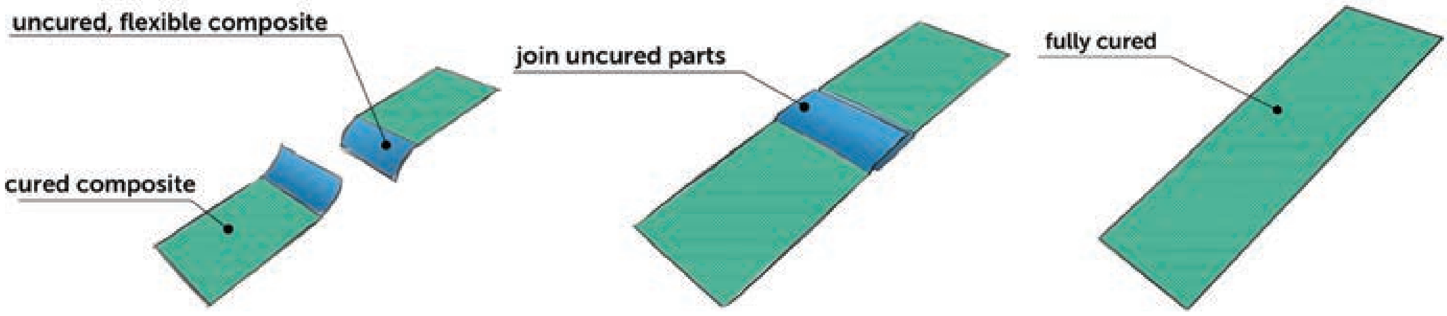
REVOLUTIONARY COMPOSITE JOINING METHOD

From an aerospace thesis research to founding a new company



MOCS

In 2011, Peter Madlener started his graduation thesis at the Aerospace Engineering faculty on a new joining technology for composite sandwich panels. The promising results gained in this thesis led to the foundation of MOCS: a young company with the ambitious goal of introducing a revolutionary joining technology in the market. At this moment, MOCS is introducing its technology in the composite pipe industry. In this article you will read how MOCS was founded and how the technology it invented works.

TEXT **Ir. Anande Bergman, R&D engineer at MOCS**

WHERE IT STARTED

Industries are increasingly convinced about the major advantages and endless capabilities of composite materials. This results in large-scale composite material innovation programs that are run in the aerospace and automotive industry and contribute to an increasing popularity and understanding of this material type.

In a bid to push this technology forward and to increase the knowledge based about marine composite product development Damen had set up the FLIGHT R&D project, together with DSM, Teijin Aramid, Lightweight Structures, Delft University of Technology and Bureau Veritas. One of FLIGHT's goals was to develop or improve production methods that could reduce the current upfront investments required for fabrication of the plugs and moulds for composite ship structures.

THE NEED FOR A BETTER JOINT

The panel-wise building principle is a method that could be adopted for this. The principle is based on the assumption that cost driven mono and catamaran hull shapes can be constructed out of separate sandwich panels. These panels are produced by an automated process in a controlled environment and can be assembled at an arbitrary shipyard.

Excluding the usage of a plug and mould is the philosophy behind this building principle. In addition, it reduces the production time and possible lay-up mistakes since the lay-up and impregnation process of the core and laminates, which is often done by hand, is excluded from the process. When adopting this building process, it all comes down to the connection. Large-scale implementation of existing connection methods are limited by the fact that they are vulnerable, non-reliable, time consuming and costly.

FROM THESIS RESEARCH TO COMPANY

Under the supervision of Dr. ir. Otto Bergsma from the Design and Production of Composite Structures research group (DPCS), Peter Madlener's master thesis research goal was to develop a sandwich panel connection method that is suitable for large-scale implementation. This method has to stimulate a fast assembly process without having negative effects on the structural integrity.

The study on a B-stage resin type showed it has the ability to overcome the negative effects on the aforementioned criteria. Experimentally determined strength reductions are of negligible magnitude. Moreover, it can be assumed as a continuum since it is based on chemical bonding, also known as a primary bond.

During the thesis, several questions were raised: can this connection technology be implemented in other industries? Can it accelerate the composite usage? These questions led Peter Madlener and Wouter Riedijk, a former classmate, to founding MOCS. MOCS is focusing on the heavy industries (civil, offshore and ship building) where structures are large and have to be made out of modules. Currently MOCS is testing the applicability of the B-stage technology in connecting fiber-reinforced pipes that are used for transportation of fluids.

THE PIPE MARKET AND THE WEAK LINK

The use of Fiber Reinforced Plastic (FRP) pipe has been rapidly growing in the last ten years because of their advantages over pipes made of traditional materials like iron, concrete and plastics. Their superior mechanical and anti-corrosion properties, lower conductivity and longer life cycle make FRP pipes a natural choice both for general purpose as well as in specialty applications. FRP pipes also have shown to be competitive for the large diameter (150 mm to > 4000 mm) pipe market, which is estimated to be worth $127bn, in high-pressure areas and in elaborate pipe networks extending over several thousand kilometers.

The old proverb says: "a chain is no stronger than its weakest link", and FRP pipe systems are no exception. Despite the superior properties of composites in comparison with traditional materials, the increased interest in the combination of large diameter and high pressure is also highlighting the weak link: joints, which are responsible for more than 95% of the failures in FPR pipe systems. One of the main issues with current permanent joining technology is the lack of control on the process. Bonded and laminated joints are the most common permanent joint in the FRP pipe industry. In both cases, the first step is to prepare the pipe segments by machining and sanding the surfaces to be joined.

For bonded joints, the adhesive is prepared and spread manually, after which the female and male pipe segments are fitted. To realize a laminated joint both segments are placed next to each other and are connected by manually applying and impregnating several layers of glass fiber fabrics around the two segments to be joined. In both approaches, the quality of the joint is highly dependent on the skills of the pipe fitter and repeatability of the joining process. Quality cannot be ensured as there is almost no control of critical parameters like surface roughness, thickness of the adhesive layer, curing cycle, contact pressure or fibre volume fraction of the laminated patch.

MOCS' WAY

MOCS' aim is to introduce a highly reliable joint to the market. Instead of creating a secondary joint with adhesive or a FRP patch MOCS joining technology generates a primary joint at chemical level with mechanical properties comparable with a co-cured joint. To realize this joint special B-stage resins systems are used. The main difference between a B-stage and standard resin formulations is that the polymerization (curing) process is interrupted in an intermediate state, where a sticky and flexible polymer is obtained. The material at this phase is called B-Stage, which can be maintained at room temperature for undetermined time without curing. When the temperature of the B-stage material is raised to the appropriate level, the polymerizations process is reactivated and a solid resin is obtained. MOCS joining technology makes use of the two curing steps. The basic principle is schematically demonstrated for a plate in Figure 1. First, most of the plate is totally cured (hard-out), with exception of the ends that remain in B-stage phase. To join two plates, the uncured ends are connected and cured under pressure, resulting in one solid plate.

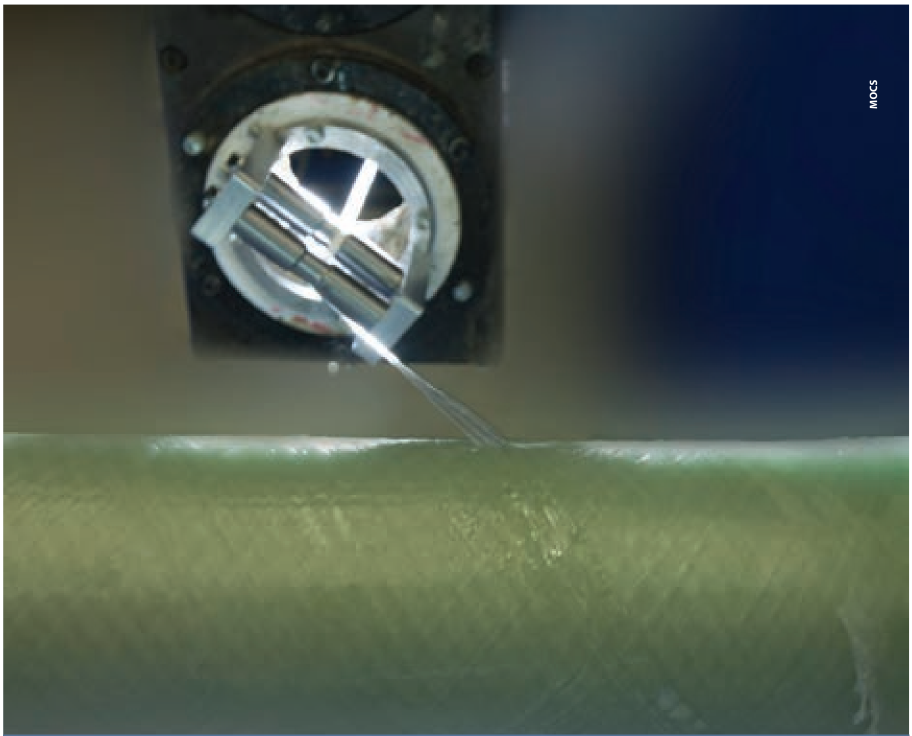


Figure 2. Detail of the filament winding process

The key to ensure a reliable joint is to maximize control over the process parameters by automation in the joint manufacturing process and the in-field joining process. For pipe connections, MOCS develops a series of tools that can be integrated in the current filament winding process (see: Figure 2) to automatically manufacture integrated pipe joints. On field the task of the pipe fitter is limited to placing the pipes and joining tools into position; however all the critical joint process parameters are controlled and registered by the tools integrated microprocessor, ensuring a reliable and repeatable joint quality.

THE FUTURE

In close cooperation with TU Delft and big industrial parties, MOCS is developing the B-stage joining technology towards a market ready product. Starting from an idea for a graduation assignment in 2011, MOCS has developed into a rapidly growing company, consisting of twelve employees and graduates at this moment. The mission of MOCS is to make a strong contribution in adapting these materials in the heavy industries with the aim of contributing to the world with more durable and sustainable structures and processes. MOCS' forecast is that the composite material market will increase but it will never replace the market of isotropic materials. The adaptation of composite materials in the offshore, shipbuilding and civil industry will be related to the replacement of specific components where composites showed to have the best business case. MOCS' goal is to keep on building strong relationships with the heavy industries and launch several technologies where the B-stage joining technology is the first to come.

If you are interested in this technology and its potential application or want to contribute to this research as an intern or graduate student, please be sure to contact the author at abergman@mocs.nl.