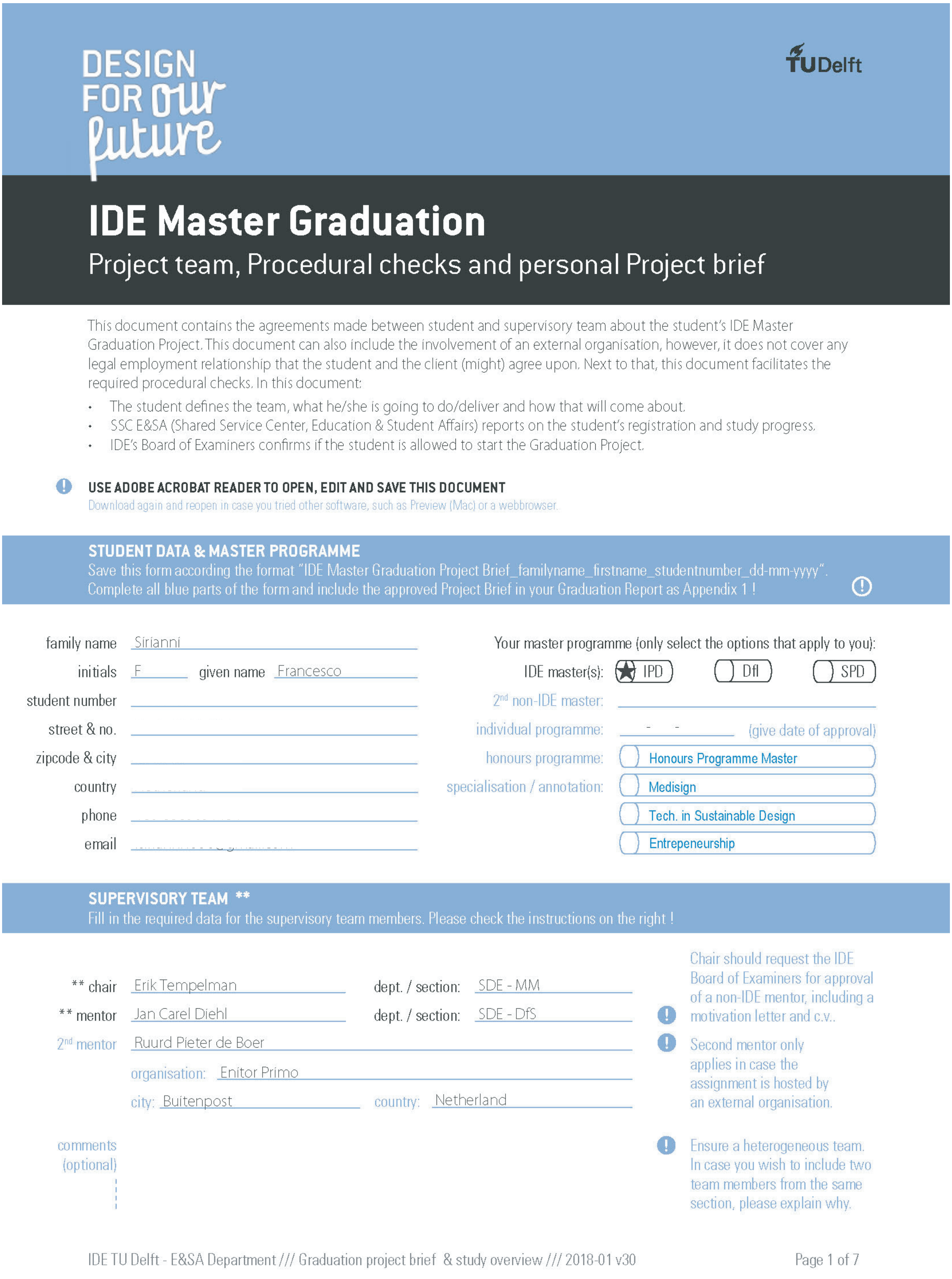
APPENDIX A: PROJECT BRIEF



DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy". Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name Sirianni

initials F given name Francesco

student number

street & no. [redacted]

zipcode & city [redacted]

country [redacted]

phone [redacted]

email [redacted]

Your master programme (only select the options that apply to you):

IDE master(s): ● IPD ○ DfI ○ SPD

2nd non-IDE master:

individual programme: - - (give date of approval)

honours programme: ○ Honours Programme Master

specialisation / annotation: ○ Medisign

○ Tech. in Sustainable Design

○ Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair Erik Tempelman dept. / section: SDE - MM

** mentor Jan Carel Diehl dept. / section: SDE - DfS

2nd mentor Ruurd Pieter de Boer

organisation: Enitor Primo

city: Buitenpost country: Netherland

comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair Erik Tempelman date 09 - 10 - 2021 signature Erik Tempelman Digitally signed by Erik Tempelman Date: 2021.10.09 09:20:47 +02'00'

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: ______ EC

Of which, taking the conditional requirements into account, can be part of the exam programme ______ EC

List of electives obtained before the third semester without approval of the BoE ______

○ YES all 1st year master courses passed

○ NO missing 1st year master courses are:

name ______ date - - signature ______

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ○ APPROVED ○ NOT APPROVED

Procedure: ○ APPROVED ○ NOT APPROVED

comments

name ______ date - - signature ______

Initials & Name F Sirianni Student number 5160936

Title of Project A solar Heated Plastic extruder for Ulundi

A solar Heated Plastic extruder for Ulundi

project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 01 - 05 - 2021

17 - 11 - 2021 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Waste management and plastic pollution are two acknowledged problems of contemporary society of which we are starting to see the effects more and more. These problems that we still consider distanced to us are a huge problem for societies in low-income countries like the Ulundi region in South Africa, whose inhabitants have to deal with these issues daily. As stated in the 2017 waste report (Waste Management Report Ulundi LM, 2017), waste management was identified as one of the critical issues in Ulundi, as it is closely related to health issues and poses a threat to both access to clean water and subsistence farming.
Most of the household waste from the Ulundi municipality is composed of disposable items as, plastics, packaging wastes, bottles, etc. Most of the recyclable wastes are made of plastics, which the most common are PET, LDPE, HDPE. Moreover, the missing presence of infrastructures is making the recycling and collection processes impossible, consequently, small villages and cities with poor connections are destined to cumulate waste in illegal dumping sites.

One of the most common consumer plastic recycling machines is the Plastic Extruder. The extruder itself has high energy consumption. Specifically, an average of 5kW, of which the heating elements of the extruder consume themselves 3kW, the remaining energy is used by the motor. In South Africa, only a few people can afford that amount of energy to recycle plastic.
On the other side, the region has hot weather given by a high level of solar radiation and consequently a huge amount of potential energy.
The idea of using solar panels (PV), which is the most common solution in these cases, has been discarded at an early stage because of different issues:
- Dimensions: using solar panels to heat the extruder will require a surface of several square meters that make the product more complex to be used and diffused.
- Sustainability: both solar panels and accumulators are elements with partial and very complex processes of recycling. Consequently, the process of plastic recycling that should be sustainable can easily become very impactful.
- Efficiency: Every step in which the energy is converted has its dispersion. With solar panels, the dispersion is high because of the three conversions steps that the energy has to do before melting plastic (rays to electricity, electricity to heat)

The envisioned solution is to create a small scale plastic extruder that uses the technology of a parabolic solar collector to heat the melting barrel and consequently halve the energy consumption of a classic extruder.

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WORKING PRINCIPLE

CURRENT USES

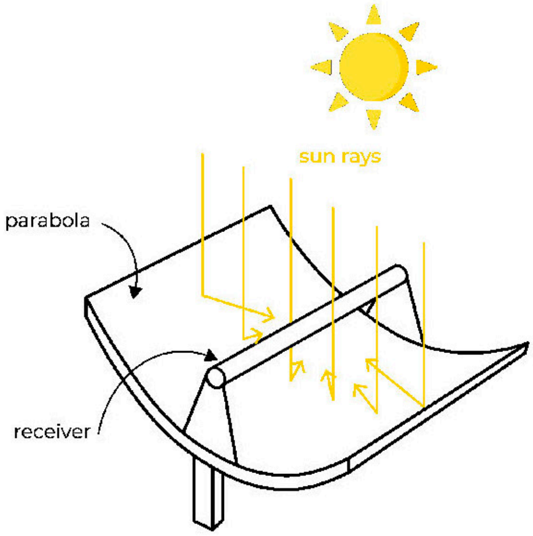


image / figure 1: Working principle

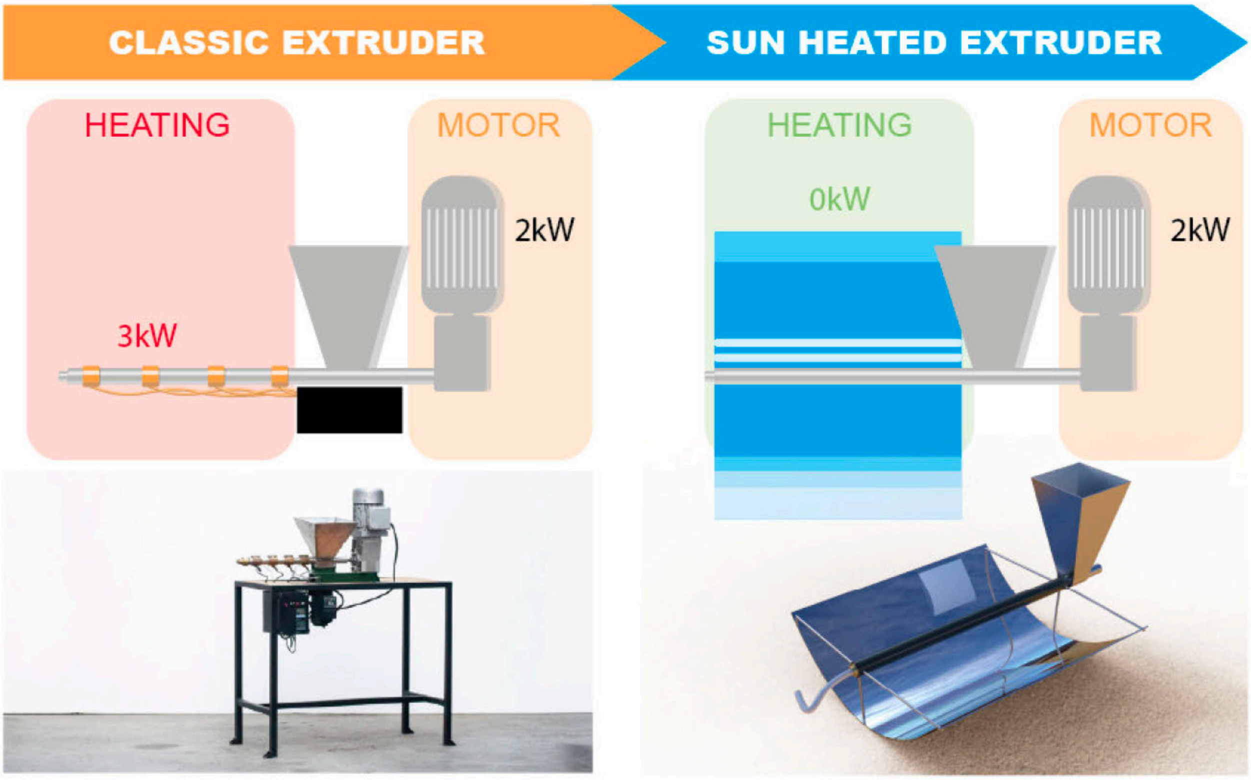


image / figure 2: Actual plastic Extruder vs Sun Heated Plastic Extruder.

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

At this very moment, the solar trough collector is a technology used mainly in the field of energy production, and sometimes in solar cookers. One of the biggest challenges of this graduation is to integrate this technology in a plastic extruder, studying the technology from every point of view, discover the possible interactions and markets in order to develop a design that is Feasible, Desirable, and Viable. To do so, many aspects of the design have to be explored and analyzed.

Energy Reduction: I can consider this as the biggest challenge of the entire process. The thermoplastics extrusion process is very high energy-consuming, different researches/tests have to be conducted to figure out this issue in the best way.

Sustainability: Being a plastic recycling plant doesn't directly mean being sustainable. To make this product sustainable is necessary to consider the sustainability factor in the entire life cycle of the product.

User Interaction: The nature of the product itself makes the interaction with the user very difficult, the product has to be easy to understand and to work with, and most of all, safe. To do so a huge focus of the project will be related to the product interaction and perception of it.

Design fo BoP: In order to have a proper design for Ulundi, many factors have to be considered, including material availability, interaction, and perception of the product, different weather conditions, etc.

Market: The envisioned product will be the first of his kind, consequently studying his future market, business plans, and design his roadmap are fundamental steps to make a concrete project.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

The graduation project aims to design a Solar Heated Plastic recycling extruder. The main objective is to integrate and adapt the technology of solar trough collectors in a small-sclae plastic extruder. To achieve this goal the extruder should reach a TRL of 5.

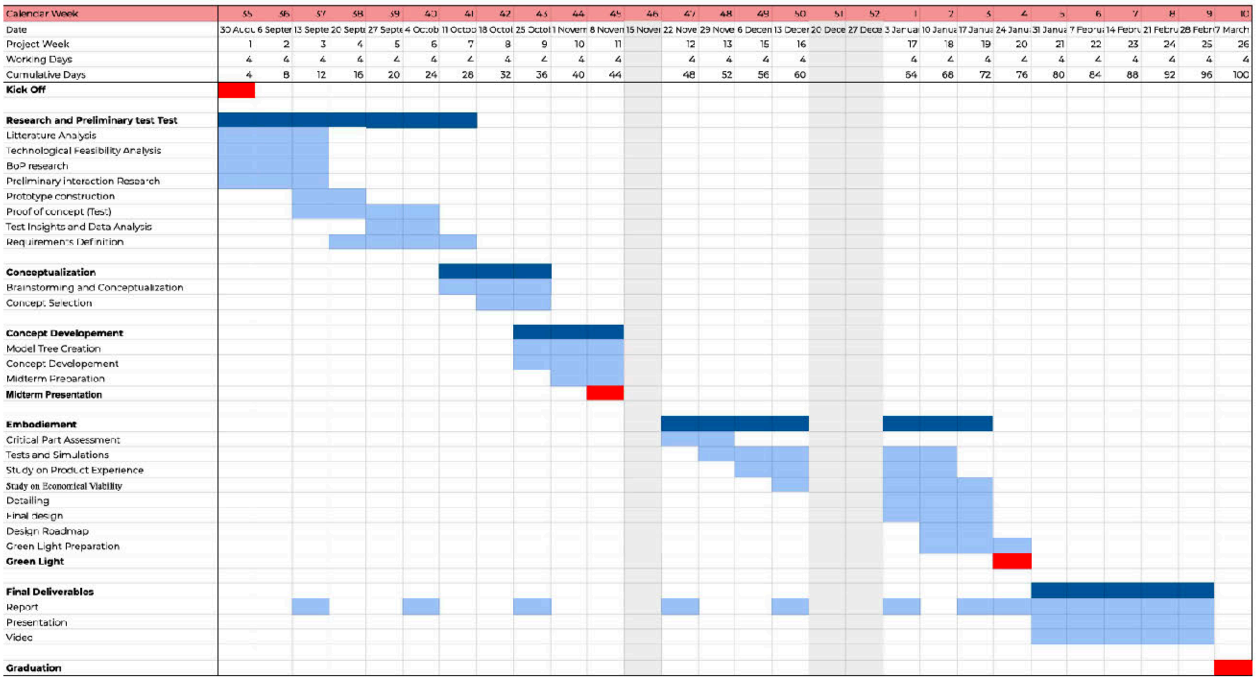
Research
Before the actual design engineering can start, it is essential to have a mathematical-physical model of the solar extruder. This model will therefore be made early on in the project. It will link the outcome, in terms of amount of extruded plastic per unit time, to the overall dimensions (in particular, extruder length and size of the trough reflector unit), and the climate at the targeted location (i.e. sunlight hours and intensity). This allows me to check if the design is feasible in terms of first principles, and make overall choices for key dimensions. To make this model, I will perform a literature search, consult with experts (in extrusion, polymer processing, climate/weather), and computer modelling. After the test, some preliminary user interaction and researches will be conducted to envision the interaction, usage, needs, and risks of the design. The final phase of the research is meant to state all the design requirements of the project and define the working scenario.
Design
All the requirements, scenario, and outputs from the research phase will be used as design tools for the development and of the final concept. Moreover, as the solar extruder will be complex design, multiple ideas for eventual sub-problems must be developed and quickly evaluated through tests, simulations, etc. The goal of this phase is to reach a TRL 5 for every subsystem of the design. Other than the technology part (feasibility) other elements have to be considered to make the product viable and desirable, specifically will be conducted studies on Product Experience, Product Interaction, Business Model,Design Road-map.

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 1 - 5 - 2021

17 - 11 - 2021 end date



Calendar Week	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10
Date	30 Augu	6 Septer	13 Septe	20 Septe	27 Septe	4 Octob	11 Octob	18 Octol	25 Octol	1 Novem	8 Noven	15 Nover	22 Nove	29 Nove	6 Decen	13 Decer	20 Dece	27 Dece	3 Januar	10 Janua	17 Janua	24 Janu	31 Janua	7 Februa	14 Febru	21 Febru	28 Febr	7 March
Project Week	1	2	3	4	5	6	7	8	9	10	11		12	13	15	16			17	18	19	20	21	22	23	24	25	26
Working Days	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4			4	4	4	4	4	4	4	4	4	4
Cumulative Days	4	8	12	16	20	24	28	32	36	40	44		48	52	56	60			64	68	72	76	80	84	88	92	96	100
Kick Off	🟥																											
Research and Preliminary test Test	■	■	■	■	■	■	■																					
Litterature Analysis	🟦	🟦	🟦																									
Technological Feasibility Analysis	🟦	🟦	🟦																									
BoP research	🟦	🟦	🟦																									
Preliminary Interaction Research	🟦	🟦	🟦																									
Prototype construction			🟦	🟦																								
Proof of concept (Test)			🟦	🟦	🟦	🟦																						
Test Insights and Data Analysis					🟦	🟦																						
Requirements Definition				🟦	🟦	🟦	🟦																					
Conceptualization							■	■	■																			
Brainstorming and Conceptualization							🟦	🟦	🟦																			
Concept Selection								🟦	🟦																			
Concept Developement									■	■	■																	
Model Tree Creation									🟦	🟦	🟦																	
Concept Developement									🟦	🟦	🟦																	
Midterm Preparation										🟦	🟦																	
Midterm Presentation											🟥																	
Embodiement													■	■	■	■			■	■	■							
Critical Part Assessment													🟦	🟦														
Tests and Simulations														🟦	🟦	🟦			🟦	🟦								
Study on Product Experience															🟦	🟦			🟦	🟦								
Study on Economical Viability																🟦			🟦	🟦	🟦							
Detailing																			🟦	🟦	🟦							
Final design																			🟦	🟦	🟦							
Design Roadmap																				🟦	🟦							
Green Light Preparation																				🟦	🟦	🟦						
Green Light																						🟥						
Final Deliverables																							■	■	■	■	■	
Report			🟦			🟦			🟦				🟦			🟦			🟦		🟦	🟦	🟦	🟦	🟦	🟦	🟦	
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Video																							🟦	🟦	🟦	🟦	🟦	
Graduation																												🟥

As shown in Gaant Chart above, during the following months the project will follow the methodology of the Basic Design Cycle. The project will consist of five phases:

- Research and tests: In this phase, deep paper research will be conducted, moreover due to weather limitations a first test prototype will be built and tested during this step. All the insight and issues will be helpful to define a list of design requirements.
- Conceptualization: Starting from the requirements, during this phase I will develop different concepts/solutions to better fulfill the requirements.
- Develop: After defining the final concept, this phase will help to further define it in order to integrate all the requirements. This phase will be necessary to define the elements of the concept that need a better analysis or test during the following step.
- Embodiment: This phase will be the longest of the design process, I will follow the TRL methodology to define the state of every component, my goal is to reach an average of TRL 5 for all the components. In this phase will be conducted product experience researches and market plans to make the product also viable and desirable. Development and Embodiment Phases will be consequential but parallel in some moments to have a continuous iterative process and guarantee the best solution for the project.
- Deliverables: After all these phases, the last step will be related to the final deliverables; report, and presentation. Regarding the report, I will start writing it during the different steps of the design process.

The planning developed takes into account 100 working days spreaded over 25 weeks, as I'm parallelly working as a teaching assistant at TuDelft I can commit 4 days per week on the project, resulting in an extension of five weeks.

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

We as designers have a huge responsibility with the world, the race to new unnecessary product and the new shapes has to be slowed down. As a designer, I have the knowledge and the responsibility to do something to avoid or slow this problem. Instead of putting my efforts into the umpteenth product redesigned with an infinitesimal update, that requires another production, I would like to create a product helpful for the world and other societies.

As a personal ambition, I would like to work for a design studio in the role of project manager, consequently, that's why I'm going to work on this project in all the phases, to have a better knowledge of every little step, specifically the embodiment processes, but moreover to be able to have a holistic overview of the entire project.

The other reason I wanted to work on this project is the challenge embedded in itself, I've never designed something similar, and this the reason that makes the field fascinating for me. Also for this reason my future ambition is to work in a design studio instead of a company, to have every time the opportunity to work on a different project, and consequently gaining knowledge continuously.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

APPENDIX B

Solar trough technology

1 Intro

The sunlight that reaches Earth, even if it appears extremely hot, does not contain sufficient energy in the actual form in order to generate thermal power. To use his high potential, the sunlight from a large area has to be concentrated. This can be achieved with magnifying lenses but would make every application very expensive. The most suitable solution is a concentrating reflector.

For the properties embedded in its shape, the parabola has the most potential in order to concentrate the solar rays. Every light ray that enters it travelling parallel to the axis of symmetry is reflected toward the focus.

1.1 STORY

The principle of collecting heat with parabolic mirrors can be traced back to Archimede; he used mirrors to convey sun rays in order to fire enemies boats during the Siege of Syracuse (213–212 BC). Chinese civilization documented the use of mirrors for the same purpose later in 20 A.D(Richardson, 2020).   Is also reported that Leonardo da Vinci made several studies on parabolic mirrors (Duprè S., 2005) and hypothetical usages. The first operational parabolic trough collector system in the electricity field was near Cairo in 1912, the system was built to generate steam that feeds a stream engine pump. The current operating PTCs (Parabolic Trough Collectors) follow the same principle of the Cairo's one but with a developed design and advanced technologies.

2 Technology

Translating this concept in the plastic recycling field, only a few studies have been conducted in order to verify and test the possibility to apply why the trough collectors. Consequently, technology has to be explored and learned from every point of view.

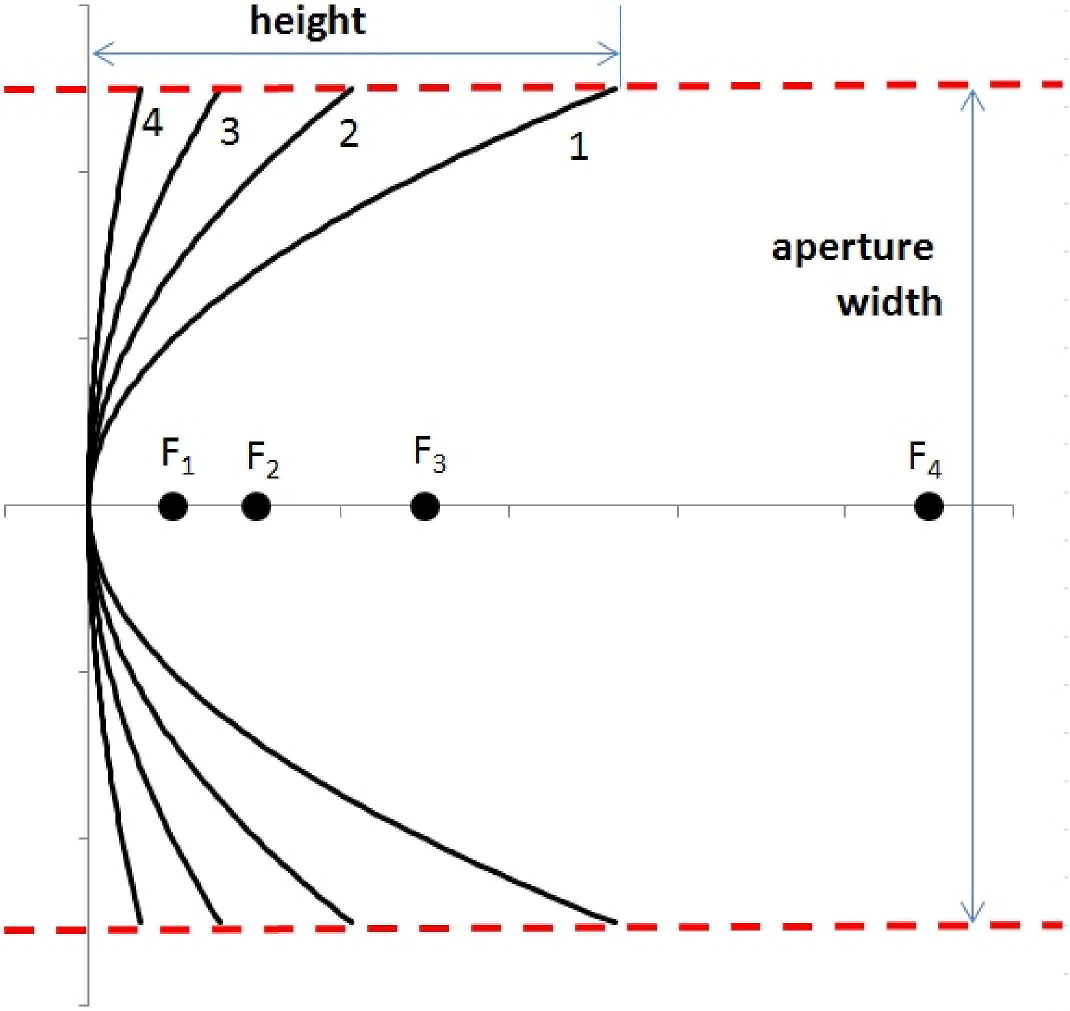
To develop a proper solar trough collector different properties have to be considered, properties related to different elements of this technology, shape of the parabola, material and dimensions of both collector and parabola. in the following paragraphs, I'm going to analyse and give an explanation of the most common properties used in the actual solar trough collectors.

3 Parabola Properties

The design of a parabolic reflector takes into account the available aperture size, focus location and height of the reflector.
These parameters are interrelated by a mathematical formula, this relation is shown in the figure below, the flatter is the reflective surface, the longer is the focal length (distance of the focus from the parabola). (Fedkin & Dutton, 2020)

Consequently, the consideration to take into account is that for the same width there are infinite possibilities of parabola, which have different lengths. That is going to influence many factors such as the weight of the mirror, the overall dimension of the final product and the production costs.

4 PTCs Properties



Mirror material and other mirror materials

4.1 Mirror Reflectance

The reflectance of the mirrors plays a key role in the efficiency of the PTC.
As mentioned by Jamali H [2019], one of the main factors influencing the reflectance, is the material of the mirror and the coating of it. In the following chart, retrieved from the above-mentioned research, are reported some of the most common material-coating configurations and their relative reflectance. index.

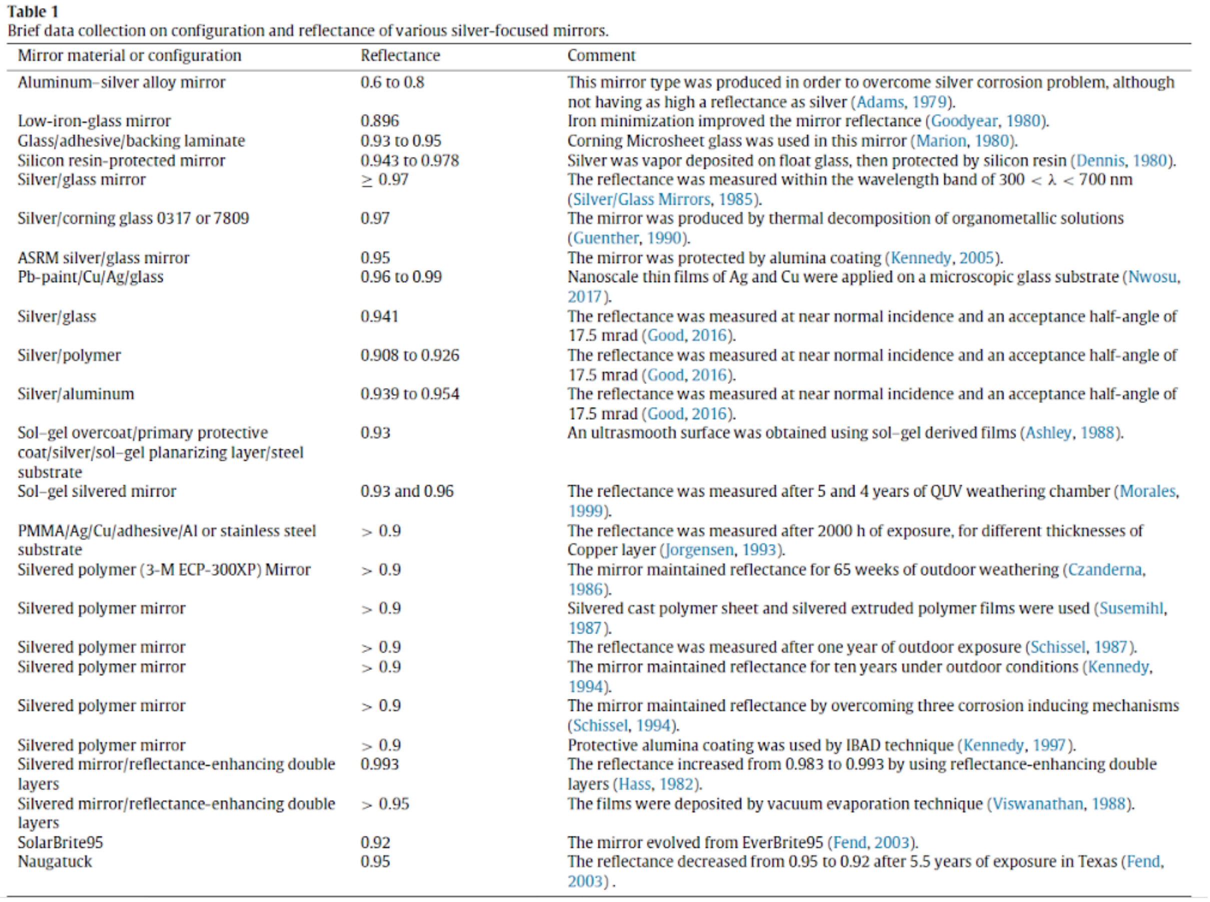
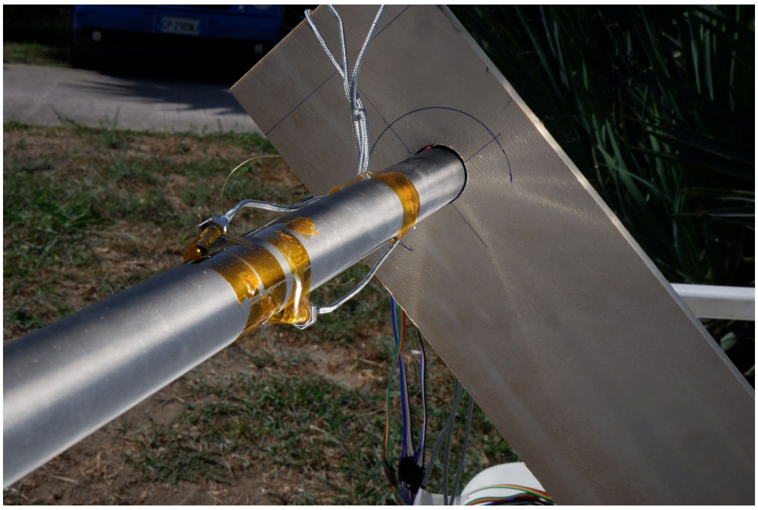


Table 1
Brief data collection on configuration and reflectance of various silver-focused mirrors.

Mirror material or configuration	Reflectance	Comment
Aluminum–silver alloy mirror	0.6 to 0.8	This mirror type was produced in order to overcome silver corrosion problem, although not having as high a reflectance as silver (Adams, 1979).
Low-iron-glass mirror	0.896	Iron minimization improved the mirror reflectance (Goodyear, 1980).
Glass/adhesive/backing laminate	0.93 to 0.95	Corning Microsheet glass was used in this mirror (Marion, 1980).
Silicon resin-protected mirror	0.943 to 0.978	Silver was vapor deposited on float glass, then protected by silicon resin (Dennis, 1980).
Silver/glass mirror	≥ 0.97	The reflectance was measured within the wavelength band of $300 < \lambda < 700$ nm (Silver/Glass Mirrors, 1985).
Silver/corning glass 0317 or 7809	0.97	The mirror was produced by thermal decomposition of organometallic solutions (Guenther, 1990).
ASRM silver/glass mirror	0.95	The mirror was protected by alumina coating (Kennedy, 2005).
Pb-paint/Cu/Ag/glass	0.96 to 0.99	Nanoscale thin films of Ag and Cu were applied on a microscopic glass substrate (Nwosu, 2017).
Silver/glass	0.941	The reflectance was measured at near normal incidence and an acceptance half-angle of 17.5 mrad (Good, 2016).
Silver/polymer	0.908 to 0.926	The reflectance was measured at near normal incidence and an acceptance half-angle of 17.5 mrad (Good, 2016).
Silver/aluminum	0.939 to 0.954	The reflectance was measured at near normal incidence and an acceptance half-angle of 17.5 mrad (Good, 2016).
Sol–gel overcoat/primary protective coat/silver/sol–gel planarizing layer/steel substrate	0.93	An ultrasmooth surface was obtained using sol–gel derived films (Ashley, 1988).
Sol–gel silvered mirror	0.93 and 0.96	The reflectance was measured after 5 and 4 years of QUV weathering chamber (Morales, 1999).
PMMA/Ag/Cu/adhesive/Al or stainless steel substrate	> 0.9	The reflectance was measured after 2000 h of exposure, for different thicknesses of Copper layer (Jorgensen, 1993).
Silvered polymer (3-M ECP-300XP) Mirror	> 0.9	The mirror maintained reflectance for 65 weeks of outdoor weathering (Czanderna, 1986).
Silvered polymer mirror	> 0.9	Silvered cast polymer sheet and silvered extruded polymer films were used (Susemihl, 1987).
Silvered polymer mirror	> 0.9	The reflectance was measured after one year of outdoor exposure (Schissel, 1987).
Silvered polymer mirror	> 0.9	The mirror maintained reflectance for ten years under outdoor conditions (Kennedy, 1994).
Silvered polymer mirror	> 0.9	The mirror maintained reflectance by overcoming three corrosion inducing mechanisms (Schissel, 1994).
Silvered polymer mirror	> 0.9	Protective alumina coating was used by IBAD technique (Kennedy, 1997).
Silvered mirror/reflectance-enhancing double layers	0.993	The reflectance increased from 0.983 to 0.993 by using reflectance-enhancing double layers (Hass, 1982).
Silvered mirror/reflectance-enhancing double layers	> 0.95	The films were deposited by vacuum evaporation technique (Viswanathan, 1988).
SolarBrite95	0.92	The mirror evolved from EverBrite95 (Fend, 2003).
Naugatuck	0.95	The reflectance decreased from 0.95 to 0.92 after 5.5 years of exposure in Texas (Fend, 2003).

A secondary factor that influences mirror reflectivity is the Local Shape Deviation (Sauerborn et al., 2012), small imperfections and bumps in the parabola can deviate the trajectory of the sun rays from the collector, or create zones with different temperatures in the collector. In the following image, you can see how this phenomenon has been noticed during the preliminary tests. (see more in chapter 7)



4.2 Receiver

In between all the elements of a PTC system, the receiver is one of the most complex to design since absorption, reflection and transmission occurs when electromagnetic radiation impacts a solar it. (Sauerborn et al., 2012) (see figure x) Consequently, the classical receiver is composed of two concentric pipes, an inner steel tube, containing the moving fluid and glass pipe, mostly borosilicate or quartz, to surround it and deal with absorption, reflection and transmission. Both the pipes have a protective coating to increase their thermal properties.
Receivers can be classified as Evacuated or Not Evacuated; evacuated pipes are suitable for working temperatures higher than 300° (Lovegrove & Stein, 2012). As mentioned by Wang (2019), the thermal properties and life of the parabolic trough receiver tube are directly influenced by the vacuum degree of the evacuated interlayer. If the vacuum layer is damaged, not only will the respective heat losses rapidly increase, but also the selective receiver film of the steel receiver tube surface will deteriorate due to oxidation.
The glass pipe is generally provided with an anti-reflective coating to achieve a higher solar transmittance and reduce the heat dispersion (Lovegrove & Stein, 2012). The following chart is shown an example of three commercialized receivers and their relative properties. (Lovegrove & Stein, 2012).

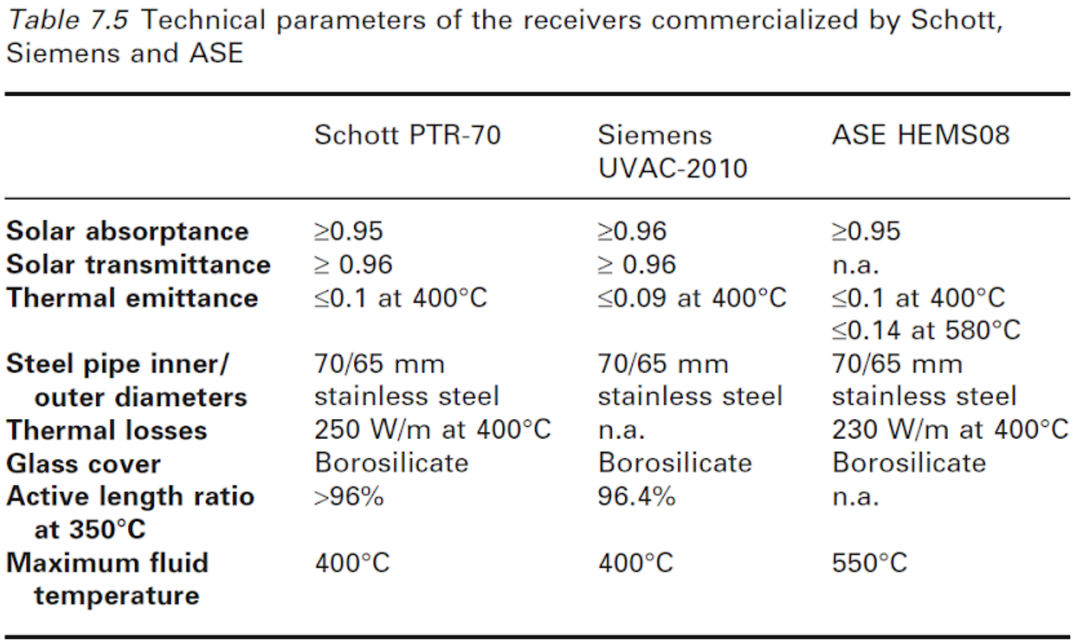
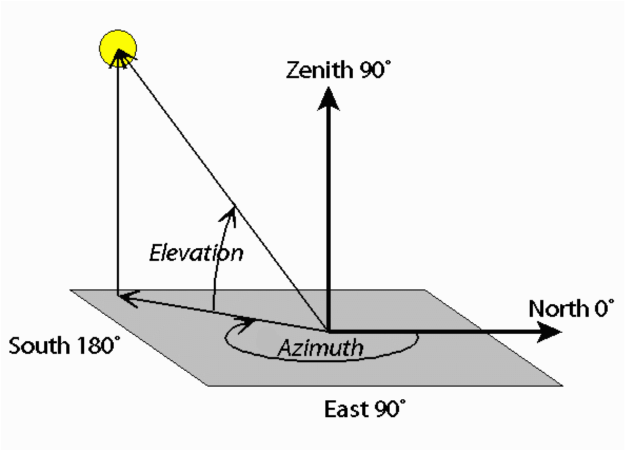


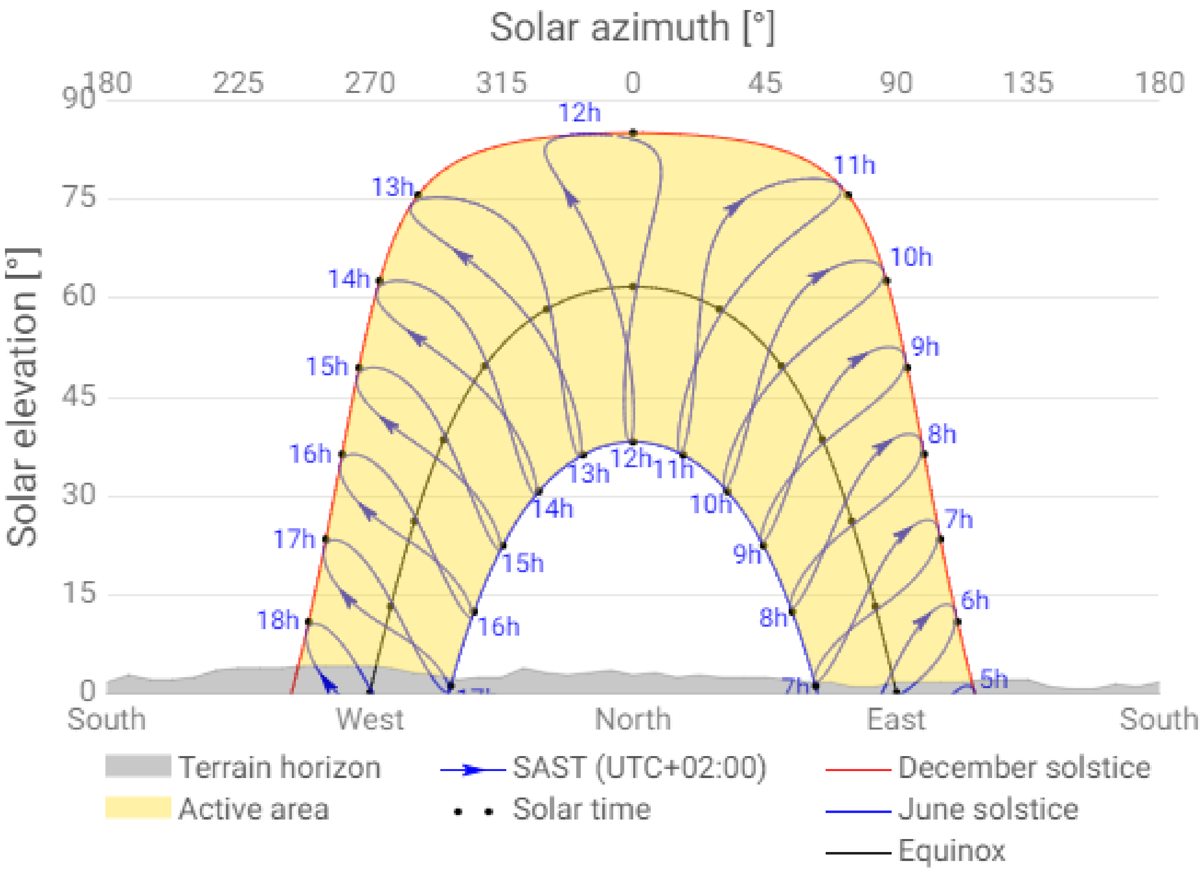
Table 7.5 Technical parameters of the receivers commercialized by Schott, Siemens and ASE

	Schott PTR-70	Siemens UVAC-2010	ASE HEMS08
Solar absorptance	≥0.95	≥0.96	≥0.95
Solar transmittance	≥ 0.96	≥ 0.96	n.a.
Thermal emittance	≤0.1 at 400°C	≤0.09 at 400°C	≤0.1 at 400°C ≤0.14 at 580°C
Steel pipe inner/ outer diameters	70/65 mm stainless steel	70/65 mm stainless steel	70/65 mm stainless steel
Thermal losses	250 W/m at 400°C	n.a.	230 W/m at 400°C
Glass cover	Borosilicate	Borosilicate	Borosilicate
Active length ratio at 350°C	>96%	96.4%	n.a.
Maximum fluid temperature	400°C	400°C	550°C

4.3 Sun Path



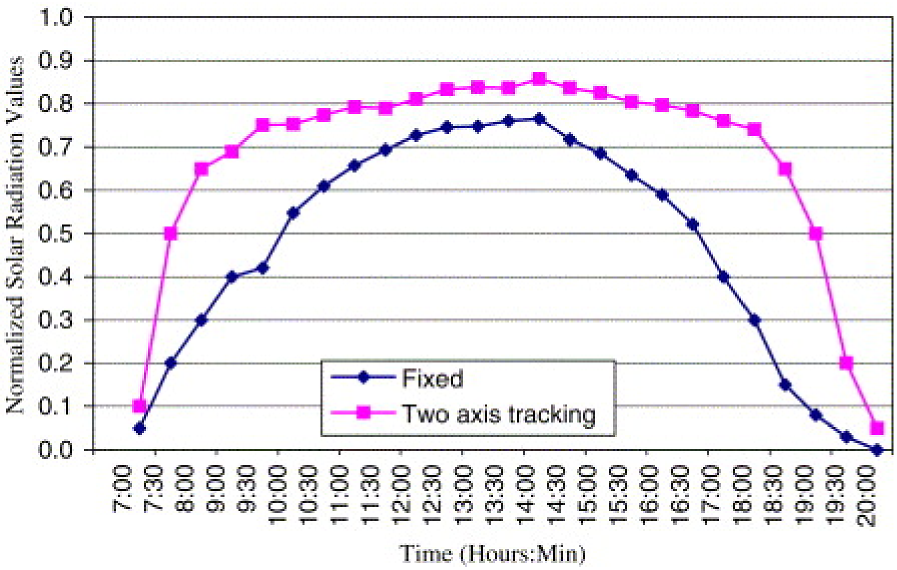
Sun path, also known as day arc, is the arc-like path that the Sun appears to take across the sky on a daily and seasonal basis as the Earth rotates and orbits the Sun.
The path of the Sun influences the length of day and amount of daylight received along a given latitude during a given season; the seasonal differences are caused by the heath axial tilt. The position of the sun in the sky can be measured by the introduction of two angles Azimuth and Elevation. In the figure below, with the area in yellow, we can notice the yearly sun path range in Ulundi, specifically the range is considered in between the longest and shortest day of the year, December and June solstices.



4.4 Solar Tracking

A solar tracker keeps the collector's aperture perpendicular to the incident rays to maximize the solar radiation.
The tracking system is generally controlled by a solar position algorithm, fine-tuned with the implementation of light sensors. The software part drives a hydraulic system that allows small step movements, typically with a precision of 1/10mm. (Sauerborn et al., 2012)

On large scale applications most of the solar trackers follow the sun path only along one axis, the PTC rotates around the receiver axis. New researchers (Bakos, 2006) are developing two-axis tracking systems that allow higher energy efficiency and moreover, as shown in the graph below, they increase the daily working timespan of the PTCs.



4.5 Maintenance and operation

The most frequent activities of maintenance of the solar systems are a periodic measurement of mirror reflectivity and their washing. A major issue can be the mirror-soiling that is indeed influenced by the application site. As happens in Spain in which the reflectivity decreases at a rate of 0.0025% per day. Consequently, in the first ten days after the washing, the reflectivity passes from 93% to 90% causing the necessity of washing and other costs involved. (Lovegrove & Stein, 2012)

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APPENDIX C

Thermoplastic Extrusion Technology

Through literature research, expert interviews and a company visit, a list of insights will be gathered that have important implications on the design process.

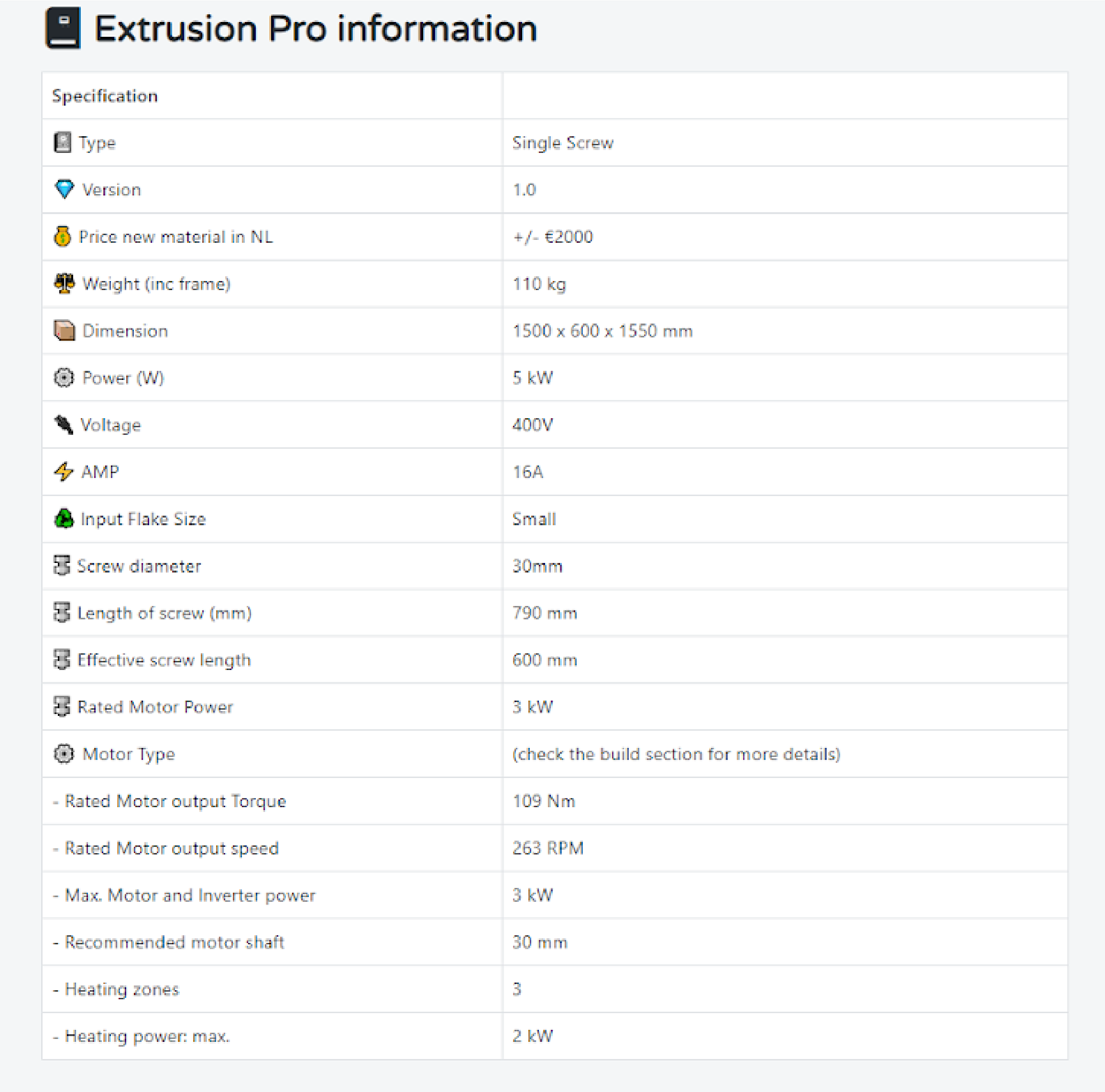
1. Technology

Plastic extrusion is a high-volume manufacturing process in which raw plastic is melted and formed into a continuous profile. Extrusion produces items such as pipe/tubing, weatherstripping, fencing, deck railings, window frames, plastic films and sheeting, thermoplastic coatings, and wire insulation.
Lately, with the introduction in the market of user extruders, the range of extrusion products has broadened also into mold based products other than the classic linear profiles.

This process starts by feeding plastic material (generally pellets, granules, flakes or powders) from a funnel into the extrusion barrel. The material is gradually melted by the mechanical energy generated by turning screws and by the heating bands arranged along the barrel. The molten mass is then forced into a die, which gives shape to the polymer.

2. Precious Plastic Extruder

In the last decade, there has been a growing trend toward local recycling plants and low technology recycling machines. One of the most diffused plastic Extruders is the Precious Plastic one. The concept behind Precious plastic aims to create a network of plastic recycling facilities spread around the globe in order to allow small realities or low-income countries to recycle plastic. This goal has been achieved by a DIY low technology design, the design is conceived to be created with materials and components available everywhere, moreover, being an open-source project, all the building information are available on the Precious Plastic website.



Extrusion Pro information

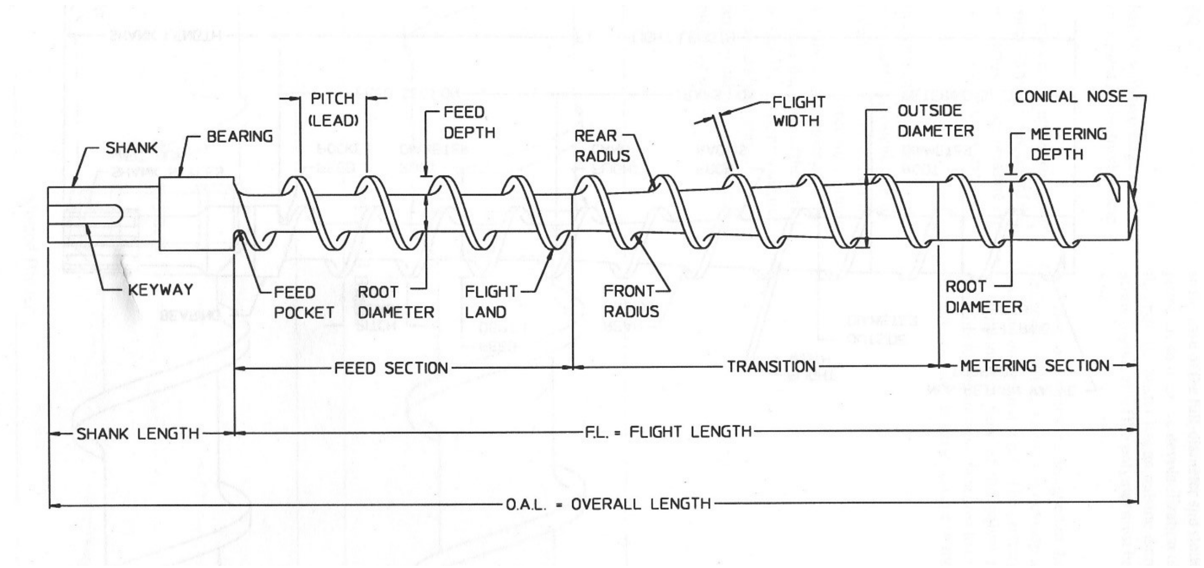
Specification	
Type	Single Screw
Version	1.0
Price new material in NL	+/- €2000
Weight (inc frame)	110 kg
Dimension	1500 x 600 x 1550 mm
Power (W)	5 kW
Voltage	400V
AMP	16A
Input Flake Size	Small
Screw diameter	30mm
Length of screw (mm)	790 mm
Effective screw length	600 mm
Rated Motor Power	3 kW
Motor Type	(check the build section for more details)
- Rated Motor output Torque	109 Nm
- Rated Motor output speed	263 RPM
- Max. Motor and Inverter power	3 kW
- Recommended motor shaft	30 mm
- Heating zones	3
- Heating power: max.	2 kW

3. Properties and Components

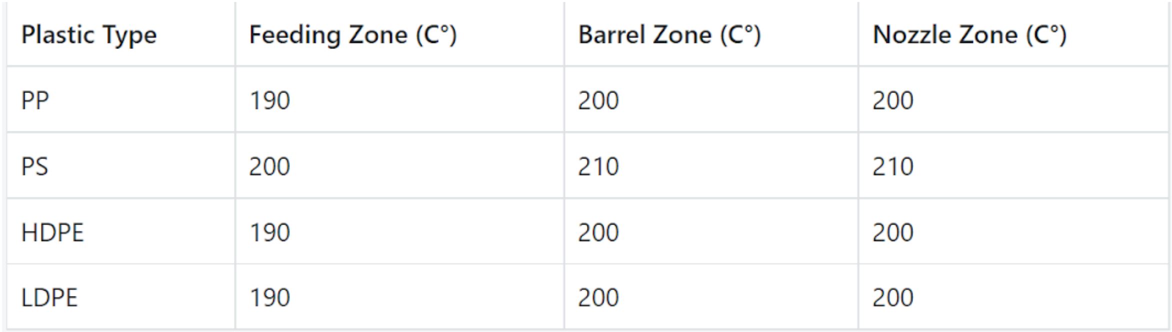
In-between all the properties in characteristics of a classic Plastics extruder in the following paragraphs will be analysed only a few with high relevance for the project purpose, some of them will consider as examples the Precious Plastic Extruder Pro.

3.1 Screw

A typical extrusion Screw is composed of 3 different zones, respectively feeding, compression(barrel) and metering zone. As noticeable in the image below, the core of the screw in the feeding zone is conical, the scope of this shape is to convey plastic flakes in the transition zone. With the increase of the internal diameter of the screw core the pressure increases, consequently, in the transition zone, the plastic starts melting and compacting. The metering zone uniforms the plastic flow in order to have a constant flow.



Every zone of the screw needs a different working temperature depending on the polymer, in the following chart are shown the temperatures suggested by precious plastic related to their Plastic Extruder Pro(Precious Plastix, 2021)



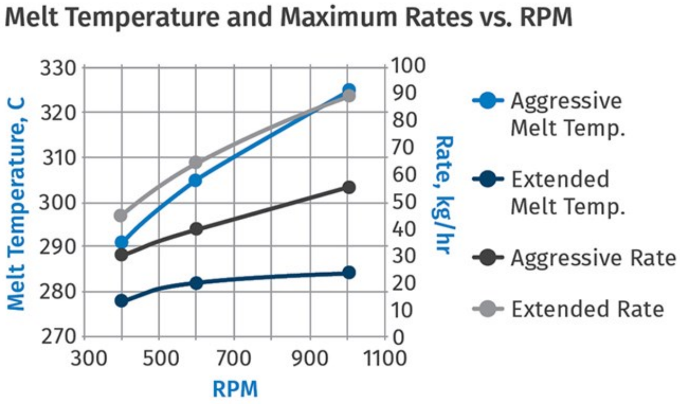
Plastic Type	Feeding Zone (C°)	Barrel Zone (C°)	Nozzle Zone (C°)
PP	190	200	200
PS	200	210	210
HDPE	190	200	200
LDPE	190	200	200

3.2 Rpm - Friction - Temperature Interrelation

Another important factor to consider in plastic extrusion is the interrelation between RPM of the motor, Temperature and Extrusion volumes.

High RPM raises the internal temperature because of the friction caused by the screw touching the internal side of the barrel. Consequently, high RPM can increase the melted Rate (Kg/h). (Personal interview with Pieter de Boer, July 8, 2021).

In the following chart, the behaviour of RPM and Temperature related to the melted volumes is shown.



In this specific case (Martin, 2020)is also noticeable how different screw designs in different conditions are going to influence the Melting Rate, but generally, we can state that increase of rpm is causing an increase in temperature and consequently can allow a higher Melting Rate.

3.3 Plastic melting temperature range

In between the material properties of polymeric materials, for the scope of the graduation projectl, the Melting Temperature Range is taken into account. This range of temperature can help to derive the working temperature tolerances of the envisioned product.

The following chart, retrieved from Manufacturing and Design (Tempelman E, et al. 2014) shows the melting ranges of the most common polymers.

Plastic	Tp [C°] Range
LDPE	170-245
HDPE	200-300
PP	200-300
PVC (hard)	150-210
PS	160-280
ABS	200-270
PLA	150-200

3.4 Temperature Control

Temperature control is an important aspect of the extrusion process in industrial manufacturing to ensure good quality.

Temperature tolerances in industrial manufacturing range from 0.1 C° for small in section and highly detailed shapes to a maximum of 0.5 C° for most products; in my case, the tolerance can be as high as 5 C°. (Personal interview with Pieter de Boer, July 8, 2021).

Heating bands and fans are two elements that play a crucial role in temperature control. Both elements are operated by PID controllers, however, because the heating bands heat and cool at a slow rate, the fan helps to keep the temperature constant and consequently allow a high level of tolerance in the production.
In the Precious Plastic extruder, the temperature is managed only with the use of heating bands, without fans.

LITTERATURE

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INTERVIEWS

Personal interview with Pieter de Boer, July 8, 2021

APPENDIX D. PRELIMINARY DIMENSIONING MODEL

In the following chart are shown the formula created during a Call With Giuseppe Nicotera, Physics Double Master Degree Student, University of Pisa and Sorbonne.

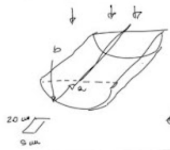
Call with Giuseppe Nicotera, Physics double MSc student, University of Pisa, Sorbonne

I FLUSSO DI POTENZA

$[I] = \frac{W}{m^2}$ $\left[\begin{array}{l} I = 1000\ W/m^2 \\ W = I \cdot A \end{array} \right]$ variabile potenza /srf lat-alt P/S

$A = a \cdot b$ $I \propto$ (ALTITUDINE LATITUDINE T.)


Solar radiation calculator



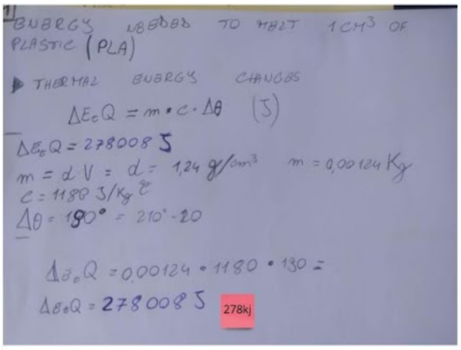
$\boxed{1\,KW = P_{SOLAR}}$

$\rightarrow \boxed{R = 1 \quad \text{REFLECTIVITY}}$

$\boxed{Q_{ABS} = \underset{\text{EFFIC.}}{\varepsilon}\, Q_{SOLAR}}$

$Q_{LOST} \propto T^4$

$Q_{LOST} = A \alpha T^4$



1 ENERGY NEEDED TO MELT 1 CM³ OF PLASTIC (PLA)

▶ THERMAL ENERGY CHANGES

$\Delta E_c Q = m \cdot c \cdot \Delta\theta$ (J)

$\Delta E_c Q = 278008\ J$

$m = d\,V$ = $d = 1{,}24\ g/cm^3$ $m = 0{,}00124\ Kg$

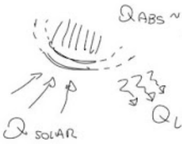
$c = 1180\ J/Kg\ °C$

$\Delta\theta = 190° = 210° - 20$

$\Delta E_c Q = 0{,}00124 \cdot 1180 \cdot 130 =$

$\Delta E_c Q = 278008\ J$ 278kj

$Q_{ABS} \sim Q_{SUN} - Q_{LOST}$



Q_{LOSSES}

RAD. BLACK BODY $\propto A T^4$

$\boxed{1\ Kwh = 360\ KJ}$ ← 1 hour exposition

$210°$

$1\,KW \cdot 3600\,s = 360\,KJ$

$P_{SUN} \cdot \underline{\underline{Tempo}} =$ ENERGIA (JOULE)

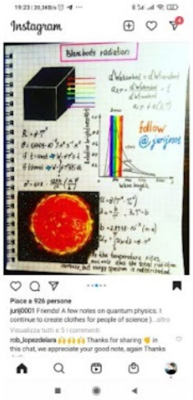
en.wikipedia.org

Concentrated solar power - Wikipedia

Concentrated solar power (CSP, also known as concentrating solar power, concentrated solar thermal) systems generate solar power by using mirrors or lenses to concentrate a large area of sunlight onto a receiver.

$\varepsilon \in (0,1)$

$$\varepsilon = \underbrace{\left(1 - \frac{\sigma T_H^4}{I}\right)}_{\text{BLACK BODY RAD.}} \cdot \underbrace{\left(1 - \frac{T^0}{T_H}\right)}$$



Piace a 926 persone

jurij0001 Friends! A few notes on quantum physics. I continue to create clothes for people of science)... altro

Visualizza tutti e 5 i commenti

rob_lopezdelara 🙌🙌🙌 Thanks for sharing 👏 in this chat, we appreciate your good note, again Thanks

$Q_{LOSSES} = A \varepsilon \sigma T^4$ $(\varepsilon = 1)$

area cilindro

emissività +1

$2\pi (0{,}4\,cm) \cdot b = A$ area esterna del cilindro

η_{optics}

$210° \rightarrow 483K°$

$max(Q_{LOSSES}) = A \sigma (483)^4$

$\sigma = 5{,}6 \cdot 10^{-8} \frac{W}{m^2 K^4}$

$\overbrace{2\pi \cdot 4 \cdot 10^{-3}}^{r} \cdot \overbrace{0{,}2}^{b} \cdot 5{,}6 \cdot 10^{-8} (483)^4$

0.0004

$483^4 = 54{,}5 \times 10^9$

$2\pi \cdot 4 \cdot 0{,}2 \cdot 5{,}6 \cdot 10^{-2}$

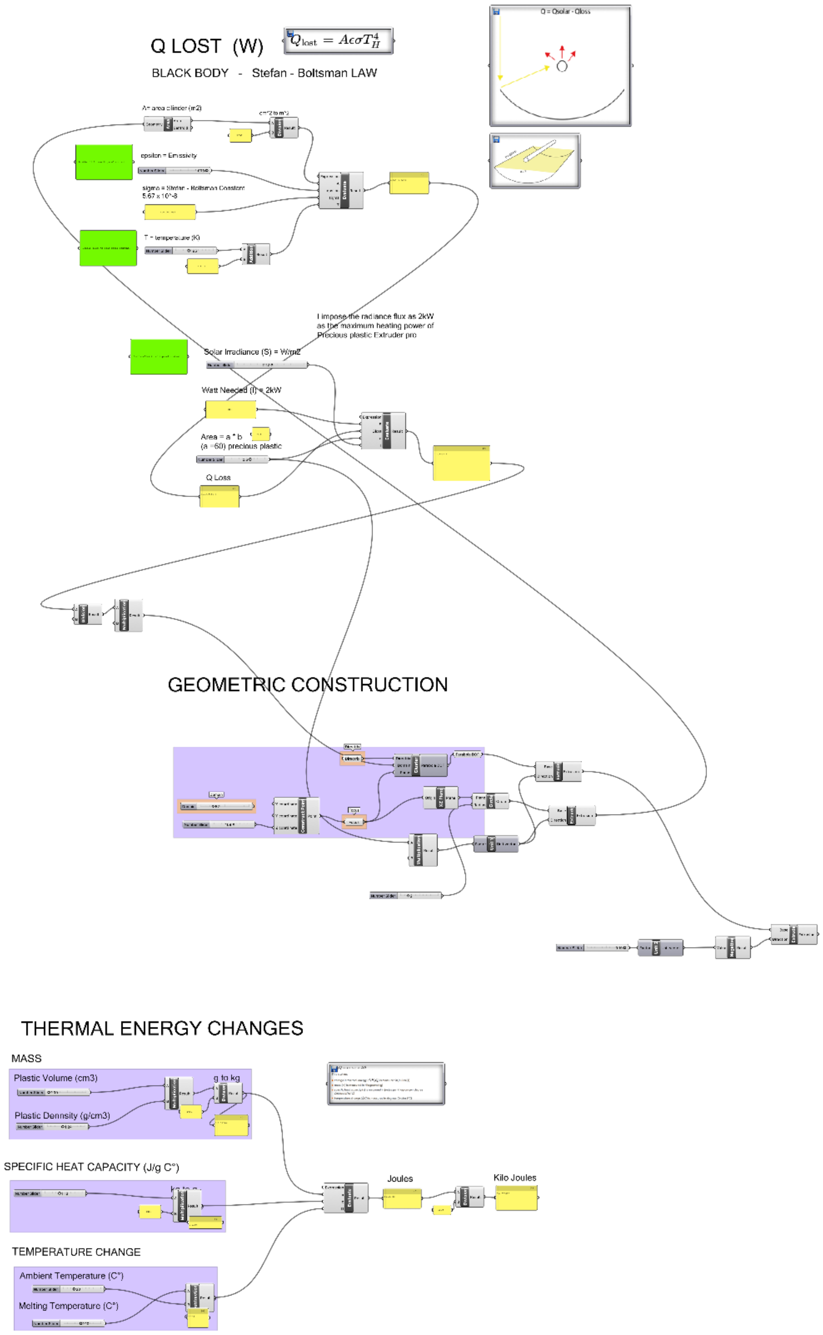
$0{,}3\,W = 0{,}0003\ KW$

$Q_{LOSSES} \sim 1KJ$

$\frac{28}{100} = 0{,}3$

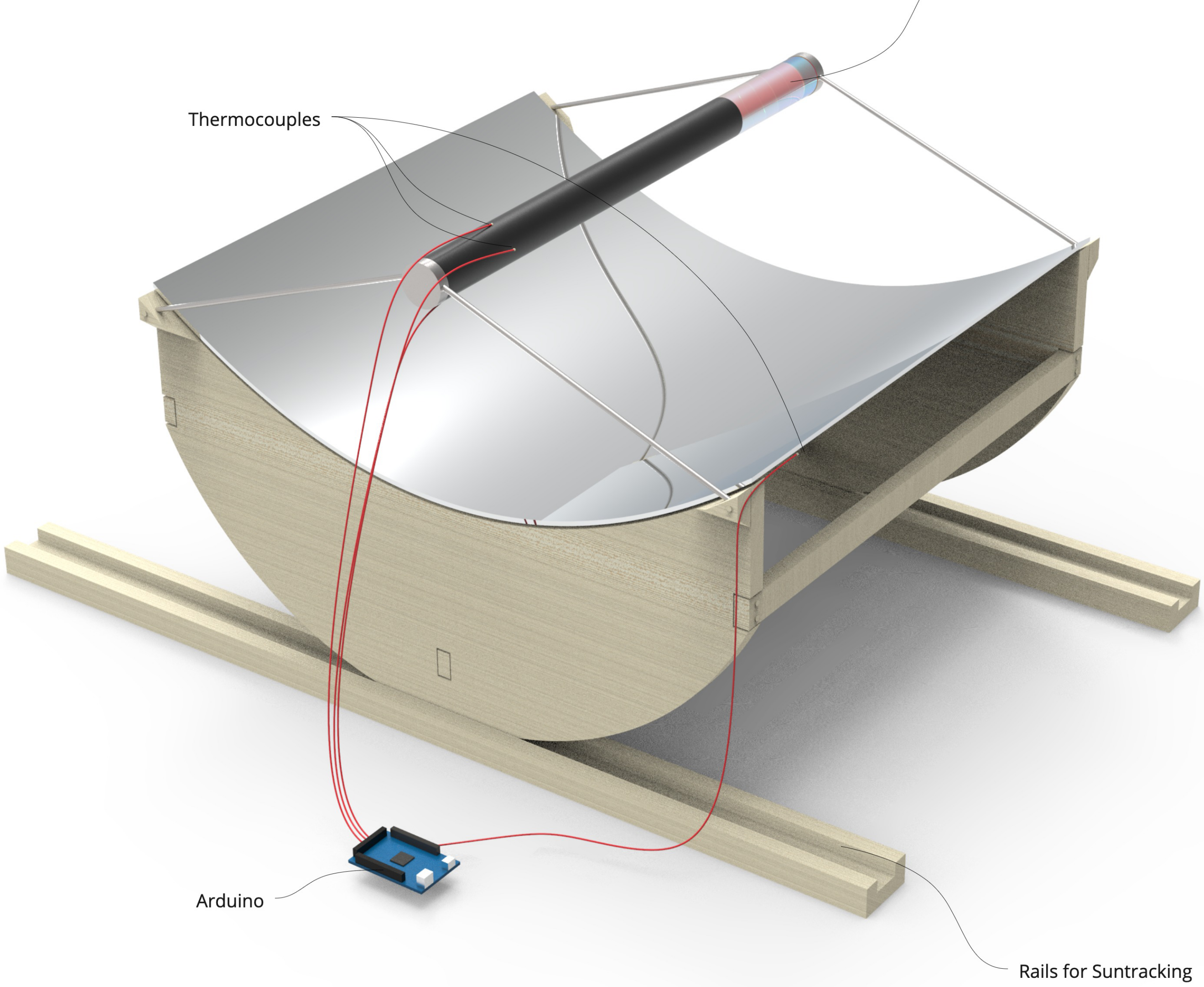
$300\ KJ$

In the following image is shown the parametrization of the model with the usage of Grasshopper, parametric software that allowed a direct conversion from formula to parabola geometry and dimensioning.



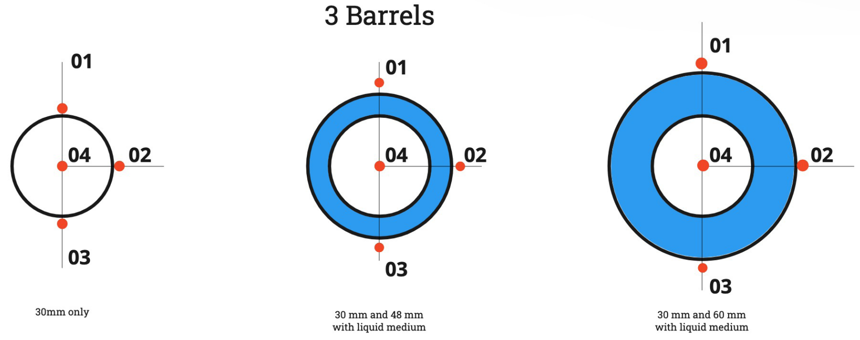
I impose the radiance flux as 2kW as the maximum heating power of Precious plastic Extruder pro

APPENDIX E: TESTS



SENSORS POSITIONING

3 Barrels



30mm only

30 mm and 48 mm
with liquid medium

30 mm and 60 mm
with liquid medium

● Thermocouples K tyme (MAX 6675)

others

- Thermocouple K type (MAX 6675) - Below the parabola **05**
- Ambient Thermocouple - External to the prototype, under shadow
- Light sensor - External to the prototype

QUESTIONS

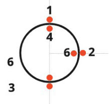
Heading time?
Temperature difference from top and bottom of the barrel? (with and without oil)
Temperature in shadow zones? (shadow due to the structure)
Heating Displacement - top bottom?
Heating Displacement - side of the parabola (due to misalignment with solar normal rays)?
Melting time?
Melting behavior?)
Influence of a cloud or other obstacles?
Fan cooling efficiency?

03 August

TEST SUBJECT

Parabola: Single layer of Aluminium PIPE: steel 30mm external diamenter, 26 internal

SENSORS DISPOSITION



WEATHER

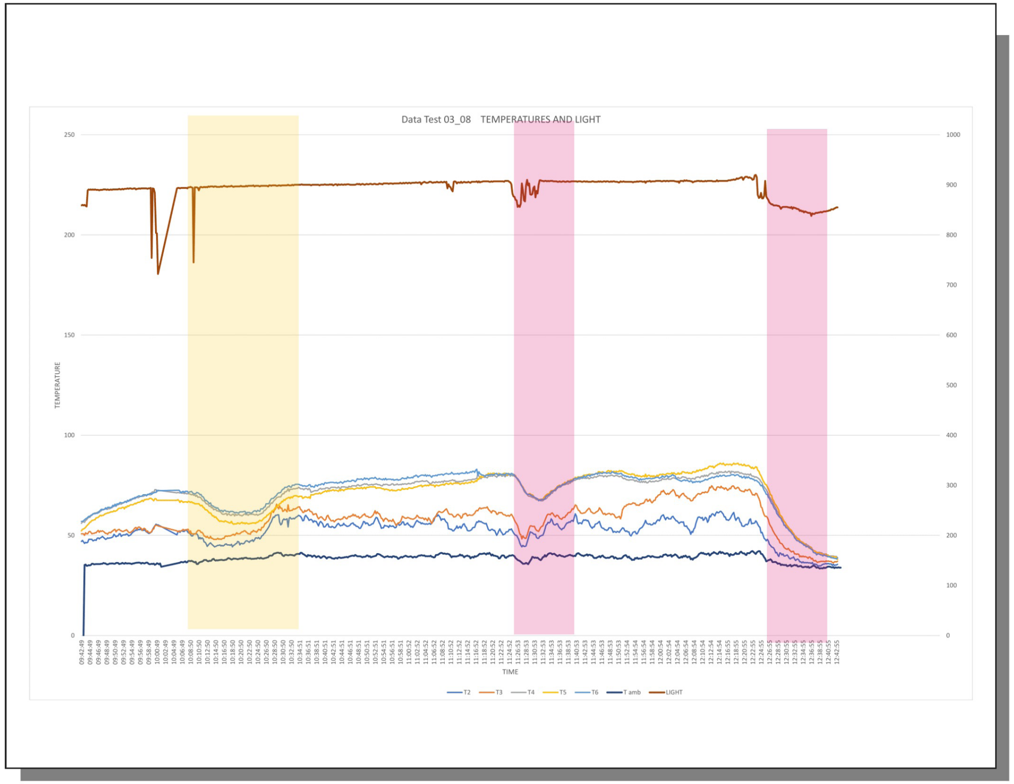
- Room Temperature 45°
- No Clouds
- No wind

NOTES AND INSIGHTS

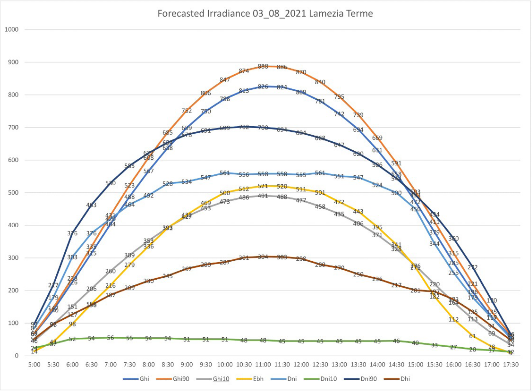
- The test ended because it become coludy
- A misalignment of few degrees can drop the temperature
- The presence of a cloud can drastically drop the temperature more drastically than the misalignment
- YELLOW=Misalignment
- PURPLE= cloud

PICTURES

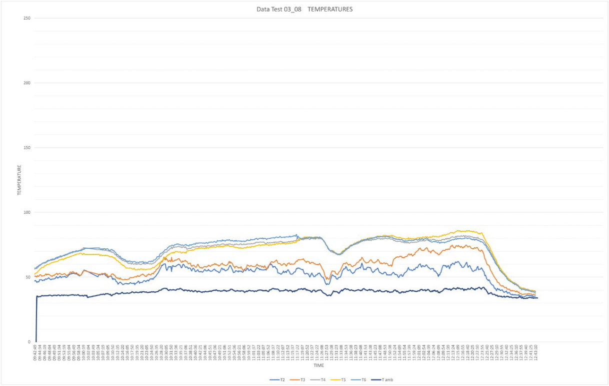
TEMPERATURE AND BRIGHTNESS GRAPH



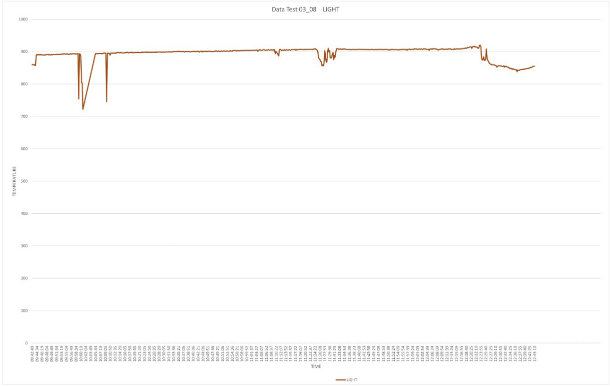
IRRADIANCE



TEMPERATURE



BRIGHTNESS

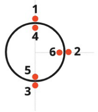


11 August

TEST SUBJECT

Parabola: Single layer of Steel
PIPE: steel 30mm external diamenter, 26 internal

SENSORS DISPOSITION



WEATHER

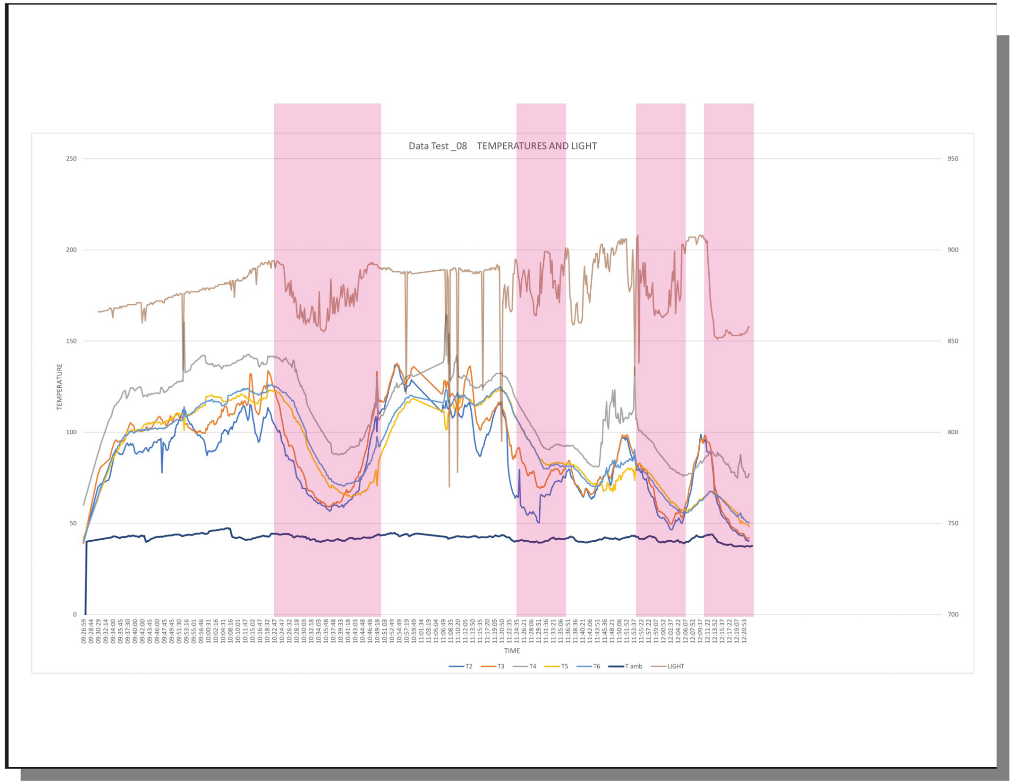
- Room Temperature 45°
- MUGGINESS DAY
- No wind

NOTES AND INSIGHTS

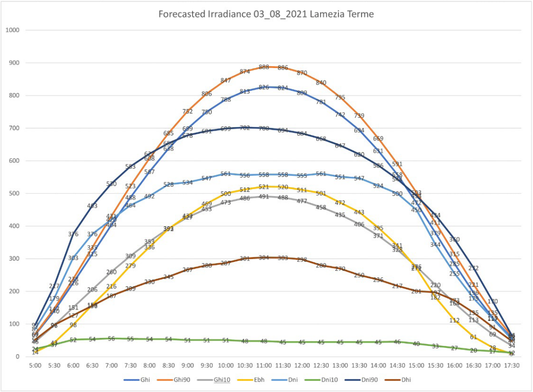
- Muggy noticeable looking at the light graph, that is averagely lower than the other days

PICTURES

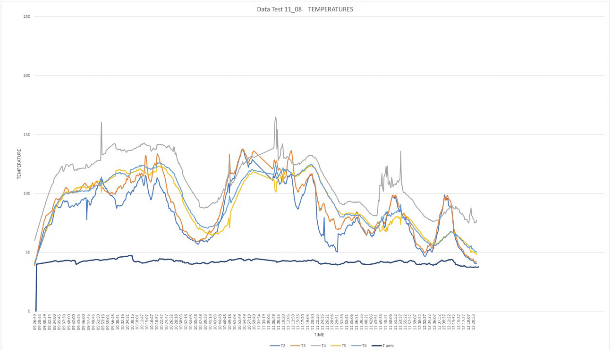
TEMPERATURE AND BRIGHTNESS GRAPH



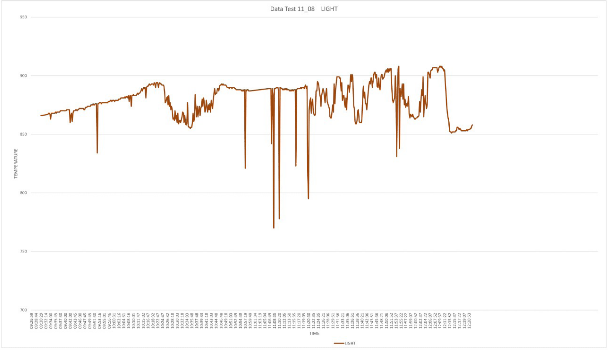
IRRADIANCE



TEMPERATURE



BRIGHTNESS

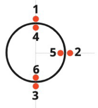


25 August

TEST SUBJECT

Parabola: Double layer of Aluminium and Steel
PIPE: steel 30mm external diamenter, 26 internal

SENSORS DISPOSITION



WEATHER

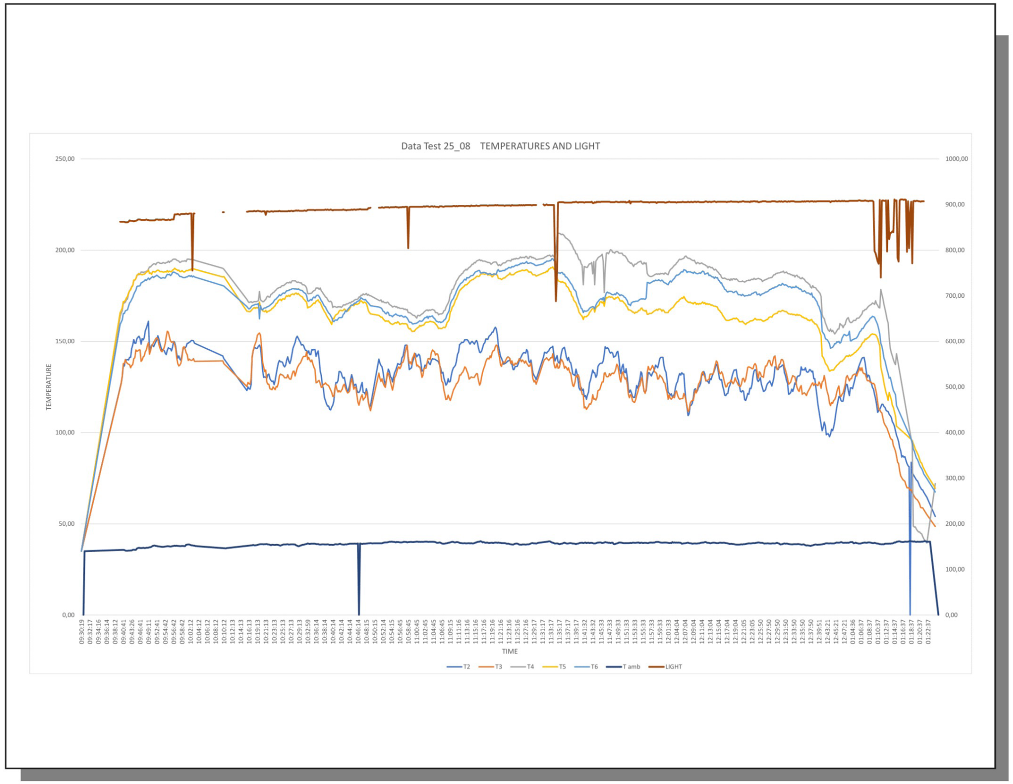
- Room Temperature 41°
- No Clouds
- No wind

NOTES AND INSIGHTS

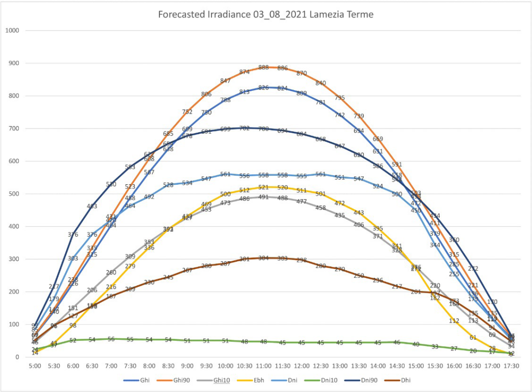
- SENSOR 1 GOT BROKE DURING THE TEST
-
- After 11:30 the alignment is easier to do
- T4(inside at the top) is the highest temperature because it iss constatly under sunrays.
- From 40° to 190° in the first 20 minutes

PICTURES

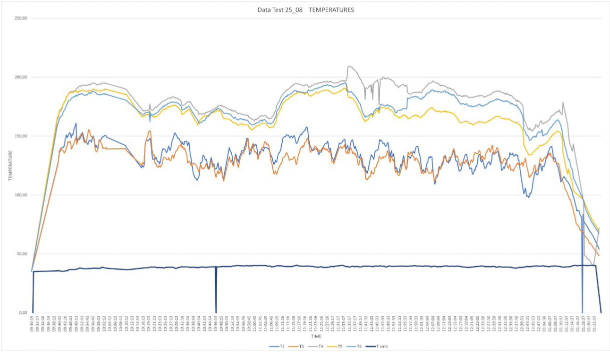
TEMPERATURE AND BRIGHTNESS GRAPH



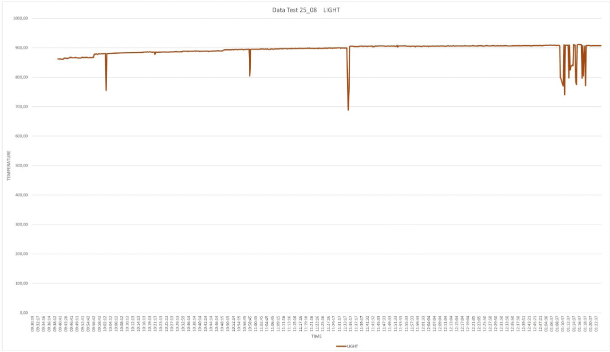
IRRADIANCE



TEMPERATURE



BRIGHTNESS

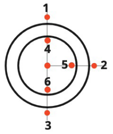


31 August

TEST SUBJECT

Parabola: Double layer of Aluminium and Steel
PIPE: Duble layered pipe with engine oil as medium

SENSORS DISPOSITION



WEATHER

- Room Temperature 35°
- No Clouds
- No wind

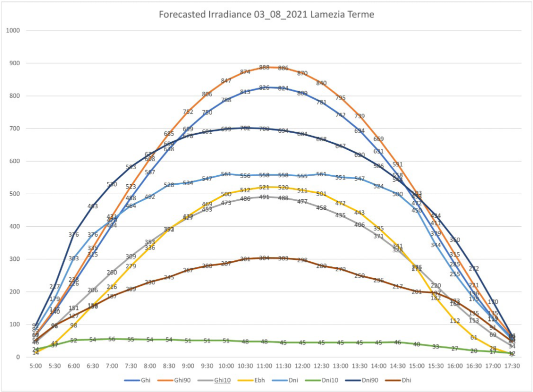
NOTES AND INSIGHTS

- More constant heating but slower
- Slower cooling down phase
- Easier alignmend due to wider pipe diameter
- Small temperature difference in between outside and inside sensors
- T1 has a lower temperature because of missing reflection

PICTURES

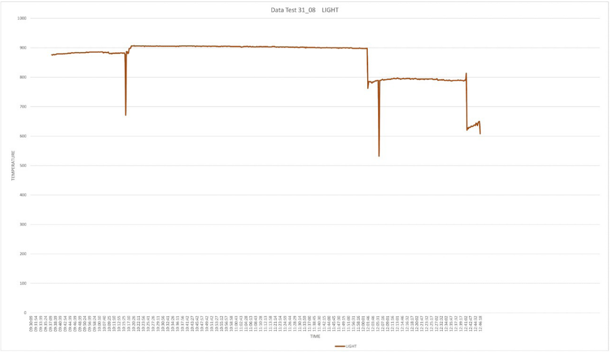
TEMPERATURE AND BRIGHTNESS GRAPH

IRRADIANCE



TEMPERATURE

BRIGHTNESS



APPENDIX F: INTERVIEW

STEVE GRAY, DURBAN MAKER SPACE

FEASIBILITY

PARABOLA SOILING: In ulundi is present many sand dust around

Train someone to keep it polished

TRANSPORTABILITY

SHADE AREA

DURABILITY AND STURDINESS

5/6 YEARS AT LEAST: WILL ALLOW THE RETURN ON INVESTMENT

MACHINE COMPLETELY AUTONOMUS

PHOTOVOLTAIC TO POWER THE MOTOR

steam generator that creates energy for the motor

DC MOTOR instead of AC MOTOR

??? WINDSHIELD WIPER MOTOR ???

NICE IDEA TO OVERSIZE THE PARABOLA FOR THE CLOUD EVENTUALITY

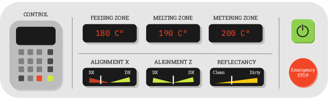
It would be perfect for molds, since the extruder would be also uset to make molds

INJECTION MOULTING MACHING

you need only one heating zone

SLOPING AXIS

DESIRABILITY



WORK PERCEPTION 1

SOLAR TRACKING SYSTEM: Design to be more simple, don't automatize the tracking.

Train someone to move it

The tasks will be to feed the plastic and keep it aligned

PROBABLY SMALL MOTOR ONLY FOR THE FINE TUNING

INSTEAD OF MOTORS: CREATE A MONITOR SYSTEM (INTERFACE) TO DIRECT ON HOW TO ALIGN THE PARABOLA

IT WOULD BE A TOO EXPENSIVE PRODUCT

And you know what I'm saying is, there's two ways to do it.
One is to make it much more manual and rely on the person to to do the the work and the thinking of alignment and and whatever else you need to do.
The other one is to make it much more automated and then. You know, over engineer it almost and then I don't think practically if you put that in there, Ulundi.
You know how long would it last for before it gets damaged and broken?
Unless you make it very robust and then you're talking like very lots of money, you know with stainless steel and those big bearings you've got there to rotate

SHOULD BE VERY ROBUST, FOR ULUNDI, OTHERWISE IT WOULD EASILY BREAK (BEARINGS, parabola etc)

BETTER A MORE ROBUST PARABOLA AND LESS PERFORMING

"THE USER (FROM ULUNDI) DOESN'T WANT TO FEEL AS THEY KNOW NOTHING,

The user here doesn't want to be treated like they know nothing. They want to have some
They want to feel like there's a skill into this thing that they they know how to align it and and they can move it.
And they've got work to do, you know?
So they feel productive, so I think like I'm saying you can, it's it's obviously up to you and it it might be a bit late for you too.
Maybe you could include it as an option in terms of your your your studies as as like a the two approaches and and phase one might be a more rudimentary version.

2 VERSIONS: FIRST MORE RUDIMENTARY AND SECOND WITH AUTOMATIZATION (FOR FUTURE OR FOR DISABLED)

USAGE TIME

2 TO 4 HOUR A DAY SOUTH AFRICA DOESN'T HAVE POWER

We can't supply enough power for everyone.

IT WILL DRASTICALLY LOWER THE USAGE TIME OF THE MACHINE; YOU CAN HAVE POWER BUT NOT SUN, OR THE OPPOSITE

EVALUATE A WORKING PROFITABILITY OF THE MACHINE, IF IS ENOUGH FOR LIVING COSTS


www.google.com

SOUTH AFRICA POWER CUT - Google Search

The South African Energy Crisis is an ongoing period when South Africa experiences widespread rolling blackouts as supply falls behind demand, ...

They need a shade space to operate a machine

WORK PERCEPTION 2

WORKER PRIORITY IS PROFIT, not saving money or CO2

They then just need enough money for the day to buy enough food for the day, so for them paying for electricity or not paying for electricity, making a little bit more money or spending a little bit less money, it's not a massive priority.

PRODUCTS NEEDS

A MACHINE THAT WORKS ENTIRELY OUT OF THE GRID CAN CREATE A LOT MORE POSSIBILITIES

oblem is how do you get the precious plastic extruder machine in New London to work and make and make somebody living?

VIABILITY

OPEN SOURCE

Local Material

Parabola cutted in pieces, easier to handle, no need for a truck

SAVING IS NOT APPEALING AS A VALUE PROPOSITION

A MACHINE THAT WORKS ENTIRELY OUT OF THE GRID CAN CREATE A LOT MORE POSSIBILITIES

But if you can, if you can offer something that works entirely off the grid, then you open up a whole new opportunity to people who may be even more, have even more poverty and even more desperate.

Becames a game changer


circulareconomy...

African Circular Economy Network - Connecting Europe to 'Circular Africa'

Its vision is to build a restorative African economy that generates well-being and prosperity inclusive of all its people, through new forms of economic production and consumption which maintain and regenerate its environmental resources. Research The r...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