Application areas of one-side stitching technique

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Abstract

New applications in composite industries require innovative technologies for the assembling and reinforcement of 3-dimensional structures. Stitching is of utmost importance in these new fields. But, there are different demands on quality and rate of automation especially from the aerospace industry. Therefore, new stitching processes and systems have to be developed which will be the focus of the presentation on the basis of composite applications. Advantages and disadvantages of preforming will be described compared with prepreg technologies as well as possibilities, functions and the influence to structure design and performance of composites by stitching.

Principles of one-side stitching technology

The typical design of a machine resulting from the necessary sub-construction for thread manipulation is known from household and classic industrial stitching machines. The stitching of extensive structures depends on the available clearance zone between the upper and lower part of the machine. This can be optimised to the greatest possible extent. Furthermore, it is possible to separate both manipulators which are necessarily to be synchronised appropriately. For two dimensional applications the realisation in a portal system is relatively uncomplicated, however, for three dimensional structures the use of such a system is not to be taken into consideration. For this purpose stitching technologies are

necessary which operate without a thread manipulating tool on the under surface of material. Two of these technologies are described shortly below:

Tufting

During this process the thread is inserted into the work piece by only one needle and without chaining. Depending on the demand and function of seam, the insertion of thread is realised under an angle of 90° or 45°. On Tufting, the material which shall be stitched can either be penetrated completely in the way that the thread loop is created underneath the material or partial. In this case the defined formation of the loop is realised in the work piece.

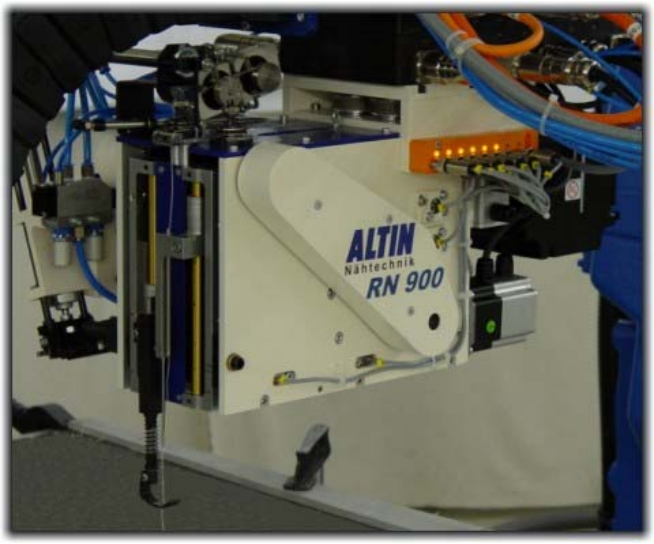

Figure. 1 – Tufting stitching head

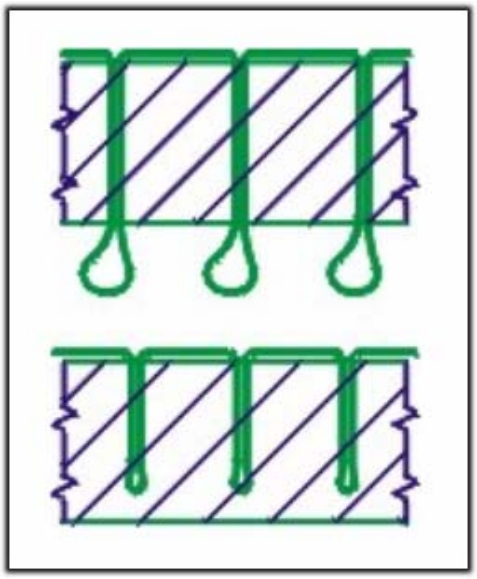

Figure 2 – Stitch pattern Tufting

One-side stitching

By using two needles and one thread a variation of a single chain stitch is realised in this process. One needle penetrates the stitching material under an angle of 45° and forms a loop underneath which is caught by a catcher needle under 90° and brought to the top side of work piece where it is chained with prior loop.

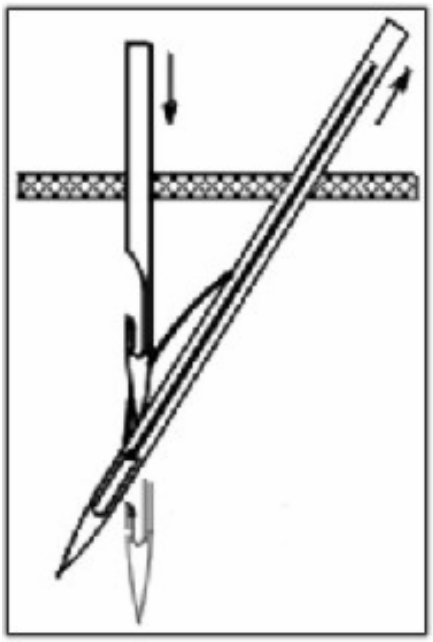

Figure 3 - One-side stitching head

Figure 4 – Stitch pattern

Up to now the stitching material was fed to the stitching machine. However, for processing of large three dimensional structures it is necessary to revise this principle. Beside a high precision and repeat accuracy the possibilities and advantages of the one-side stitching technique can be utilised optimally by CNC-manipulators which operates the stitching tools.

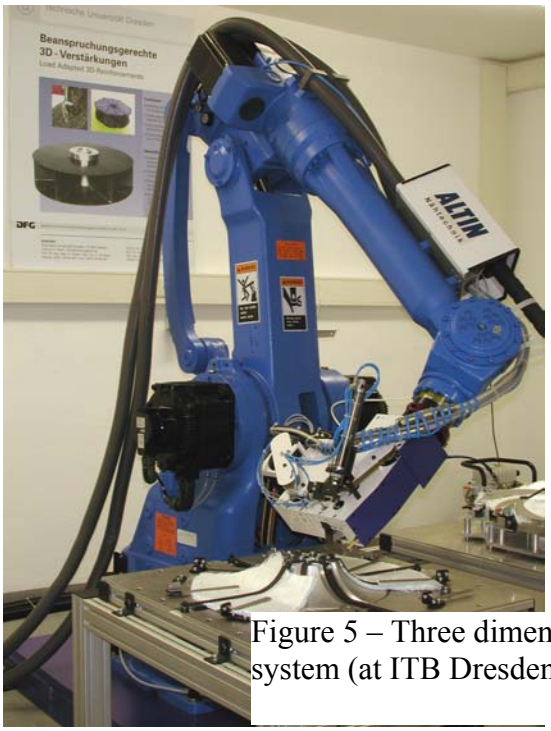

Figure 5 – Three dimensional robotic stitching system (at ITB Dresden, Germany)

Applications of stitching for example in the fiber composite industry

For production of fiber composite components different technologies are already established. At high standards the prepreg and the performing are preferred processes. Whilst on handling of prepregs the fibers are already resinated, in the preform process the materials are assembled to the definite shape before resin injection and consolidation.

Stitching is not applied in the prepreg technology since the resin in the materials of prepregs would stick together the needles and a safe stitch formation is not allowed any longer .

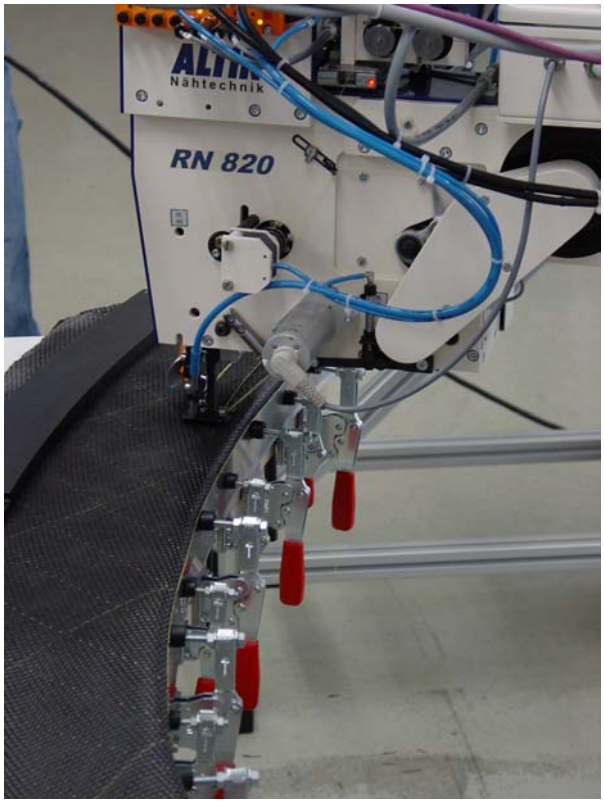

Figure 6 and 7 – Assembling of carbon fiber component from the aerospace

However, for the preform process stitching represents an effective solution to assemble structures and to influence the properties of components by a targeted reinforcement. By the principle of one-side stitching technology operated by a three dimensional handling system the processing of components is possible nearly independently from geometry and dimension. In this way stitching of large and complex structures as they are found in the aerospace industry will be enabled. For example, three dimensional reinforcing profiles can be assembled and directly fixed to the area which is to be reinforced. In this case the seams are used for joining, fixing or assembling. Since during the stitching process the material is fixed and only the stitching head is in motion the precision and repeat accuracy are allowed which are up to the high standards of aerospace. The materials are fixed in such way that during the stitching process the layers are not displaced or reorientation of fiber direction which is very important for high-performance parts is excluded.

Figure 8 and 9 – Assembling of profile

But, also for structures not exposed to high load and consequently being subject to lower standards the preforming by the use of stitching technique represents an advantageous joining technique. Such components to be found especially in the rail vehicle construction are often laminated manually with a high expenditure of personnel. By joining of already cut layers a constant quality can be ensured and the expansive use of personnel can be reduced by automation.

Beside pure glass fiber structures so-called sandwich structures are used in the rail vehicle construction as well. In this case a heart made of foam is wrapped by glass fiber material which is necessary to be fixed temporary. For such an application tufting is a very suitable process with a comparatively high stitching speed because on the one hand a thicker materials can be stitched, on the other hand it is not absolutely necessary to penetrate the material completely.

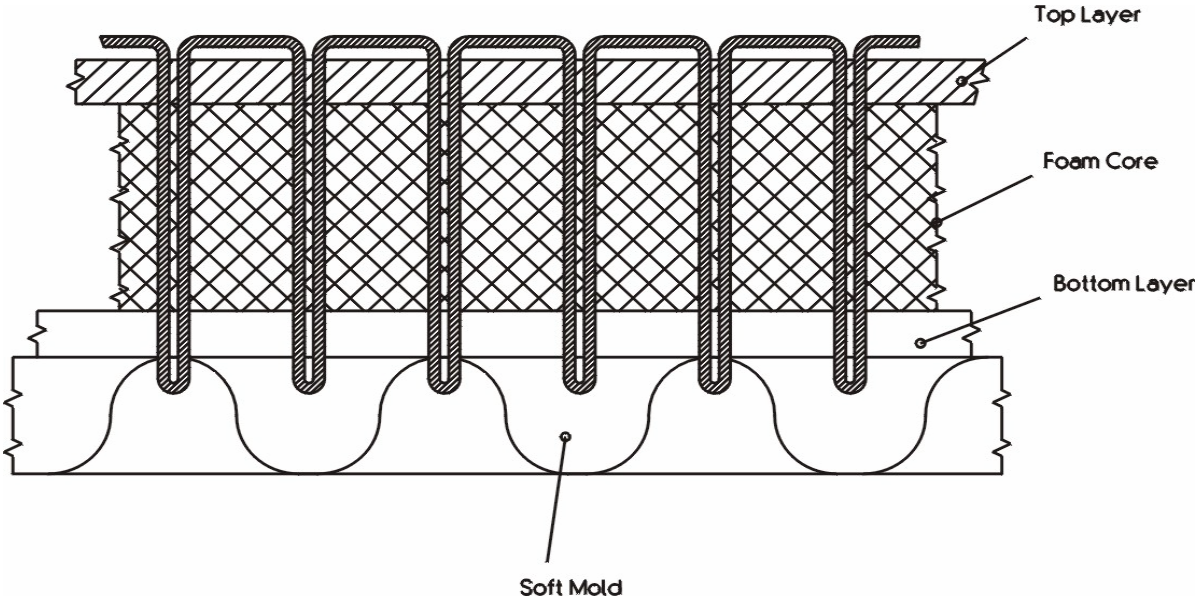

Figure 10 – Scheme of a sandwich structure fixed by Tufting

As already mentioned in addition to joining, the reinforcement of structures is very important as well. So components which are found for example in the automobile and aerospace industry have to show tolerances of damage which partly can be reached only by additional reinforcement of fiber composite. Threads inserted into the structure in z-direction and under an angle of 90° or also 45° effect a positive influence on properties of components. Because of their specific seam formation, that means insertion of threads under the according angles, both introduced stitching processes can be applied for this purpose.

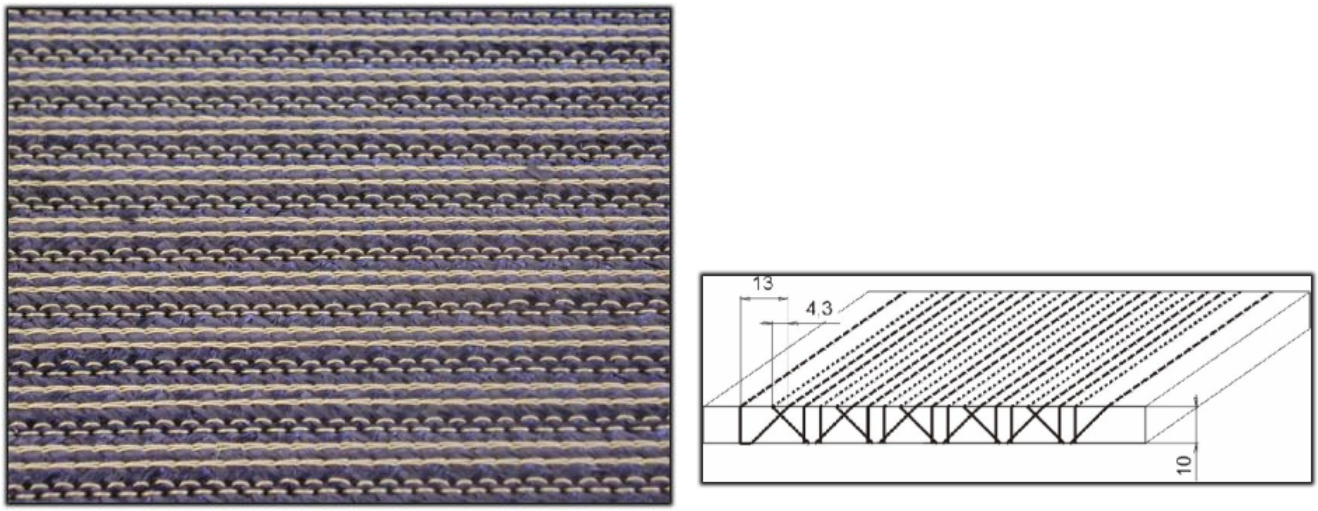

Figure 11 and 12- By chain stitch reinforced structure

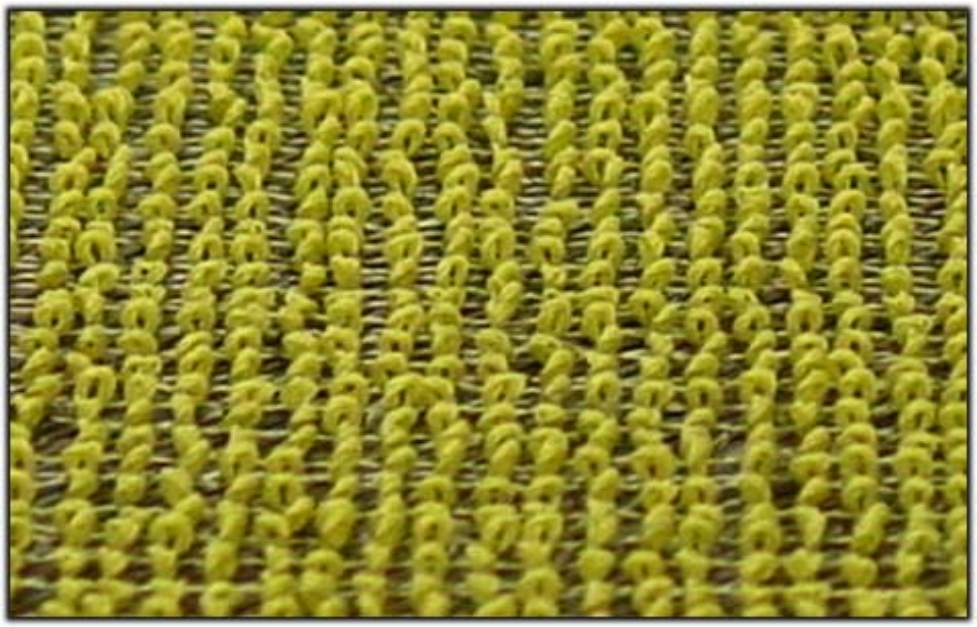

Figure 13 – By Tufting reinforced structure

Summary

Stitching of dry performs has a high potential for the manufacturing of fiber composite parts. The joining as well as the reinforcement of structures can be realised. Additionally, inserted threads can be used as structural elements for the improvement of component's properties. The three dimensional stitching technology as it is realised by the one-side stitching technique enables the processing of preforms nearly independently from dimension and geometry. The use of robots as handling system for the stitching tools allows the precision, repeat accuracy and automation which is required for high-performance components.