Non-crimped fabrics: Production, Tendency of Development and their potentials for aircraft structures

Felix Kruse, Andreas Schnabel, Thomas Gries

Institut fuer Textiltechnik der RWTH Aachen Univerity, Otto-Blumenthal-Straße 1, 52074 Aachen

A longheaded focus of research at the Institute for Textile Techniques of the RWTH Aachen (ITA) is the development of efficient automated production technologies for shell structures made of fibre composite materials.

In this process dry textile semi-finished products such as multiaxial layers, fabrics or braids are joined to a near-netshape textile structure by stitching or binders. These so called preforms are then impregnated in one shot. An example for the industrial application of this production technology is the pressure bulkhead of the Airbus A 380.

Fig. 1. The Airbus A380 rear pressure bulk head, made of carbon NCFs [Saertex]

Especially for shell structures multiaxial, non-crimped fabrics (NCFs) are gaining importance as the semi-finished product to start from. These NCFs contain up to seven layers which can be produced with orientations up to +/-20° to the direction of production. 0°-layers can be supplied additionally, but only as the last layer on the topside of the NCFs. The single layers are fixed by knitting and therefore form an easy to handle, plain structure of any desired length.

By the use of NCF a highly lessened time is needed for the production of large components such as the wing-shells or sparwebs can be expected. Instead of a multitude of unidirectional prepreg-layers which need to be laid singulary and slowly by a tape laying machine, the layup now consists of only a few multiaxial NCFs with the desired layer-setup.

Beside of all advantages, the production of NCFs is actually restricted to a constant areal-weight and a constant width. Thus, in the last decade, a focus of the research at the ITA was to eliminate the disadvantages of NCFs in respect to the demands of aeronautical applications.

One first step was the integration of endless braided stiffners continuously during the production process, which was shown in
Fig. 2.

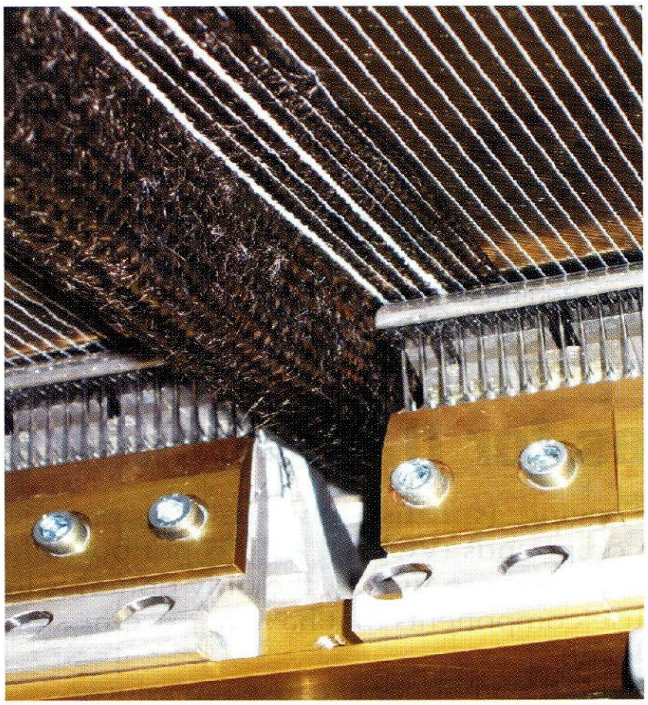

Fig. 2: Integrated production process of stringer stiffned NCF panels

Furthermore an aim of the current research program DFG Researchgroup 860 at the ITA, is to develop the technology in a way, that NCFs with several local or endless reinforcements can be produced continually.
This is done by an innovative supply modul, which cuts preproduced NCFs or UD-Layer to the desired length and feeds them on the basis layers on every position between the weft insertation systems.

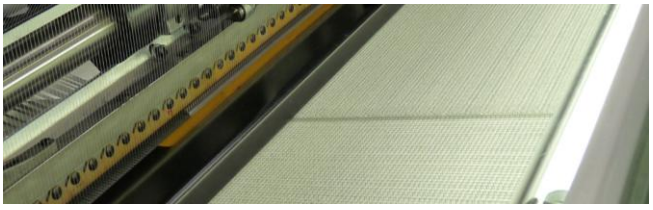

Fig. 3: Production of a 24 layer NCF with variation in thickness

On second focus of the currend research at the ITA is the warpknitting-unit. As a result to the undulation of the warp knitting-stitches, the ultimate (compression-) strenght in the plain of the laminate usually lower than those of Positive effect on the compression strenght after impact.

Hence the goal was, to change the knitting-type, the stiching-length and the tension of the knitting yarn continuously while production in order to the local requirements of drapability and strength.

To fulfill this mission, a newly electro-mechanical driven an computer controlled guidebar was realized instead of the common mechanical cams-disks, note Fig. 4.

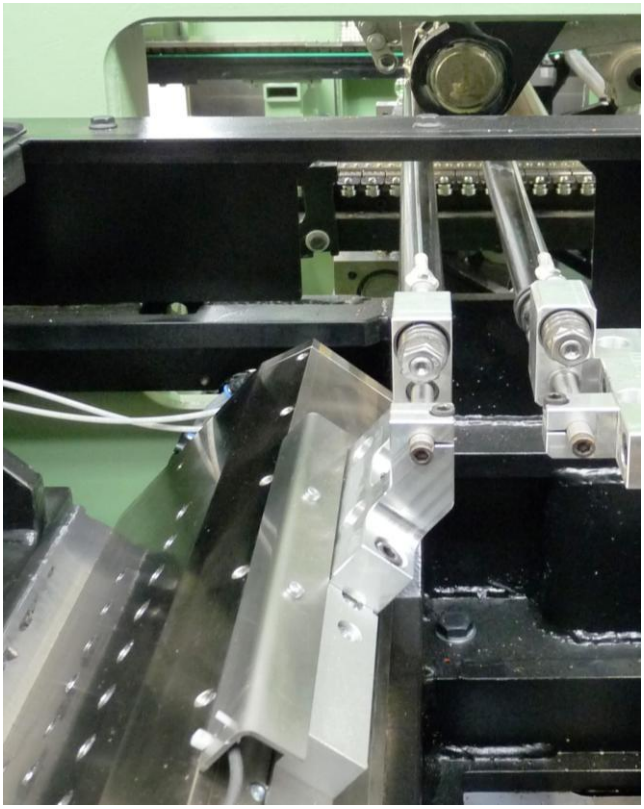

Fig. 4: linear actor and connecting rods of the electro mechanical driven guide bar at the ITA

This newly developed and integrated technology is currently proved and tested. Subsequent the effect of the local adapted stitch type on the drapability and the mechanical properties will be analyzed.

In order to eliminate the disadvantages of the undulations due to the warp knitting stitches, an actual tendency of the development of the machine technologie is to use binder systems to fix the several layers. The first puplication was an patent of the French companies S.N.E.C.M.A and Hexcel Fabrics, which was awarded on 20th Nov 2003 with the patent nr. EP 0972102 B1.

In the preamble of the patent it was stated, that in a common production of NCFs a certain amount of fiber-undulations is unavoidable due to the warping-loops. In follow of this fact, reduced mechanical properties are to be expected. One goal of the patent therefore is to avoid undulations and improve the mechanical properties by using alternative methods to fix the single layers of the NCFs. Another goal of this patent had a great influence on the development of production-technologies for NCFs.

The primary goal of the invention was a cost-reduced production-method for NCFs, especially of such, which are made from carbon fibers. Furthermore the production-cost can be lowered by using tows with a very high number of filaments, e.g. heavy tows. The inventors of the Hexcel-patent were among the firsts, who identified the huge potential of using spread heavy-tows, especially made of carbon fibers.

In the following, a wide number of methods to produce multiaxial NCFs out of heavy-tows by spreading them to very low areal weights are given in the patent.
Meanwhile the use of spreaded carbon tows up to 50k ore more is the state of the art technology while producing NCFs. The spreading technology is used as well to produce NCFs with a very low areal weight down to 80 grams per square meter.

References:

Kolkmann, A., Nickel, R. Gries, T.: Integrated manufacturing process for stringer stiffened panels. Technical textiles 04/2005 E201.

Kruse, F.; Schnabel, A.; Behling, T.; Gries, T.; Automated textile preforming of semi-finished fabrics for the mass production of fibre-reinforced plastic components; In: Lahlou, M.; Koncar, V. (Ed.): 2nd International Scientific Conference "Intelligent Textiles and Mass Customisation" ITMC'2009, November 12 - 14, 2009, Casablanca, Morocco. - Casablanca ; Roubaix : ESITH ; ENSAIT, 2009, S. 25-26

Acknowledgement:

We would like to thank the Deutsche Forschungsgemeinschaft (DFG) for supporting and funding the FOR860 working group of researchers (“The development of new process chains for fibre-reinforced plastic components and the integration of preforming, forming and crosslinking processes”).