine builders

Innovation

Innovations are not actively looked for. When new innovations happen in the market, the machine builder expects to get informed via his suppliers. The statement made is: if the supplier has something new, they want to sell it, so the machine builder will be informed.

When their customers complain or have problems, the machine builder will start looking for innovative solutions themselves.

Energy

In the design of a new machine, the energy usage for pneumatics is not seen as very important. The energy usage of electric motors is taken care of by applying new government regulations, prescribing the usage of energy efficient electric motors.

At this moment customers are not actively asking for energy usage and the costs of running the machine. When designing new machines, usually all pneumatics are over dimensioned to guarantee flawless functioning. Products have to work quickly to be used in new machines. This way, the machine builder is able to compete with machines from competitors on the output level.

DMU

Suppliers are chosen on their image, intuition, service and quality. Service is very important because when something breaks down the service level of the machine builder is as good as the service level of the supplier of the machine builder. Image is important because it helps to reinforce the quality aspect of a product and company continuity. Often the established brands are used due to their perceived high quality, being a sales argument.

Conclusions end users

Innovation

When time and people are available, innovations are searched for. End users keep themselves updated through websites, shows and by reading technical magazines and service journals. They also rely on suppliers to inform them.

The maintenance department describe themselves generally as: sufficiently educated generalists. There is enough knowledge available about cylinders and valves to place and maintain them. For precise calculations, external experts are consulted.

Energy

End users are very diverse. In some companies the maintenance staff has the time to work on optimising the pneumatic system, thereby actively saving energy and creating an as efficient production as possible. In other cases, the focus is more on keeping production up and running. In those situation, energy savings are only rarely done by the maintenance people. In companies where time is available, structural energy saving actions are sometimes undertaken. This drive for optimizing the company's production line differs a lot per company. Structural leak detection within companies is gaining popularity and attention continuously. Leak detection can be considered as the first step in energy saving measures. The target is the same for all companies : reducing costs.

Producing as efficient as possible is seen as a strategic goal especially in an economic crisis. This efficiency can strengthen the company in the competition and increase profits. When the return of investment is 1.5 years or less, new solutions or energy saving possibilities are generally directly implemented.

DMU

Suppliers are chosen to replace broken parts on the machines quickly and effectively. This is mostly done by the local technical trading company who almost acts as a part of the customers maintenance department. Mostly, leading brands are used for the replacements. When new machines are ordered, the machine has to be effective and should do what it has to do. It has to do nothing more and nothing less. The total cost of owner ship is currently no criteria in the buying process. The reliability, quality, price, service and image or past experience are currently the key buying criteria. If parts are specified they are mostly from leading brands, which are currently already used in the factory.

DMU Clarification

Within companies, decision making and responsibilities are often divided over multiple people. The maintenance department is usually responsible for machine reliability. They might also judge upon the maintenance costs. Due to the fact that energy consumption is the main cost of compressed air production, savings made here are under the responsibility of the purchase and finance departments and mostly not under the maintenance department.

To stimulate managers and employees from factories to be aware of the energy costs of compressed air, measuring the air usage, could be a good motivator for stimulating and initiating energy savings. Measuring energy costs and having the results available for all employees to see, can give an extra stimulant and insight in the air/energy usage of companies.

Summary of motives and interests

Having a summary the motives and interests obtained from the interviews give a good overview of what both groups have as important motives and interests. Importance is based upon the number of times it was mentioned in the interviews.

Motives and interests Machine Builders	**Importance**
Machine and parts reliability (product lifespan)	+++
Competitive price	++
Reliable end products (over dimensioning)	++
Quality of service from suppliers	++
Looks for new solutions when confronted with problems	+
Wants to have the quickest products	+
Choose for known brands for image	+
Interest in new energy saving solutions	-

Motives and interests End Users	**Importance**
Keep the production up and running	+++
Machine and parts reliability	+++
Saving energy (management)	++
Interest in new energy saving solutions (management)	++
Competitive price components	+
Interest in new energy saving solutions (maintenance)	-
Structural leak detection (maintenance)	--
Saving energy (maintenance)	---

Market analysis conclusions

In industry, saving energy is gaining popularity every day. In saving energy, many options are available, though many still need to be implemented. Within the world of creating new machines, the machine builders strive to create machines that are quicker and cheaper than their competitors' products. Innovations are expected to be gained via their suppliers. The key conclusion about the end user is in the large differences between the end users. The difference in attention and

knowledge between the large end users and the smaller factories is very large. Larger companies have more time and recourses available for making all aspects of the production process as effective as possible. As end users are often neglected by the large pneumatic manufacturers, end users need attention, extra knowledge and support. The smaller the company, the larger this needs becomes.

Product SWOT on the Q Plus energy saving system

As the newly designed product has its strengths and weaknesses, a product SWOT makes all these insightful. The SWOT analysis hereafter will assist me with developing the strategic market possibilities.

Strengths

- High relative and absolute energy/money saving potential
- Easy implementation in new machines, less easy in machine retrofits
- Hardly any extra costs when implemented in new machines: short ROI
- Easy to adapt for any machine
- Complete range for all cylinder sizes
- Quicker response rate can bring higher machine output
- Low total cost of ownership for the production line
- Low total cost of ownership as sales advantage for machine builders
- Clear technology, no technical downsides, no difficult technology

Weaknesses

- Products are not presented by a market leader
- Fear for new products/technology
- Training and education might be needed for both machine builders as end users
- Could be seen as just another energy saving solution
- More work needed for installing the product in existing machines, more components have to be installed.
- Slightly higher investment costs
- More space needed in the factory and machine for an extra low pressure air network
- Extra calculations have to be made to select the right size pressure tank
- Retrofit of machines, they have to be reprogrammed or its in-/out-puts have to be switched
- Retrofit of machines by re-engineering and rebuilding existing older machines will have a longer ROI due to extra engineering costs

Opportunities

- Great momentum towards energy saving solutions in all areas of the industry and society
- National or international regulations and legalisations can boost the adaptability of the concept (energy saving and CO2 reductions)
- Huge turnover/sales growth possibility due to the worldwide economic crisis due to increased motivation to save energy and cut costs
- Increasing dynamic market, global market, global communication, global interchange, making it easy for customers to switch brands
- Governmental support on CO2 reduction

Threats

- New products are thought to have large risks attached
- Many major brands and established names with large R&D departments are in the market
- Because Q Plus is a small company, being overtaken with comparable products by a large competitor is a risk. Patent protection, costs of lawsuits

- Both maintenance as engineers want to have reliable products, making it difficult to change between different brands (perception)
- Failing product quality, technical failures
- Not getting the patents approved
- Financing too costly for a small company
- Disbelieve “proof of concept”
- Unable to reach and motivate the market, unable to take away any fear

Confrontation Matrix

A confrontation matrix [4] has been set up to find out which challenges are most important for Q Plus to have its focus upon. Several members of Q Plus were asked to participate in the creation of this matrix. The goal of setting up this matrix was to find out what elements in the SWOT were deemed the most important for Q Plus to focus on when setting this product up for market release. Each participant has assigned a certain score to all parts of the SWOT, using the 5-3-1- method. This means that each participant assigns 5,3, and 1 point(s) to the combinations with the most potential. All scores combined lead to an accumulation of points on elements of the SWOT which are found to be most important.

		Opportunities			Threats		
		Government regulations	Global communication & market access to customers	Momentum→ energy saving	Disbelieve	legal costs patent defending	Quality
Strengths	Immense energy saving potential	5533 **16**	5300 **8**	5555 **20**	5005 **10**	5333 **14**	0000 **0**
	Easy implementation in new machines	0011 **2**	0151 **7**	0300 **3**	0111 **3**	1005 **6**	3350 **11**
	Increased machine cycles	0000 **0**	1010 **2**	1010 **2**	1000 **1**	3100 **4**	0100 **1**
Weaknesses	No market leader	3300 **6**	3503 **11**	3003 **6**	3300 **6**	0510 **6**	1505 **11**
	Lack of air cost knowledge→ motivation/lack of interest	1155 **12**	0335 **11**	0131 **5**	0550 **10**	0051 **6**	5013 **9**
	Retrofit difficult/ more expensive	0000 **0**	0000 **0**	0000 **0**	0003 **3**	0000 **0**	0001 **1**

From the confrontation matrix, four challenges have been selected:

- How can Q Plus use the energy saving potential to take advantage of the great momentum towards energy saving in the market?
- How can Q Plus use the energy saving potential to take advantage of regulations made/created by the government?

- How can Q Plus use the energy saving potential to ward off the legal costs of patent defending?
- How can Q Plus enhance the knowledge about the costs of air and the lack of interest in saving energy to take advantage of regulations made/created by the government?

The next chapter will discuss the strategic options Q Plus has concerning the patent and sales options. In chapter 9, the market introduction, I will show how, the strategic choice taken, should be carried out.

8. Strategic options

In the green tables, the pro's and con's of the strategic possibilities are shown, this is followed by a value estimation of each option. The purple tables show the pro's and con's for direct sales in the Benelux. This is followed by the decision tree showing the combinations between these possibilities, direct sales possibilities and the vision of Q Plus resulting in my advice on the choice.

Strategic possibilities

Since the goal of new product is earning money, the first goal is to repay the investments and the second goal to generate profit for the company. Due to the large potential of this product, especially the energy saving potential and its uniqueness, it has all the possibilities of being a great product for Q Plus. Because Q Plus is quite a small company, multiple strategies are interesting and valid options. Whereas a big company would launch such a product by itself, having a network and the financial means to support it, a smaller company like Q Plus should have a close look at all the different strategic possibilities as there are: sell the patent completely, sell product licences or sell products. A small company might also consider to use multiple strategies, fitting the best strategy to the geographical location. Q Plus might want to follow a different strategy in the Benelux, Europe, Asia, United States, etc. Q Plus has a solid network in the Benelux, but for serving the rest of the world with this product a network of partners would probably be preferred.

List of Q Plus strategic possibilities

Many strategic possibilities are available to Q Plus. Each option has its own benefits and disadvantages. The three most important options are: sell patent, sell licences or sell products. First, I will show the pro's and con's for each option. Then an estimation of the value of each of the options will be discussed.

Sell Patent

If the patent is solid and therefore valuable, this patent could be sold to an interested company. The companies expected to be interested are the world market leaders as SMC, Festo, Norgren, Parker or Bosch Rexroth. Below the list of pro's and con's of this option for Q Plus:

Pro	Con
Removes many concerns on development, sales, production, distribution, legal issues	Price offered might be low due to not having the product tested and proved in the market
Gain a good sum of money	When the patent is not tight enough, it will not sell but get copied
No big investments needed for production	Value of the patent increases when the products are in the market and sold
No technical and production doubts	No influence on market development
No legal issues to be handled on patent violations	No possibility to market and sell the products and or cross selling
	No technical fun and challenge left

Sell licenses

If the patent is granted to Q Plus and its strength and energy savings are proved, maybe one or multiple global competitors are interested in buying a license and putting the product into the

market. Also the companies in pneumatics with lower turnover could be interested and use their known products with adaptations to step in the market at relatively little investment costs. Below a list of the pro's and con's for Q Plus:

Pro	Con
Pays per product sold	Little influence on product development, production, market introduction and argumentation
No logistic or technical responsibility	Patent has to be rock solid
Multiple licensees might be possible generating multiple gains	Company has to be/get interested in the innovation
Licensee has to invest, resulting in a large drive to sell the products	Value of the patent only increases when the products are in the market
Direct access to the sales networks already available (worldwide distribution)	Every licensee makes the same big investment for production
When the product is an success the value increases	Might result in a high price per product due to the payback needed for all production resources per licensee
	Handle legal issues on patent violations

Sell products

Q Plus could also take the step to become a manufacturer and sell their own products. They will be responsible for the design of the products, manufacturing, quality control, sales and marketing and distribution. This is already known territory, however, the scale will be new. Direct selling includes sales under private label to other pneumatic companies as well as direct sales to machine builders and end-users. Below a list of pro's and con's for Q Plus:

Pro	Con
Create and follow your own market strategy	Higher chance of losses
Facilitate your own production and transport	Chance copies are made
Manufactures perspective, sell products	Costing large marketing and sales effort
Having your own sales force which has a clear overview of the DMU in companies	No experiences in a manufacturer's role
Give demonstrations and show the product strengths	Requires production resources and investments
Highest level of control	Have manufacturing responsibilities
Huge market potential under own reach.	Requires a good sales network
Could be supported on legal issues by the licensee	Requires global market knowledge
	Handle legal issues on patent violations

Value estimations on the possibilities

For each of the three options an estimation of the potential value can be made. As the world market for pneumatics is estimated on € 10 billion, using the rule of thumb (as indicated, 30% is generated by valves), results in € 3 billion turnover per year for valves. The average price of a valve is around €

50. With a valve market of € 3 billion, the world pneumatic valve market would exist of 60 million valves a year.

Suppose Q Plus is going to produce products and sell those around the world using sales partners. If via this way, 0,1% of the market can be reached and the new valves get sold. This would equal 60.000 valves and a sales revenue of € 3 million. Having a margin of € 5,- will generate € 300.000,- in profits a year. Because it's very common to cross sell other products along, sales of other pneumatic products in the product range are expected to increase also. As the investments are expected to be between € 100.000 to € 150.000, the ROI is to be expected within 1 year. When sales increase to 1% by using networks worldwide, this increase would equal a profit of € 3 million a year, calculating with a margin of € 5,- per valves, which is a moderate assumption in case of direct sales.

Suppose a licence is given to larger manufacturers, requesting a fee of € 1,- per valve sold. Suppose these manufacturers promote and market this valve well and they sell this valve to 1% of the market. This would equal 600.000 valves and thus generate a profit for Q Plus of € 600.000 a year. The target should be to sell multiple licences.

Suppose the patent gets sold. A large pneumatic manufacturer expects to gain a valve market share increase of 2%. When this increase of sales is generated by this valve, because 2% of the market of valves is 1,2 million valves which equals a profit of € 6 million on a € 5,- margin per valve. As the patent lasts of 5 years, the total profit of just the valves sales would equal € 30 million in those 5 years. Also an increase in cross selling and image is to be expected, increasing the profits even further. Therefore the value of the patent can be expected to be around € 15 million. In this case a negative argument to the possible buyers can be put forward: Can you afford to give this opportunity to your biggest competitor?

Direct sales of products in the Benelux

In the market, there are three possible customers for selling valves: pneumatic trading companies smaller pneumatic producers, machine builders and end users. Each group has their own pro's and con's as a customer.

The pro's and con's of end users for sales are:

Pro	Con
High margins on products	Urgency logistics in case of product stops
Cross selling can increase sales	Time consuming for sales force due to the large market and time costly advice and support
Create "pull mechanism" for new machines (end user is the decider)	Low sales per individual user (only replacements)
Product image improvement	Retrofitting machines is very expensive

The pro's and con's of machine builders for sales are:

Pro	Con
High technical expertise	Reasonable margins on products
Create "push mechanism" implementing the products in new machines automatically	Uses strong pneumatic brands to improve the machines image
Co-development, high adaptability	Conservative towards change(wants to deliver highly reliable machines)
High sale volumes	
Cross selling with other pneumatic products like: cylinders, push-in fittings, tubing, etc.	
Ordered logistics	
Product image gain	
Easy repeat orders without efforts	

The pro's and con's of the pneumatic oriented resellers for sales are:

Pro	Con
Large network	Lowest margins on products
Large volumes	No cross selling of products
Motivated to present a unique product	Focus on profit maximization
Low level of support after initial training	Private labelling will be used
	No product image gain

Deriving the main goal from the vision of Q Plus

Vision of Q Plus

The vision of Q Plus is explained in chapter 3, and it is a large influencer in making the final decisions on the direction to take with this new product. The list below has been set up to summarise this vision into a criteria list guiding the decision process:

- Educate next generation pneumatics to the machine builders and end users
- Provide technical support to position Q Plus in the market
- Sell more products to enlarge the sales in the Benelux to more customers
- The Benelux is the home market of Q Plus, it fits the company structure and provides access to customers
- Support customers to create better and longer lasting relationships
- Support customers in saving energy, for image building and positioning
- Q Plus wants to keep the role as reseller/importer and not move into R&D to develop any other new products

The goals of Q Plus

Due to the many strategic possibilities available to Q Plus, the next part will take the step from the vision of Q Plus into a goal Q Plus desires to go into:

- Sell 100.000 products a year after 5 years
- This equals about € 5 million of sales value and allows return on investment within three years, but these sales will cannibalize on the current sales in these product groups, on the other hand, cross selling will increase, minimizing the financial effects of cannibalisation for Q Plus
- Reach the global market by giving the relevant energy saving information
- Creating global understanding on the function of the system
- Putting the trade name of the product in the market and getting global recognition

The core challenge of the new concept

This new concept has as a core challenge four main points:

- Finalise and produce the products
- Introducing the new energy saving concept
- Getting customers to understand how this system can save energy
- Create awareness about the costs of compressed air, thus savings in energy consumption
- Create sales momentum

Making an evaluation of the strategic options, sales directions and the vision of Q Plus will lead to a strategic direction which would suit Q Plus best.

Strategic choice

To provide greater insight into the decision, I have build a decision tree (fig. 22). Each option in the tree will be explained and this chapter will be closed off with my advice for the direction to pursue.

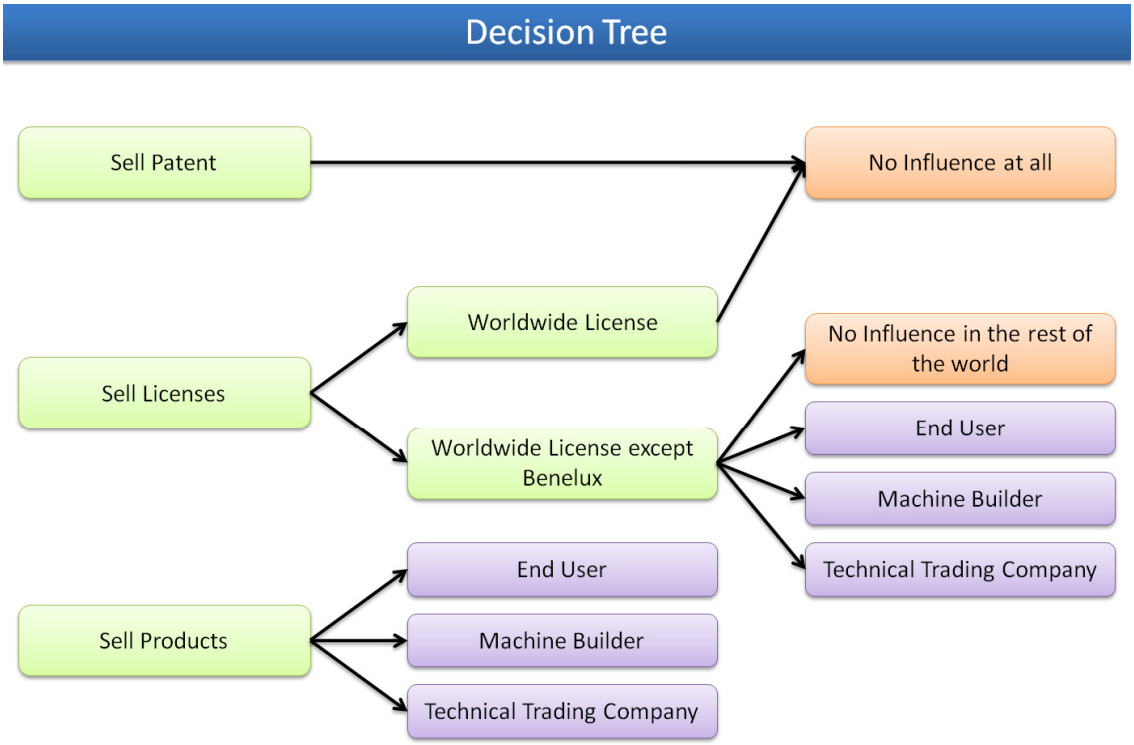

Fig. 22: Decision Tree

The patent can be sold, generating one great sum of money, but leaving no influence in the sales of the products at all.

Worldwide licenses can be sold, generating one or multiple continuous flow of money, but having no influence in the sales.

If worldwide licenses are sold without the Benelux, this would generate multiple continuous flow of money from the rest of the world, and leaving room for selling the products to the three groups (end user, machine builder and technical trading company) in the Benelux.

When products are sold, this would generate a continuous flow of money by selling products to the end user, machine builder and technical merchant.

The decision tree

By the use of this decision tree, the strategic choice will be explained (See fig. 22).

Patent

Q Plus wants to increase its product sales, therefore selling the patent will not be the first option for Q Plus. If the patent were to be sold, there would be no market advantage of Q Plus towards the competitor who would have acquired the product. As soon as the product would have been

produced by the competitor, it is more likely that their sales increase instead of the sales of Q Plus. The second important reason for not advising this course of action, is the tightness of a patent. If the patent is not tight enough competitors can still copy the product and no money is gained from the invention at all. Having products produced and sold with the first movers advantage does generate money. The value of the patent increases as the product gets sold. Therefore, selling the product in the market first, greatly increases the concept's / patent's value. When the product is in the market and large pneumatic manufacturers want to buy the patent, this option could become very attractive and should not be neglected if the price offered is high enough. The large pneumatic manufacturers are most suitable for acquiring the patent. Especially a company like SMC, who is technically very advanced in pneumatic energy saving products and has a patent on supplying air back to the compressor, would have great benefits from such a patent to stay technically ahead of its competitors.

License

Selling licenses for the whole world would be a good option. No effort, knowledge and production investments are needed and a continuous flow of money is generated by the sales of licensee. The disadvantage is the lack of room for Q Plus to sell products in the Benelux.

Therefore, the best option would be to sell worldwide licences except for the Benelux. Q Plus knows the market of the Benelux well and Q Plus wants to sell products in this specific market. In this market, the sell products strategy would have a good fit with the vision of Q Plus as they want to increase their product sales in the Benelux. To sell products in the Benelux, produced products are needed. These products should be produced via partners because Q Plus does not have, or want to set up, production facilities. There are already contacts with different partners for the different product parts who are able to produce these parts.

For the rest of the world, worldwide licences would suit the vision of Q Plus best. This could be one licence to a large pneumatic manufacturer or multiple licenses to multiple manufacturers. When a pneumatic manufacturer produces these products under a licence, it could redesign the product to fit in their own branding, production capabilities and portfolio. Their sales network and distribution are also great additions to generate large sales in the rest of the world. Agreements on price per product sold and a selection of markets could also be agreed upon.

Products

Becoming a manufacturer of their own product is no option for Q Plus. Q Plus is a relatively small company and does not have the financial means or the drive to set up its own production facilities. When the product does not gain the share aimed for, very large losses are to be expected. Basically the risk of becoming a manufacturer and produce these products is extremely large. There is the possibility to have the product parts produced by partners, what will decrease investments, and reduce risks, but gaining a large market share worldwide will be very difficult for a small company like Q Plus.

Advice

My advice to Q Plus is to sell licenses to one or multiple large pneumatic manufacturers, to be able to benefit from available distribution and sales force, generating profits from the world market. Within this agreement, Q Plus should stay in control of the Benelux by either producing the products

themselves or being able to sell the licensee's products private labelled in the Benelux. In the decision tree in fig. 23 this route is shown.

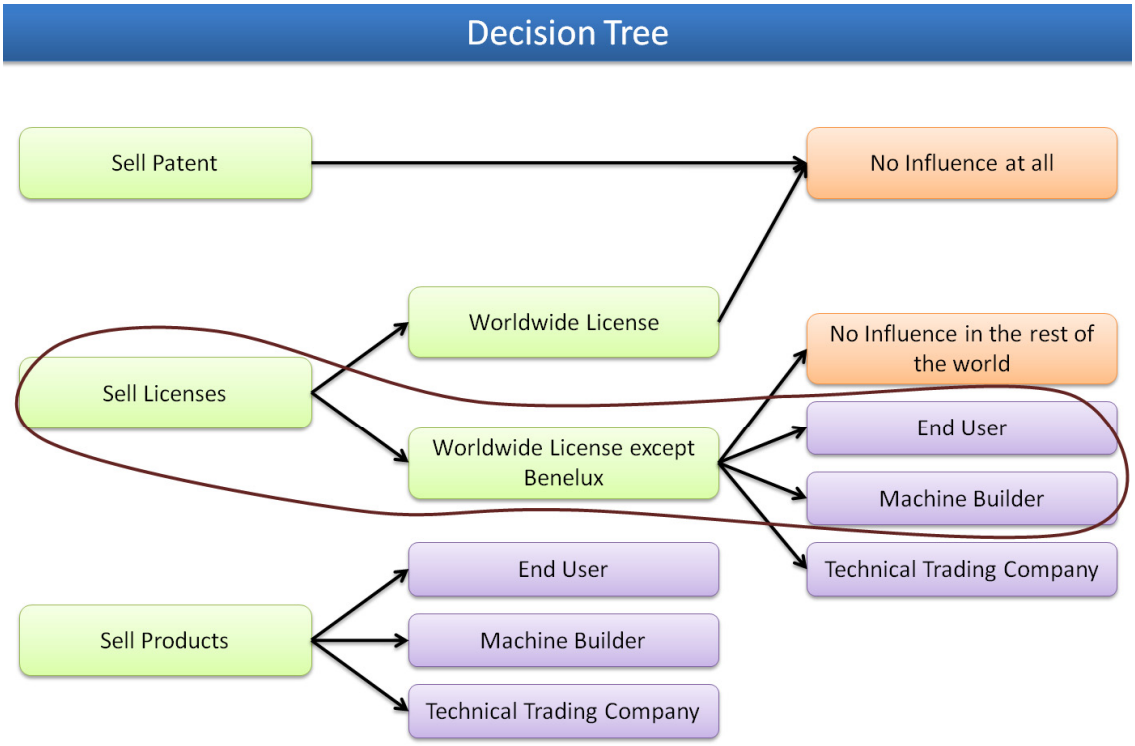

Fig. 23: The Decision

The next chapter elaborates on this choice and shows several possible steps which have to be taken to sell the product in the Benelux and the use of licenses in the rest of the world.

9. Market introduction

The strategic direction I would advice with this new product created by Q Plus should be aimed at increasing sales in the Benelux and generating profits in the rest of the world. Also, it should help Q Plus to increase its opportunities in the market. Strategic choices about licenses, production, price strategy, branding, sales strategy, communication, distribution, government and a website impression will have to be made and elaborated. For each choice, possibilities are presented here, followed by an advice to provide Q Plus with a direction tailored on this company.

In chapter 7 the confrontation matrix showed four areas to focus upon for enhancing the product argumentation:

1. How can Q Plus use the energy saving potential to take advantage of the great momentum towards energy saving in the market?
2. How can Q Plus use the energy saving potential to take advantage of regulations made/created by the government?
3. How can Q Plus use the energy saving potential to ward off the legal costs of patent defending?
4. How can Q Plus enhance the knowledge about the costs of air and the lack of interest in saving energy to take advantage of regulations made/created by the government?

Argument 1 is about selling products and will be discussed under branding. Arguments 2 and 4 are dependent on government regulations and will be discussed under government. Argument 3 is discussed under licenses.

Licenses

To get the products from the concept sold worldwide, licenses could be sold to one or multiple pneumatic manufacturers. This should be done after prototypes have been produced and tested, the savings are proved, and thus the potential value of these licenses. Licenses are interesting for the larger companies. These companies have the possibility to produce products that fit their current portfolio and benefit from the concept. The margins made on sold products are larger than reselling private labelled products. Disadvantages are the much larger investments needed for the moulds and engineering. A disadvantage for Q Plus could be that the licensee produces a product that does not meet the standards of the product and its concept.

When these products are copied illegally, Q Plus and the licensees will want to have those copies removed from the market as soon as possible. These legal costs can be expensive and require time and attention. The companies who have a license have the same intentions in this case as Q Plus and could support Q Plus in these cases.

Advice

My advice to Q Plus it to sell the license to one or multiple of the large pneumatic manufacturers. This should be done as soon as testable prototypes are ready and have proved the savings percentage. Special agreements about the Benelux should be made to increase the sales of Q Plus.

For legal issues of patent defending and removing copied products from the market, Q Plus might want to agree with licensees for support in these cases.

Production

Q Plus does not want to be both a manufacturer and also still a reseller/importer. As a way of still making production of the new energy saver possible, partners have to be found to produce the product for Q Plus.

A good solution could be to find one production partner to produce and assemble all the elements needed for this product. This has several good points: it keeps communication lines short and control stays relatively easy. At the same time, however, the only companies capable of producing all that is needed are large multinationals, which significantly increases the risk of copying. When this multinational has already a license, this risk is gone what makes it the best option. Another option is to have the product produced and assembled in multiple factories, each partner being capable to produce the best high quality parts for a good price. It makes it more difficult to keep every part of the manufacturing process under control, but the risk of copying is greatly decreased. At the same time, the explicit specialization of each separate company ensures high quality standards. Due to this experience, maximum support will be received in this so-called engineering stage, getting the product from the design stage ready for production. Q Plus already has several manufacturing partners who have the capabilities to produce all the parts of the new product.

The biggest drawback of these relationships is the openness required to show exactly what you need to your suppliers. Any untrustworthy supplier could steal a design, which would have huge consequences for both the product as the company, resulting in legal issues. Quality control and testing are also important and can be difficult to monitor when having multiple partners for production. The place where the products are assembled is also the most logical choice for testing and quality control.

Advice

My advice to Q Plus would be to have the products produced by one partner, preferably the company that already has a license. The advantage of having only one production partner, is that their engineering can improve the products and keep control of all the tolerances. Combining this with production and testing at one location, this will benefit the quality greatly. Q Plus is not large enough to facilitate their own complete production process. Also, Q Plus does not want to set up their own production facility or develop any other new products.

A good course of action for Q Plus in the prototype, engineering and test phase is to employ the service and experience of specialised partners. It is a great advantage to have the parts produced by these specialised manufacturers. It will of course have to be observed that non-disclosure agreements are signed. Also, Q Plus will have to be careful in sharing information with production partners, to not make it easy to copy the products or the concept.

Pricing strategy

For the new concept of Q Plus, a penetration and growth strategy would suit the concept best. Q Plus wants to price their products fair and set them competitively in the market place. For such a new product, a skimming strategy would not be the most suitable an option for Q Plus because their market share is currently quite small and has been pursuing growth due to the their competitive and fair pricing. Thus for gaining market share a penetration pricing would suit the strategy of Q Plus best. Because the product uses stronger and more expensive seals compared with competitors products, the product is expected to have a much longer life span. Facilitating a saving in energy and lasting longer, this product is allowed to be more expensive compared to normal pneumatic products. Combined with the first mover advantage, such pricing would stimulate sales and increase this advantage. Together with the licensee, agreements on pricing could be made to sell the products worldwide for a suitable price.

Advice

As the product has two large benefits towards standard competitors products, saving energy and a tenfold lifetime expectancy, the price of this product would be suitable when it is a little more expensive as the competitors products. If a similar pneumatic product from the competitor would cost 100%, I suggest a price of 120% - 140% would be suitable. This way, the product is not only branded as a high quality product, it is also priced as an exclusively high quality and high energy saving product. This will make both the product quality as its future savings much more believable. As customers always get discounts when buying large quantities of products, their discount could increase with the quantity of products ordered.

Branding

The product needs a brand to be recognisable in the market place. As Q Plus is a company who imports and resells products, it might be a good decision to find a different brand name which fits the product. Naming the product solely after a company would likely create confusion.

The product name should fit the product and should at the same provide a name that fits the customer's perception on energy saving pneumatics. Q Plus and the licensee should also go for a name which is unique in pneumatics and not easily interchangeable with all the other "Energy Savers" products from competitors. A link to the company is of course an extra way of marketing the brand. As the name should be clear and contain a message, see fig. 24, for a suggestion of a possible product name.

The product/concept name

Q Plus has been looking for a name which supports the compressed air recover energy system, explains the product, differentiates from competitor's "energy savers" and is original. Having considered and brainstormed about many names, an abbreviation in which the system would be explained was most appealing. CARES is the abbreviation of Compressed Air Recovering Energy System. In this abbreviation, the words tell what the system actually does, while the abbreviation itself shows the positive meaning the word caring already contains. Therefore the choice for the name CARES is well thought through. Outside of the Benelux, this name could also be used, although

it would also be very likely, the licensee wants to use their own product or brand names for the products of this concept.

Fig. 24 Who CARES?

Who CARES?

When using the product name CARES, the uniqueness grows because it supports the new approach to pneumatics and no pneumatic company has used this message yet. The combination between Who and CARES is of course a positive invitation for the customer to act on saving energy in pneumatics.

When companies want to communicate a message, stories can provide a good and positive structure. In addition, a story-based structure can have an effective and motivating impact on the customer. When the story line is clear, simple and covers all the important sales points, the customer connects any emotion produced by the story with the product/company. Therefore the story should be told showing the strong points of the product.

The focus of the storyline of this product should be on saving energy and money when using this new pneumatic invention.

Reliability

To guarantee high quality products and energy savings, certification by TNO and/or TÜV would provide reliable communication tools for convincing future customers. When this is combined with information about the materials used, the product strengths gets communicated even more clearly.

Product support

Supporting the customer with advice on energy usage, calculation tools and configurators, empowers the user and provides insights into both their own factory/machine as the new product.

Advice

My advice for Q Plus is to create a brand which can compete with the large competitors, a new brand with a unique and simple name is needed. When one or multiple licenses are sold, these manufactures will probably pursue their own brand and introduction strategies.

In the Benelux, argumentation should focus on the products removing possible barriers. The most important strength argument should be the high energy saving potential. Taking away any doubts on reliability by certifications from important independent institutes, reinforces the most important motive of the customer: reliability.

Sales strategy

As the discussed in the previous paragraph, Q Plus should sell this product under a different brand name. For generating new and increasing sales, Q Plus has to convince both the machine builders and the end users.

As identified in chapter 7, the market has basically three markets, resellers/technical merchants, machine builders and the end user. Within the Benelux the resellers/technical merchants are least interesting. They basically do the same as Q Plus, generate the lowest margins, do not allow for cross selling focus on profit maximization and have no product image gain due to private labelling. Due to these reasons, resellers/technical merchants are least interesting for sales. Machine builders and the end user are important for Q Plus and the concept in the Benelux.

Market introduction strategy

There are two markets each in the need of their own approach. Due to the different motives and interest of the machine builder and the end user, two sets of arguments and approaches are needed. In my opinion, the machine builders could be used to create a "product push", choosing the components from this concept for their machines and sell it to their customers (end user). The end user should be used to create a "product pull" from the machine builders, convincing the machine builder that only machines that have this concept included will be purchased. These sets of arguments can be used as the basis when creating the content that will be communicated to each customer group.

Machine builder arguments

- To the machine builder the most important is machine and parts reliability. To convince the machine builders the new products fulfil their reliability demands, test certifications by TNO and/or TÜV will increase confidence.
- Because this new system is saving energy and thus money, the price of these new products might be higher. Machine builders often look for a high quality and low price ratio for products, therefore, this product should explain this ratio and especially its saving argument well.
- Over-dimensioning of cylinders will increase energy usage, which results into less efficient energy usage. When machine builders can create machines which are reliable without large over-dimensioning, energy usage can be lowered here too especially when using this new system.
- Service quality needs to be on a high quality level. When a product fails at the end user the machine has to be up and running again as soon as possible. The availability of spare parts and the time needed for acquiring these parts has to be short.
- Machine output increase due to higher cylinder response rate.
- High reliability due to carefully selected materials and manufacturers.
- Low TCO and short ROI for the end user due to the large energy savings in usage.
- Green image and large CO2 reductions.
- Modern innovative design with state of the art pneumatic components.

Advice

When products are ready to be sold, the machine builders should be shown the benefits this system has compared with current pneumatics. This will be a difficult but challenging task for the sales force of Q Plus. Using the right arguments and showing the benefits in their three most important motives and interests, which are described in chapter 7, should help the concept to get integrated in the machine builders' products. The four most important motives which should be used are: reliability, operating speed, energy saving and product costs. It is important to have these integrated in the communication with the machine builders. As soon as the machine builders are convinced of benefits of these products compared with other pneumatics and want to implement these new product into their machines, a "push strategy" is created helping the product to be pushed by the machine builders to the end user. As implementation into new machines is most suitable for this product, the market of the machine builders is the most important market.

End user arguments

- The most important motive of the end user is to keep production up and running. To keep production up and running, machines have to work properly. As concluded in chapter 7, end users want products which are reliable, do not break down easily and are easy to replace when broken. Thus the most important condition for the end user is to communicate the reliability of the offered products. This feeling might be enhanced by a TNO or TÜV certification and a good design.
- At the end user the management is interested in saving energy. This is found to be interesting due the possible savings on energy costs, which in the end results into higher company profits due to lower costs. When able to communicate with the management, these products offer substantial energy savings, the likeliness these products getting implemented increases.
- End users are interested in competitive, reliable and high quality components, but price might be an issue. Especially in times of crisis end users are spending more time finding cheaper priced components, machines or processes. When the Q Plus products offer energy savings while being similar or slightly higher priced as normal competitor products, these products might become a good choice.
- Saving energy is often not high on the agenda in the maintenance department. Structural leak detection and fixing the leaks have a much lower priority compared with repairing and servicing machines. When there is spare time for the maintenance department, this available time is sometimes used for finding and fixing leaks.

Advice

My advice to Q Plus to just focus on the Benelux for sales. Q Plus does have the capacity, facilities and strength to sell the concept together with the rest of the product range of Q Plus. The rest of the world is currently too large for Q Plus to reach with their sales force and can be served by the manufacturers who have acquired a license. Therefore my advice to Q Plus would be to keep its focus for sales on the Benelux concerning sales to the end users, to create a "pull mechanism" from the end user.

Increasing the level of awareness is the first step that has to be taken for convincing the end user. Due to the low awareness of energy saving possibilities in pneumatics at the customer, creating this

awareness is the first logical step to take for Q Plus. Organising lectures, gain governmental interest and support, create articles and use the world wide web. Generating awareness at the end user can be done by performing a 3 step strategy. Guiding the customer through these three steps might be most effective and applicable for Q Plus and its sales force.

1. Leak detection
2. Pressure loss calculations
3. Introduce energy saving concept

Doing leak detection is the first basic step. Q Plus can show the end user how a simple investment in energy savings in pneumatics can save a great sum of money. As leak detection and repairing has a ROI of maximal one and a half month, this investment is logical and valuable for companies. The sales force of Q Plus could point out that such a leak test is a good idea, redirecting that customer to a leak test company who can be a partner of Q Plus. This way the test is done by an independent company, which could advise products from Q Plus to be used for repairing the leaking products. This first step of leak detection could be started with directly, with the main goal of making the customers more aware of the costs of compressed air. As soon as companies are getting used to do leak detections and save great sums of money on the electrical energy bill (when the leaks are fixed), step two can be taken.

Step two, is doing pressure loss calculations to reduce the electrical energy bill a step further. Each component in the pneumatic system evokes a pressure loss. When the pneumatic system is calculated for optimal flow and minimal pressure loss, optimization can take place to reduce the energy bill further. Having the correct flow in the pneumatic system is choosing the right diameters and having the best components without any leakage and with the lowest possible pressure drop. This step is more difficult as the first step because it requires more knowledge from the sales force. This might require some education for the sales force, learning the basics of these calculations. The big advantage of this step is the large sales potential. Many pneumatic components are currently undersized and could therefore be replaced with components which have better flow characteristics. When pneumatic products are broken and the sales force has the technical knowhow on flow calculations/estimations, the best products can be selected and pressure loss can be expressed in euro's saved per year. These figures can then be used in the sales strategy to convince customers to select the right/best components and advice which they should get.

Step three is the introduction of the new energy saving concept. When the customers of Q Plus have become aware of the major amounts of energy saved by Q Plus in the 1st and 2nd step, taking this 3rd step of saving even more energy with an attractive ROI, is very logical.

By taking the customer by the hand and guiding him/her through these steps of energy saving, each step has a longer ROI and requires both more technical knowledge and effort from the company. As Q Plus gains trust and is seen as a reliable partner for pneumatics, each step increases energy savings and the knowledge of the customer. The first two steps can be taken before the new product gets to the market. This way the market gets educated by Q Plus on saving energy with the most basic energy saving solutions. So the customer will gradually see Q Plus more and more as a company which has the knowledge about this subject available.

The key to sell these product to the end user is via the machine builders. Refitting old machines with this new pneumatics far more complicated than having it integrated into new machines. Therefore, the end user should be acting as a “pull mechanism” towards the machine builders, asking for implementation of these pneumatics into their newly build machines.

Distribution

As soon as larger pneumatic companies get interested in these products, their sales network and distribution might be utilised for extensive international sales. These larger pneumatic companies might want to develop their own products under a license, that fits in their portfolio or want to have the products private labelled. Product distribution in the Benelux is no problem, after all it is the specialisation of Q Plus.

Advice

My advice to Q Plus would be to focus on distributing the products in the Benelux themselves. For the rest of the world, find a large pneumatic company, like Festo, SMC or multiple smaller ones to sell and distribute the products of this concept under a license. Mainly due to their availability of sales force and distribution channels. As these companies also sell products in the Benelux, agreements about this market should be made with the licensee.

Launching the product internationally will require well selected licensees. These licensees should have good distribution channels and sales force abroad. To empower the sales force, Q Plus should provide trainings and meetings to explain the benefits of the product. These trainings should also show how to deal with the product's weaknesses.

In short, finding on or multiple licensees is key to gain and expand international sales.

Governmental influences

Governments can have large influences in prohibiting and supporting products. Due to regulations, less efficient engines, electro motors and many other inefficient systems have been prohibited. Very efficient products have been promoted like the LED lighting nowadays. Due to those kinds of regulations, innovative solutions can enjoy a large “market push”. The two government related options, from the confrontation matrix, one for regulations and one for supplying energy saving information should be exploited.

Advice

As soon as testable prototypes are available, Q Plus should get tests performed by the important institutes like TNO or TÜV. These tests should focus on the savings potential this system has compared with current pneumatics. As soon as the results are available, these should be used for convincing both national as European governmental organs who have the ability of creating new regulations on this subject. Standardization of such a concept into an ISO norm (like the Sustainable Development Standardizations [5]) could also create a large opportunity for making this system

standard and available worldwide. It will be a long and difficult road getting the governmental organs to listen and it will be even harder to get regulations introduced. Therefore my advice is to consider dedicating someone to get this on the governmental agenda.

When the governmental organs acknowledge the large energy saving potential of this system and has this on their agenda, it is very likely they will not hesitate including this solution among the other promoted energy saving possibilities. The government is already undertaking multiple initiatives to enhance the knowledge on the subject of saving compressed air.

Communication

In the business to business communication, many ways of communication are possible. Communicating with current customers can be done via direct mailing and the website. Getting attention from new customers, can be done via four major ways: general advertising, internet, fairs and via energy efficiency companies/government regulations. See appendix 5 for details on communication like: suitable magazines, preferred fairs, selected web addresses, etc.

Product website

Having a product website is very important for communicating the concept worldwide. This website has to introduce the new product and explain how it works to many companies. The product website should be dynamic, structured and explanatory. Next to have a professional look, the product benefits should be explained and its differences compared with current pneumatics. Providing a structured explanation of the products and combine it with certifications from independent institutes increases the credibility and the perceived quality of the product. When this is combined with a very professional website, the product will be taken seriously straight away. The website could look like this (see fig. 25), explaining the product benefits, information about the manufacturer(s), case studies and system benefits. The website should also explain how the system works and be able to do some estimations on energy savings achieved.

Fig. 25: Website impression

Internet advertising

Having exposure on the web, communicating both the products as the concept will be very important. Showing the new products and their unique properties will influence customer buying behaviour. Many ways are available for generating publicity on the web for example, banners guiding to the product web site, being high in search results and get recommended via social media.

General advertising

General advertising includes magazines, newspapers, radio and television. Where both radio and television are not preferred for branding this product in the business to business market, magazines and newspapers are. Next to these important ways of advertising, natural media advertising could be an interesting example. Natural media advertising is the usage of nature for making advertising statements. This is very diverse ranging from: growing moss in the shape you want on the wall, removing dirt from floors and walls(clean advertising), having the clean/dirty part show the message and things like beach tagging and crop mowing (see fig. 26). Making use of these kind of communication tools would distinct this product directly from its competitors, staying in the minds of new customers longer. These natural media advertising ideas could be done near Q Plus or at fairs. The images from these ads can then be used on the website and other communication as visuals.

Fig. 26: Natural media advertising – Curbmedia [6]

Fairs

Having exposure on fairs helps the invention to get know by a larger public. Fairs should be chosen that are attended by people who are working in the manufacturing industry and interested in motion, drive and automation. Currently, Q Plus does expose itself on fairs. The most important fair for introducing this concept could be the Hannover Messe. This fair is the fair to visit for pneumatics in Europe and would generate a large amount of attention.

Energy efficiency companies and regulations

Not only the end user and the machine builders could be the communication target. When energy efficiency companies and the governments are also informed and convinced of the energy saving potential, these energy efficiency companies and the government might prescribe companies this product.

Higher education exposure MBO, HBO etc.

Education could also be a great step for introducing these products as standard products to future maintenance employees. When students work with your product, they are very likely to influence

their future employers and colleagues. Get integrated into the education system on the pneumatics is a long term investment in brand building

Advice

When good advertising is combined with a good website, which also has many links from the important engineer websites, the communication will get solid. For the product launch, the Hanover Messe is a probably the best way for getting this product introduced. Having the product used at high schools gives students the possibility to learn to work with these kind of pneumatics and therefore it is much more likely the students will apply these same products later on in their job. Although this is a long term investment for the product, it might be interesting to do on a selective basis.

10. Conclusion

Q Plus is a small company with a large innovation. Pursuing an increased market share in the Benelux, products have to be developed and produced. This graduation project supported Q Plus with the design of: the product and a strategic market introduction advice. The product design started from the design brief and has resulted in products fitting these wishes and demands. Via a market and analysis, strategic options and sales strategies were considered and the most suitable one for Q Plus has been chosen.

With this product, Q Plus has a new product with a high potential. Due to the lack of manufacturing possibilities in Q Plus, good partners are essential for creating a high quality product. Due to the applications in which these products have to perform for very long times, the quality needs to be excellent. Supporting arguments with a TNO or TÜV certification will increase the credibility of this product.

I recommend Q Plus to sells this product in the Benelux. To serve the rest of the world, one or multiple pneumatic manufacturer should be found to produce the products under a license. Also distributors and small companies with private labelled products could be used for this purpose. When large pneumatic manufacturers acquire licenses, their effort in distribution and sales will benefit the product sales greatly worldwide.

Introduction of this product by Q Plus in the Benelux can be done most effectively by using the 3 step strategy for the end user. This way, the end user creates a “pull mechanism” from the end user towards the machine builders. For the machine builders this product will have large benefits due to the increased speed and reduced energy usage, creating a “push strategy” towards the end users. Due to the different advice levels and integration efforts needed to install this system in a machine, this product is most interesting to put into new machines. Implementation into older machines would be too costly in both time and money. This results into the conclusion that the lowest investment costs, lowest detailed product explanation (the detailed calculations and installation details) and highest ROI and TCO for the end user are achieved on implementation into new machines.

11. List of References

[1] Freedom of Creation, Zwart, B., Visit and meeting to discover the world of 3D printing, December 3, 2009, Website: http://www.freedomofcreation.com/

[2] Ragden, P., Blaustein, E.,Compressed Air Systems in the European Union, Energy, Emissions, Savings potential and Policy actions, (October 2000) retrieved September 9, 2009 from: http://www.isi.fhg.de/publ/downloads/isi01b04/compressed-air-long.pdf

[3] Energy costs companies, Essent Business, retrieved January 14, 2010, from: http://www.essent.nl/content/zakelijk/producten/elektriciteit/keuzetarieven/tarieven.jsp

[4] S.C. Santema and J. Van de Rijt, Marketing Planning, de kunst van het kiezen, 2007 Kluwer, ISBN-13: 9789013000368

[5] Sustainable Development Standardizations, retrieved February 23, 2010, from: http://www.iso.org/iso/hot_topics/hot_topics_sustainable_development.htm

[6] Curbmedia, retrieved February 18, 2010, from: http://www.curbmedia.com/what-we-do.asp

Appendix 1: Exploration

Characteristics of pneumatics

In factories, pneumatics and electric motors are widely used for the handling and processing of products. Pneumatics have several advantages and disadvantages for its usage in a factory[1]. In short, the most important advantages are:

- Free medium
- Easy and fast transport
- Clean and dry (good for the equipment and machines in the factory)
- Temperature insensitive(but the air has to be very dry below zero)
- Safe(no danger of fire/explosion, no short-circuit, not influenced by magnetism, radiation, temperature, etc. and insensitive to overloads and blockings)
- Easy and relatively cheap components

The most important disadvantages are:

- Relatively expensive(efficacy losses: large energy loss when compressing air, transport losses and mechanical energy losses)
- Is compressible, so can result in changing speed when handling changing loads(can be solved with hydraulics or electronics)
- Moisture in the compressed air can cause corrosion, or even the forming of ice(can be solved by drying the air)
- Noisy (can be solved by damping the expanding air)

Industrial world

In the world of making machines operate, pneumatics is widely used utilizing compressed air as medium. Although people think that using compressed air is free, since it's all around in a non-compressed form, it is actually a very expensive energy carrier. When comparing compressed air to electricity, compressed air is about 10 times more expensive for powering equipment. For compressing air, most of the energy used (around 90 percent), is converted to heat. Because pneumatics have the possibility to deliver a huge amount of power (high force-to-mass ratio) for a relative low price and the low cost equipment, they are usually a logical choice for factories. In a packaging plant, one half of a machine uses electric powered motors and the other half of a machine is powered by pneumatics.

In a pneumatic system, the cylinders execute the actual movement and they are controlled by valves. These valves are usually steered by programmable PLC via a bus system. The valves are usually on a valve manifold that contains multiple valves. The valves steer by letting the compressed air into one side of the cylinders, resulting in its movement. Most valves have a life expectancy of 15-20 million strokes, so in practice, when valves are used very frequently (say 1 to 2 cycles a second) they get broken every 1 to 2 years. Some factories don't change one valve but take out the whole valve manifold and insert a new one to keep the production running. To give some idea about the price: a

standard valve manifold with 8 valves would cost between € 400,- and € 800,-, depending on the sort, size, brand and other aspects.

The market is dominated by several big corporations, of which most produce more than just pneumatics: Festo coperation (€ 1.500 million turnover and 12.000 employees), SMC corporation ($ 3.100 million turnover and 13.000), Parker ($ 12.000 million turnover and 62.000 employees), Rexroth Bosch Group (€ 5.800 million turnover and 35.000 employees) and Norgren(€ 666 million turnover and 6000 employees). The rest of the market is served by smaller manufacturers like: Metalwork(€ 125 million turnover and 850 employees), Asco Youcomatic, Ross, Univer, Vesta, and technical trading companies like: Q Plus and several more.

Pneumatics in practice, a visit to Sillevoldt Rice

To improve my understanding of pneumatics in practice, a visit to a rice packaging plant, Sillevoldt Rice was conducted. In this factory a large number of machines are packaging lots of different kinds of rice. From the folding of the package into the right shape, the filling of the package and the stacking of the packs into larger boxes, it is all done automatically. Employees clean the machines, remove obstructions and insert the flat cardboard sheets that eventually become boxes.

To keep all the machines in the factory running, the technical service keeps a close look on all the machinery. The technical service at Sillevoldt Rice has a solid stock of spare materials for servicing the machines. Currently, Festo cassette valves manifolds are used on most of the packaging machines. The disadvantage of cassette valves manifolds is when one valve is broken, whole manifold has to be taken off the machine. Then this manifold has to be taken apart and a new valve can then be placed in the manifold. Usually all this hassle is done in the workshop and not at or near the machine. This is the disadvantage of cassette valve manifolds, to replace one valve, the whole manifold has to be taken apart. To make life easier, the technical service usually replaces all the valves of one valve manifold simultaneously when one is broken. This way, the technical service only has to take off the valve manifold once instead of multiple times to replace each individual valve. When all the valves are replaced on an manifold, the whole manifold can conduct a new period of cylinder controlling.

Responsibility in Industry

In the industry, saving energy is constantly becoming more important. As energy gets increasingly more expensive and consumers are expecting companies to take their responsibilities towards the environment, an increasing amount of companies are waking up to see the potentials of saving energy. On one hand it is good for lowering their own costs and on the other hand it is good for their image.

Compressing air

Within the world of the pneumatics, saving energy is a subject that is slowly gaining interest. Within pneumatics several areas are currently popular for saving energy. According to Atlas Copco [2] a

large compressor manufacturer, 10% of the energy used in industry is used by pneumatics. Below is a small diagram of power usages in industry:

Country	Power usage of pneumatics in factories in TWh	% of the industrial energy usage
France	12	11
Germany	14	7
Italy	12	11
United Kingdom	10	10
Rest of Europe	32	11

Table 1: Power usage in industry [2]

When air is compressed, 90% of the energy used is released in the form of heat. Saving energy upon creating compressed air is done in several ways of which some will be discussed here. When generating compressed air, most of the energy of this energy conversion step gets lost in the form of heat. Some compressor manufacturers like Ingersoll Rand [3] but also Atlas Copco provide solutions to use the generated heat for preheating the water entering the boiler, or use the heat for preheating the water for heating purposes. The colder and dryer the air is, before getting compressed, the lower the amount of energy is needed for compressing the air.

Different sorts of compressors have their different optimal energy conversion. Using the right type of compressor for the right kind of flow needed is useful. In this small diagram of Atlas Copco the different types and their optimum are shown.

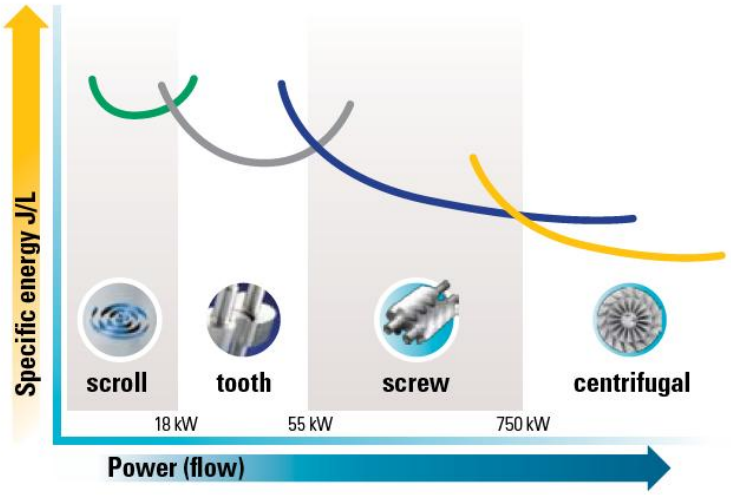

Diagram 1: Compressor differences and their optimum energy usage [2].

Atlas Copco saves energy through inventions like: variable speed drive, saving 35%,integrating a dryer, saving 20%, and many more inventions. Atlas Copco even received a TUV certificate of recovering 100% of the electric energy used by the compressor by turning all of the lost heat into heating up the water to 90 degrees Celsius, which can be used for other purposes.

Filtering and drying

To improve the quality of the compressed air, usually the air is both cooled and filtered from impurities and moisture. When air gets compressed, its temperature rises. An important property of

air is that when it gets compressed or cooled, it holds less moisture. Therefore it is very useful to remove most of the moisture from the air, firstly preventing the forming of water or even ice in the system and secondly preventing the system from breaking down. Both the filters and the dryers should be replaced/cleaned regularly to keep the flow losses as low as possible.

Pipe work

As a rule, when energy gets transported, energy gets lost. Therefore it's important to make the transport losses as low as possible. This can be done by minimizing: friction between the inside of the tubing and the compressed air, fixing leaks, avoiding sharp bends and variations in pipe diameters. All of these factors influence the flow and thus energy losses.

Pneumatic valves

Pneumatic valves are controlling the actuators, usually the cylinders. These valves are available in many different sizes and shapes. Some valves are manually operated but most valves are operated automatically through a computer, PLC or other electronics. Big machines in factories are usually operated automatically to be able to produce quickly, precisely and in large quantities.

Actuators

Normal cylinders are quite simple. These cylinders produce a linear stroke having to provide labour in just one direction(sometimes with a spring for the return stroke) or in both directions. The diameter of the cylinder determines how large the pressure surface of the cylinder is and thereby, how much force a cylinder can deliver. To give an idea, a cylinder with a diameter of 40mm and a pressure of 6 bar; produces 635 N for the inward stroke and 750 N for the outward stroke. The difference is due to the smaller surface of that side of the piston the air presses upon. This surface is smaller due to the piston rod connected on that side of the piston.

Fluidic Muscle[4], is able to generate a tenfold of the power compared with ordinary cylinders with the same inner diameter. These muscles are only able to contract themselves and can thus only labour into one direction, having a stroke of max. 25% of their nominal length. They are able to generate this much force due to the very large surface the air can press on and therefore they use less air compared to normal cylinders.

There are also many different tools available to work on compressed air. Their range is wide and contains tools to fasten bolts, shoot nails, paint, drill, screw, grind and much more. The big advantage is their resistance to jams, being light weight due to a high power to weight ratio while being cheap in purchase and safe to run. It's safer due to the absence of electricity, making short circuit or electrocution impossible.

Appendix 2: The price of a cubic meter of compressed air

The compressor company: Ingersoll Rand (Peter van der Geest, e-mail to author, September 21st, 2009) provided a simple rule for the energy needed to compress air to 7 bar. As a basic rule: 120 Wh/m3 or 0,12 kWh/m3.

With a kWh-price of € 0,05/kWh: 0,12 kWh/m3 * 0,05 €/kWh = € 0,006 /m3.

With this figure, we can make some calculation on the amount of energy/money used by a pneumatic hand tool.

For example a particular hand tool that uses 500 l/min, will use at continues usage in one hour: (500*60)/1000 m3/h * € 0,006/m3 = € 0,18/h

This figure is without: investments, service, pressure energy losses, leaks, pressure regulator at the tool, etc.

Appendix 3: Interview setup for machine builder and end user

Participants

The interview should be conducted with a diversity of people.

Pneumatic manufacturers deliver pneumatic products to machine builders, technical trading companies/importers and to the end users. Technical trading companies and importers do the

logistics for the manufacturer, serving both the smaller machine builders as the end users. Machine builders design and create machines for the end users specific to the needs of the end users. Engineering's offices serve machine builders by providing engineering's services to the machine builders.

The end users are buying their machines from the machine builders or buying pneumatic components directly from the manufacturer or via a reseller/importer. As soon as parts need replacements, spare parts are ordered via or the manufacturer or a reseller/importer.

As for Q Plus as their reseller, importer and "manufacturer/product developer", the machine builders and end users are our customers.

To gain insight in the decision making units and decision path at both the machine builders as the end users, interviews are needed.

By selling to machine builders, who are involved in the decision making process and what are the criteria to decide upon?

- Purchase
- Design
- Sales
- ?

By selling to end users, who are involved in the decision making process and what are the criteria to decide upon?

- Purchase
- Technical service
- Production management
- ?

Expected Results

Innovation

I want to know what barriers and benefits are at hand for both machine builders as end users regarding pneumatic products. How is information about new innovations acquired, understood, and chosen for implementation?

If a new energy saving product enters the market, what amount of effort is there available for implementation, what would be a realistic and attractive ROI?

Energy

I want to learn how much knowledge is available at both machine builders as end users about pneumatics and its energy losses.

DMU

I expect to gain a clear insight into the processes at hand within the buying process and designing/selecting process of pneumatics. This to get a clear overview of the Decision Making Units and its processes for both machine builders as end users.

Which selling points are used to convince customers in the decision making process(Unique Selling Points)? Is it: ROI, TCO, production continuity/reliably, efficiency, capacity, effectiveness, a combination of these points or are there other factors having a role?

Interview machine bouwer

Innovation

- *Welke technische kennis over pneumatiek is er in uw bedrijf aanwezig?* (*Wat moeten we communiceren*)
    - *Hoe blijft u op de hoogte van de ontwikkelingen in de pneumatiek?* (*hoe/via welke weg moeten we aanspreken*)
    - *Wordt er tijdens het ontwerp gebruik gemaakt van de laatste technische innovaties?*
        - Waarom wel/niet?

Energy

Wordt er tijdens het ontwerpen rekening gehouden met energieverbruik?

- *Welke argumenten spelen een rol in het aankoop/engineering proces?* (*Redenen voor deze processen*)
    - *Is energie verbruik een onderdeel van het aankoop/engineering proces?(leeft energie verbruik)*
- *Hoe wordt een cilinder gecalculeerd? (Wat zijn de energie doelstellingen)*
    - *Wat voor werkdruk wordt gekozen?* (*detail*)
    - *Hoe wordt een diameter afgerond?*
    - *Op welke criteria zijn het belangrijkst bij een cilinder keuze?*
- *Houd u rekening met energie verlies in het ontwerp?*
    - *Worden drukverliezen berekend bij een bepaalde flow? (Technische kennis controle m.b.t. energie)*
    - *Kunt u inschatten welk percentage van de ontwerptijd er besteed wordt aan drukverlies minimalisatie?(Prioriteit and beschikbaarheid check)*
- *Op basis van welke criteria wordt een ventiel gekozen?(welke criteria zijn er van belang)*
    - *Welke criteria zijn het belangrijkst?*
- *Kiest u de bewerkingen bij het ontwerp van een machine? (Is het een van de ontwerpcriteria?)*
    - *Wat dient de Return On Investment te zijn bij een investering in energie zuinige elementen in het perslucht systeem?*
    - *Vind u dat u de maatschappelijke verantwoordelijkheid heeft om zo energie zuinig als mogelijk te ontwerpen?*
- *Wat zijn voor uw klant de belangrijkste keuze criteria bij de aanschaf van een machine?*
    - *Vraagt de klant naar het te verwachten energie verbruik(bijvoorbeeld per product/pallet/dag) van de te ontwerpen/reeds ontworpen machine?*

DMU

- *Hoe wordt besloten/gekozen voor een bepaalde of nieuwe fabrikant/leverancier? (wat zijn de redenen voor het hebben/kiezen van een leverancier)*

    - *Wat zijn de voorwaarden waaraan een fabrikant/leverancier dient te voldoen?* (*Criteria*)
- *Op welke verkoopargumenten concurreert u? (prijs, kwaliteit, TOC, output, energieverbruik, etc.)*
    - *Welk argument heeft voor u de grootste overtuigingskracht?*
    - *Wordt er gedacht aan een energie label en ziet u hier vraag naar?*
    - *Heeft een groen ontwerp (weinig CO2 uitstoot/energieverbruik) een voordeel of gaat het over de feitelijke kosten?(is aanschafprijs belangrijker dan voordelen?)*
- *Kunt u vertellen of uw klant een merk pneumatiek kiest of dat dit een keuze is van de machine bouwer/ontwerper?* (*Waar ligt deze beslissing*)

Interview eind gebruiker

Innovation

- *Welke technische kennis over pneumatiek is er in uw bedrijf aanwezig?* (*Wat moeten we communiceren*)
    - *Wie beschikt over wat voor soort kennis?(Wie moeten we aanspreken)*
    - *Hoe blijft u op de hoogte van de laatste stand der techniek? (hoe/via welke weg moeten we aanspreken)*
- *Bij toevoegingen en/of aanpassingen aan machines, wie herprogrammeert de PLC?*

Energy

- *In hoeverre wordt het energie verbruik in het algemeen en van de pneumatiek gemeten?* (*Wat is het bewustzijn*)
- *Is er iemand verantwoordelijk voor het energie verbruik algemeen in uw bedrijf?* (*Wie is er verantwoordelijk voor dit bewustzijn*)
    - *Hoeveel tijd heeft "U/deze persoon" te besteden om energie verlies te beperken?* (*wat is de beschikbaarheid van deze resource*)
    - *Is er iemand specifiek verantwoordelijk voor het energieverbruik van de pneumatiek in uw bedrijf?* (*Bij wie hoort pneumatiek energie bewustzijn*)
        - *Wie en welke functie hoort dit?* (*gebeurd het*)
            - *Bij welke functie vind u energie verlies beperkingen binnen uw bedrijf horen?* (*Hoe zou het idealiter moeten*)
- *Heeft u een beeld van de energie verliezen in uw pneumatische systeem?* (*huidig system inzicht*)
    - *Wat is uw aanpak om deze verliezen te minimaliseren?(Huidige inzet m.b.t. gemakkelijke besparingen)*
        - *Wat zijn voor u de nadelen van lekdetectie en energie verbruik minimalisatie?* (*Huidige ervaringen*)
        - *Hoe ziet u de voordelen van lekdetectie en energie verbruik minimalisatie?* (*Huidige houding t.o.v. besparingen*)
- *Hoe worden veranderingen in de energie consumptie in uw bedrijf aangepakt?(Hoe verloopt het energie beheer)*
    - *Bij uitbreidingen van het pneumatisch systeem waar wordt rekening mee gehouden?* (drukverliezen en flow *wordt er over nagedacht?*)
- *Welke taak ziet u met betrekking tot uw energie verbruik weggelegd voor de leveranciers?* (bijvoorbeeld totale bedrijfsscan)

    - *Hoe staat u tegenover een totaal scan van uw pneumatisch systeem m.b.t.: lekverliezen, flow verliezen, drukval, filter verliezen, vocht verliezen, systeemdruk minimalisatie, lage druk terugsturing van cilinders, etc.?*
    - *Bij wie/van wie verwacht u zo'n soort service waarbij grote pneumatiek kennis vereist is?*
- *Bij bijvoorbeeld het nieuwe energie bespaar product zoals een reduceer op de terugsturing van de cilinder, wat moet de ROI zijn om dit te implementeren?*

DMU

- *Bij het aankopen van pneumatiek, waarop baseert u uw keuze voor een leverancier/fabrikant/merk?* (*Hoe wordt er gekozen?*)
- *Hoe verloopt een aankoopbeslissing van een machine?(Wie maakt de keuze?)*
    - *Wat zijn de criteria voor de aankoop van een machine?*
    - *Hoe loopt de beoordeling over het energie verbruik bij de aankoop van machines?*
    - *Welke argumenten spelen een rol in de aankoop overweging van een machine? (bevat het antwoord: TCO, ROI, efficiëntie, effectiviteit, betrouwbaarheid, milieu belasting, laagste aanschafprijs, etc?)*
    - *Welk van deze argumenten geeft de doorslag?*
    - *Is de total cost of ownership een afweging in de aankoop beslissing?*
- *Wordt er actief energie bespaart om winst te vergroten? (Is het bedrijf bezig met energie?)*
- *Hoe verloopt de aankoop van pneumatiek/spare parts?* (*Hoe verloopt onderhoud?*)
    - *Bij wie ligt de beslissing voor de aankoop van pneumatiek/spare parts?* (*Wie onderhoudt?*)

Appendix 4: Currently promoted energy efficiency solutions

There are multiple ways of saving energy with compressed air systems. Below, a list of different kinds of savings is discussed, each with their own applicability, gain and potential energy saving contribution:

- Minimize system pressure. When enforcing the system to work at 6 bar of air pressure instead of 8 bar, this results into a direct energy saving of approximately 14%. [1]
- Saving energy when demand is pulsing and the compressor is on off-load, can be done by using VSD (Variable Speed Drive). This technology makes it possible to save about 35% of energy usage at the compressor.[2]
- Using the rest heat from the compressor for warming water or heating up other processes in the factory. When using all this recovered heat usefully, a yield of 100% is possible to reach.[3]
- Saving energy on pneumatic tools by re-using the air from the tools.[4] When using pneumatic tools, the ears system reduces noise, by re-using the air and its left pressure. The already clean, cool and dry air is very useful for the compressor. Due to the re-usage of air, a compressor with lower capacity can be used to generate the same amount of flow and pressure.
- Lowering the standard system air pressure for specific needs. This can be done before the air enters a tool or actuator. Usually air pressure tools are provided with a pressure too high for the tool, or for actuators like cylinders. This can easily be solved by using a pressure regulator, saving a loads of compressed air. [5]
- Regular filter replacement, can keep the pressure drop at filters as low as possible resulting in less energy loss. [5]
- Nozzles should be fit with small nozzles to save air and increase pressure. Fitting smaller nozzles than the current big nozzles can save 35% of air usage. [6]
- Detecting and sealing leaks everywhere in the system. Usually a pneumatic system has several leaks accounting for about 10% to 30% of air loss. By sealing leaks this percentage can be brought down to 8-10%. Detecting leaks can be done by using an ultra sound detector or by using one's own ears when the system is not in use. [7]
- Energy can also be saved by using a lower pressure for the return stroke of the cylinder. The company Ross has created a valve that sends the cylinder back using a low pressure of only 2 bar for sending it back into its starting position. [8]
- With pneumatics, there are usually variations in demand. By having a clear overview of both the supply and demand side, a good alignment between supply and demand can minimize the energy usage. In the energy efficiency guide of Leonardo energy, this and earlier discussed solutions are presented.[9]
- Festo has created a simple list of 10 tips for saving energy with pneumatic systems. [10] This list is shown below:
    - Reduce air pressure output from the compressor
    - Use pressure boosters where required
    - Correctly size air preparation units
    - Monitor or inspect filter elements
    - Install flow meters

- Check the flow rates of fine filters
- Avoid tight bends and constrictions
- Use easy to read pressure gauges
- Avoid water in the system
- Consider using differentiated actuator pressures or single acting cylinders

- The company: Festo also has its own energy efficiency guide, providing solutions for pneumatic loss problems and advising Festo products to solve shown problems. [11]

List of references appendix 4

[1] Carbon Trust, Making business sense of climate change (2006), compressing air costs in northern Ireland , *Queen's Printer and Controller of HMSO*, London.

[2] Atlas Copco, because we care, retrieved: September 3, 2009, from: http://www.atlascopco.nl/nlnl/products/becausewecare/

[3] Ingersoll Rand, Industrial Air Power saves Terram ltd £1,000,000, retrieved: September 3, 2009, from: http://company.ingersollrand.com/sustainability/Documents/CASE%20STUDIES%20(Sustainability)/TERRAM%20case%20study.pdf

[4] Ears Europe, the compressed air revolution, retrieved: September 7, 2009 from: http://www.ears-europe.eu

[5] The Norgren guide to saving energy in compressed air systems, retrieved September 3, 2009 from: http://www.norgren.com/document_resources/EN/ENERGY.pdf

[6] Energy saving leaf UK by SMC, retrieved: September 7, 2009 from: http://www.smc.eu/portal/WebContent/resources/docs/energy_saving_pdf/energy_saving_leaf_uk.pdf

[7] Managing The 'Fourth Utility', *Emprove Resource: Compressed Air • June 2007*

[8] Ross energy saver, (March 2009) retrieved September 8, 2009 from: http://www.qplus.nl/downloads/3_groen_ventielen/Ross_energysaver/Ross%20energysaver.pdf

[9] Leonardo Energy, Power Quality & Utilisation Guide, Section 7: Energy Efficiency, (2007) retrieved September 7, 2009 from: http://www.leonardo-energy.org/webfm_send/168

[10] Festo 10 Tips for reducing costs through improved air preparation, retrieved September 8, 2009 from: http://www.festo.com/net/en-gb_gb/downloads/Download.ashx?lnk=28836/Festo_10_Tips_for_reducing_costs_through_improved_air_preparation.pdf

[11] Festo energy efficiency guide, retrieved September 1, 2009 from: http://www.festo.com/ext/en/1918.htm

Appendix 5: Communication possibilities

Natural media advertising:

- http://www.curbmedia.com/what-we-do.asp
- http://www.naturalpathmedia.com/

Magazines:

- Technisch weekblad
- AT aandrijf techniek
- Products4Engineers

Direct mail:

- Via CRM
- Via industry lists

Fairs:

- http://www.hannovermesse.de/motion_drive_e
- http://www.aandrijftechniek-online.nl/nl-NL/Exposant.aspx

Some examples of companies producing eco-friendly promotion products:

- http://www.absolutepromo.com/eco-friendly.cfm
- http://www.fairware.ca/
- http://greenpromotionalitems.com/

Engineers specific websites like:

- http://www.products4engineers.nl/
- http://www.engineersonline.nl/
- http://www.at-aandrijftechniek.nl/
- http://www.metaalnieuws.nl/site/home/home.html
- http://www.designnews.com

Energy efficiency companies:

- http://www.schneider-electric.nl/sites/netherlands/nl/oplossingen/energy-efficiency.page
- http://www.arcadis.nl/projecten/Pages/Benchmarking%20Energie-effici%C3%ABntie%20Philips%20_effectief%20omgaan%20met%20energie.aspx
- http://www.royalhaskoning.com/Royal_Haskoning/industry_and_energy/nl-NL/Fields+of+work/Energy/
- http://www.energy-online.nl/
- http://www.milieuscore.nl/
- http://www.caldic.com

energy efficiency government:

- http://www.senternovem.nl/mja/
- http://www.algemene-energieraad.nl/publicatie.asp?pageid=10
- http://www.bmdzuid.nl/nieuws/nl/MJA3-ambitieuze-doelstellingen-energie-efficiency.htm?fluxmenu=m34

- http://www.change-of-climate.com/nl-nl/Recente%20Projecten/Pages/Meerjarenafspraakenergie-efficiencyMJA-3.aspx
- http://www.rotterdamclimateinitiative.nl/nl/rotterdam_climate_initiative/samenwerken/introductie
- http://www.deltalinqs.nl/index.php?option=com_leden&Itemid=35

Energy efficiency websites general:

- http://www.energiegids.nl/home.tiles
- http://www.energieportal.nl/
- http://www.energieondernemer.nl/category/productiemiddelen/
- http://www.energiechannel.nl/
- http://www.energiecentrum.nl
- http://www.nrk.nl/energie/Pages/default.aspx

Appendix 6: Business to consumer idea directions

When checking for references and ideas in other markets, these business to consumer idea directions can be interesting for eventually implement the ideas behind these concepts into the pneumatic market. Saving energy and making products "greener" is becoming increasingly important in the current market. For example, companies like Siemens and HP show and deliver service to customers and businesses on diverse aspects of environmental aspects. Siemens[1] for example has a clear calculator to show the energy usage and money saving possibilities comparing their new and old products. These comparisons show the amount of energy and money that is saved when using a new Siemens product compared to an older Siemens model.

HP takes it even a step further. Next to showing the energy usage and carbon differences for their print products [2], they deliver a service taking the old cartridges and printers back for recycling [3]. For cartridges they really like to do this themselves, since printers are hook and bait products. The printer is sold without any profit, gaining profits from the cartridge replacements. Retrieving the old cartridges helps not only the environment, but also to keep other companies from refilling the old cartridges with new ink, decreasing profits of HP.

List of references appendix 6

[1] Siemens energy calculator, retrieved October 20, 2009
from: http://siemens.bsh.nl/Flash/energysavingscalculator/index_netherlands.html

[2] HP carbon footprint calculator, retrieved October 20, 2009
from: http://www.hp.com/large/ipg/ecological-printing-solutions/carbon-footprint-calc.html

[3] HP recycle and re-use, retrieved October 20, 2009
from: http://www.hp.com/hpinfo/globalcitizenship/environment/index.html#/RECYCLE_AND_REUSE