STAXX Compact 1700 – low scrap for high volume component parts production

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Carbon composites have been on an odyssey within the past 15 years. Starting on the highest expectations regarding the performance, reality was hitting a lot of programs hard in terms of production costs and weight. Carbon composites were introduced on a very high technical level and nevertheless, industry has shown of being capable to handle those processes in general. In particular, production never sleeps and processes undergo a continuous change. Within these changes costs remain the most critical driver. As products are improving during their lifetime, they usually increase the degree of complexity, too. According to the normal cost improvement, this has drastic consequences for production.

When setting up the first generation of composite production, the part being produced has been in the centre of attention. At a first glance this has been the correct approach, but at a second one, it initiated up a huge number of variations in production processes, as in composite production the material and the part have to be built at the same time. This phenomenon especially occurs in the production of small, monolithic parts, where prepreg technology, hand layup or resin transfer moulding is applied. The production of large quantities of carbon fibre parts occurs nowadays in several industries, where each has its special requirements. The uprising carbon component production for automotive industry seeks for short cycle times and high volumes. The demand for production is given by productivity and reliability as for most parts the quality has to be determined by the production process itself without an extra non-destructive testing step. These parts require an increased the degree of overall automation; a combination between automation equipment and a manufacturing execution systems allows a reliable logistic for a large number of parts as well as a traceable access between quality assurance and automation equipment. Standards in manufacturing will reduce production costs further. Those standards still have to be established in the production of carbon composites components, as several production technologies offer a large variety. This variety occurs in different raw materials, different automation equipment, and different skills of workers who operate the production equipment.

Today, also the variety in material is still growing. Thermosets are competing with thermoplastics, prepregs with dry fibres, fabrics with non-woven, etc. In the field of raw materials for fibre placement processes thermoset systems and slit tape are applied predominantly, but currently there are two niches developing. In the field of thermoset matrices, 50K fibres are directly impregnated into tow preg. Material suppliers promise costs advantages in comparison to slit tow, as the production of tow preg avoids slitting and slitting induced production waste. Therefore, production capacities still have to be ramped up to achieve a comparable production volume to conventional prepregs. When short cycle times are requested, thermoplastics show a high potential. Because of that, they have been applied for structural applications for small parts like clips and brackets. In automotive applications thermoplastic system like PP and PA derivatives are applied for structures. Thermoplastics are processed as organo sheets and have a lot of scrap within production, the advantages of fibre placement are to be utilized in terms of scrap reduction. As both materials are available in a unidirectional form, both of can be processed within the fibre placement process. With

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both materials parts quality and production costs will be on a comparable level. This would reduce complexity for production in general. E. g. as the trend for small, monolithic parts develops into the direction of being non-core for the production of OEM and Tier one suppliers, OEM and Tier one suppliers seek to find new suppliers for those parts, as their production will not remain profitable for those parts on the long run.

As the carbon fibre material producing companies are increasingly addressing low cost material for new applications, tow preg seems to be the most promising. Tow preg is a directly impregnated carbon fibre roving. Today's tow preg consists of 24 k fibre rovings or 50 k fibre rovings. The material development is close to market readiness and seeks new machining concepts for production, as it has already been widely used for winding technology. Further material tests have to proof the suitability of tow preg for aerospace applications. Its potential is very high, especially if tow preg is compared to use-cases, where today prepregs are applied or non-crimp fabrics and fabrics are used in combination with resin transfer moulding or liquid infusion technology.

STAXX Compact 1700 is a new machining centre, designed for the production of carbon fibre parts, using the fibre placement process. It produces prepreg carbon fibre stacks near to net shape which need to be moulded afterwards. As today's high volume production lacks a reliable production system that can handle carbon fibre with high efficiency and minimal material scrap and individual fibre orientation, STAXX Compact is the only machine especially designed for high production rates that reduces material scrap during the production process significantly. As most of the technical applications for lightweight construction, such as in the automotive and aerospace industries are 'shell' type shaped parts, fibre placement has a great potential as it is suitable to produce those type of parts. While textile production methods in applications may cause a scrap rate for small parts of up 50% for small parts, fibre placement would offer a total scrap rate of below 5%. Accordingly, fibre placement offers the design option to produce parts of variable wall thickness and local reinforcement.

Figure 1 shows the direct comparison of a part produced with STAXX technology in comparison to resin transfer moulding in terms of costs. The abscissa shows the raw material price per kg, where tow preg is in the range between 20 to 25 € per kg. Even if the resin transfer moulding process would have lower material costs today, it would not provide the material savings due to net shape layup. In the midterm increasing production capacities for tow preg will further decrease the price per kg material. Tow preg has a lower price target, as the raw carbon fibre yarn is spreaded and directly impregnated, while fabrics or non-woven fabrics have to have a spreading and weaving process before impregnation. Accordingly, the usage of pregpreg offers more costs advantages for tooling, while it offers a robust process due to the already impregnated material as well.

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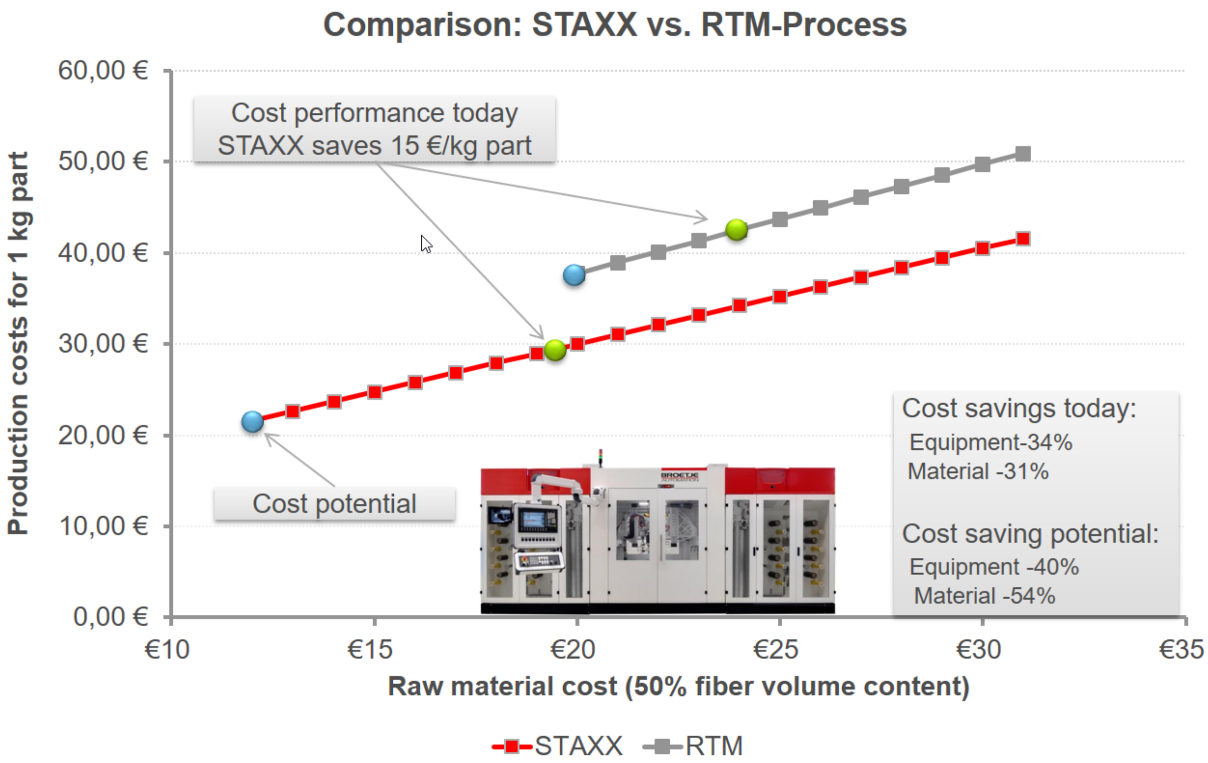

Figure 1 Comparison between RTM and STAXX technology for monolithic parts

But a cost efficient production bases upon flexibility and standards. Flexibility has to be given by multi-use production equipment and workers who are qualified for different products and the use of standards. Predominantly all standards in carbon composite manufacturing are influenced by the raw material. The aim of "one fits all" has not been followed after in the past consequently. In terms of production technology fibre placement suits most of the technical applications. Fibre placement is already an established technology in aircraft production and it is used for large fuselage panels, e. g. The potential of fibre placement is higher. It is the only technology to lay down material near net shape with an individual fibre orientation and a high, NC-machine determined part quality. As it was used in the past mostly for large structures, the industry did not pursue this particular technology for the production of large quantities, because the production equipment was not designed for this particular purpose and the raw material costs were high. But, latest developments show the advantage of fibre placement. For highest productivity and quality fibre placement has to be combined with a moulding technique, where the fibre placement process offers a carbon fibre stack which is ready to mould. Therefore, a supply chain has to be built upon standards, that helps to assess risk on investment on the one hand and on the other hand where only proven standard technology is used to build parts within a spectrum of given and controllable technology. Automation will help to put the supply chain into a place, where the assessment of the quality and the cost are becoming more transparent for all parties.

In terms of standards, only those should be applied where they are beneficial to the production. When standards meet automation it is most profitable, when automation occurs early in the process chain. Because of that the fibre placement process is most promising of being the industrial standard, as it offers a very high flexibility to build a large variety of parts. Fibre Placement has been introduced on a large scale for building fuselage structures for example. It is not applied for the production of

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small parts yet, even though it would offer several advantages. So far, production equipment for this purpose was not available. STAXX machines will close this gap. This will be an enabler to produce parts on a high level of automation and STAXX machine will improve the supply chain, too. As suppliers will benefit from the experience in automation of the OEM and Tier 1 suppliers, the entire process chain of composite parts will develop the option of becoming simpler, because of the reduction of raw materials used.

Until now, there has not been a breakthrough in the use of fibre placement in industry, due to the limitations that today's machines have with regard to high volume production. Due to the varying requirements of high volume production, the design of a fibre placement machining centre has to be revised and updated. STAXX Compact addresses this issue, to combine the advantages of fibre placement with the requirements of high volume production. Thus addressing the question, how to create a robust production system that is also able to process low-cost carbon fibre materials with minimal scrap, as well as aerospace grade slit tape.

With these requirements, the design was guided into the direction of a standalone fibre placement machining centre that uses low cost carbon fibre material or aerospace grade slit tape and creates an output in the form of a carbon fibre stack. These stacks are easy to handle within the process and ready to mould into the final shape. Therefore, the know-how was developed to combine the production requirements of both fibre placement along with the material and the moulding processes.

Figure 2 STAXX compact 1700

Hence, the value for production of composite parts using STAXX compact is to be evaluated by the following three aspects: First of all, the new machine technology enables the operator to produce parts with minimal scrap by using the full anisotropic properties of the carbon fibre. Secondly, the machine is specially designed to use standard material, which is a fibre of a standard width and impregnation. In addition to the process advantages, the machine offers the added value of being a standalone solution, which is able to conduct fibre placement in any industrial environment. Due to its embedded air conditioning system it offers constant production condition, which is beneficial for the processing of any carbon fibre.

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The technology of a fibre placement machining centre also addresses production systems. These production systems are defined by the combination of several fibre placement machining centres. Their intelligent combination into a production system enables the operator to produce parts families simultaneously, so that production can be actively aligned to actual requirements. By creating such an agile production system, individual fibre placement machining centres are connected to each other and build an agile system. Therefore, production volume can be scaled up with an established and verified technology, one which uses automation methods similar to those already applied in high volume production.

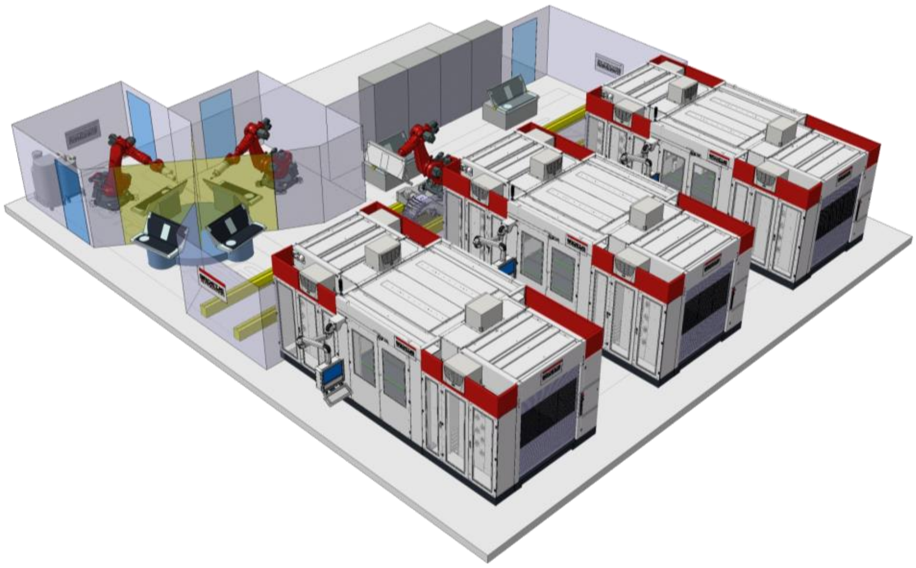

Figure 3 STAXX Compact 1700 in an agile production system

The STAXX development was driven by the need for large volume production methods for high performance composite parts, which are currently applied predominantly by textile technologies or thermoplastic prepregs if larger quantities are applied. The main aim of the development was to create a machine which significantly reduces the wastage of carbon fibre material during the production process and enables the produces to reduce the complexity in logistics causes by the use of different materials in production. As fibre placement technology proves to be the most promising technology for this purpose, fibre placement machines have to be developed further to offer a robust process, which fulfils the production requirements of high volume production. With further regard to fully automation, Siemens 840 D-SL was chosen as the machine control system which has the inherent potential to be linked up to complex production systems.

Launching the innovation involved the combination of two existing technologies. First of all, the fibre placement process technology had to become a more robust process. The second task was to find an automation method which suited the more robust fibre placement process. To handle the complexity of fibre placement coupled with the need to automate for higher production rates, the design of the machine resulted in a robust mechanism for fibre placement, as well as a second mechanism for dealing with the complexity of production parts. This second mechanism was designed to be fully independent from the fibre placement technology. Hence, the fibre placement machining centre was designed to a have a robust lay-up technology combined with a flexible positioning system.

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By combining these two technologies, a defined starting point for automation was provided. Automation for fibre placement machining should provide a high throughput of parts and a defined handling of the produced parts. One aspect was to design the machine so that it was able to load a palette while simultaneously carrying out fibre placement on another palette. This main time parallel palette loading reduces downtime of the machine significantly, especially if parts with a short cycle time have to be produced. The palette technology enables the machine to provide the produced parts under defined conditions, which is essential for further automation along the process chain.

STAXX is designed to be a key enabler for the broad usage of carbon fibre composites for high volume production because it operates standard materials, as well as uses a minimum amount of material for each part. Due to the reduction of scrap combined with a higher degree of automation, STAXX Compact will further reduce production costs significantly by using production standards consequently.

The market for this machine includes, but is not limited to the aerospace, automotive, electronic consumer goods, as well as various part productions in small and medium-sized enterprises. The technology is suitable for producing large quantities of potentially more than 1500 ship sets a day.

Its main application is the production of structural body parts, for electronic consumer goods it is for example frames for large panels, while in the aerospace industry it is for structural parts, especially like clips and brackets, ribs, fans and others. This technology will also provide applications in the seat manufacturing industry, as the technology offers benefits in terms of volume and production costs. As the machine can be operated as an agile system of several machines, as well as standalone machine, the standalone version attracts SME's to enter into the production of highly sophisticated and high performance parts.

STAXX will decrease the risk for the part manufacturer as it builds upon well-established technology and with regard on invests and production cost it is cost efficient due to being a stand-alone production system, also because one machine will be able to operate different materials. By setting standards in production using a direct fibre layup the impact on cost reduction is given by technological factors and by economic factors, because standards assure to increase the number of potential suppliers. Most importantly, it is a new and innovative machine system that demonstrates the use of fibre placement technology for high volume production, beneficial within a range of different applications and industries. The most significant benefit of this new technology is the reduction of production costs by the use of standard material and a high degree of automation. Further cost reductions are given by a high efficiency in material usage which is processed to ensure a minimum of wastage and scrap. As the option of using individual machines within an agile production system, large quantities of parts can be processed. The fibre placement technology combined with automation will increase the quality of parts and through the discrete separation of process steps; robustness along the entire process chain will be improved. In terms of installation, this machine requires no additional foundation work to accommodate, which enables the machine producer to extend turnkey capabilities. The machining centre is highly suitable for combining with automation technology, such as part or palette handling. Hence, the fibre placement machining centre combines the sophisticated fibre placement technology with a robust process, as well as a high degree of automation, for maximum throughput to produce parts in large quantities and reliable quality.

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