LEEToRB
Lightweight, Energy-Efficient Tooling for the Manufacturing of Rotor Blades

State of the art – Background
The beneficial combination of low weight and favourable mechanical properties makes carbon and glass fibre composite plastics (CFRP and GFRP) the material of choice for a multiplicity of components in aerospace. In case of rotor blades for helicopters, it accounts for the required stiffness and low inertia of the blades due to its low mass. However, the manufacturing of such high-performance blades is to a large extend still manually performed, rendering the production process very cost-intensive. Presently, the rotor blades are built by hand lay-up of prepreg (preimpregnated) material with subsequent consolidation in heated presses. This procedure is considered to be one of the main cost drivers in blade production. In addition, prepreg material itself and its storage are expensive. Recent advances in a process technology called resin transfer moulding (RTM) successively permit the use of an automated process in blade production. RTM processes allow faster process cycles and thus increasing the output rate. In case of the blade manufacturing, resin transfer moulding allows a cost reduction of up to 40 % in contrast to the conventional prepreg technique. Regarding the mould construction mainly metallic materials, commonly steel and aluminum are used. The properties of steel allow the required tolerances of the cavities and the longevity of the moulds. However the different material properties of tooling and part lead to deformation of the part which up to now can be accounted for in a trial and error tool rework, which goes hand in hand with high financial expenses.

Objectives
In the present project, a new approach of the RTM process is developed by using the light weight material CFRP as tooling material. Because of its light weight and high stiffness as well as a low thermal mass which has to be heated in the process, using these tools leads to a high reduction in deployed energy. The main topics addressed in this proposal are:

- Weight reduction by 50 % of the RTM tools (in comparison to steel tools of the same rigidity)
- Reduction of energy input for processing of up to 50 %
- Reduction of scrap for tool production

- Increased manageability of the tools in serial production
- Feasibility of CFRP tools for RTM processing
- Further enhance the tool development process towards a “first right” approach
- Comparison of the developed tool to the state of the art life cycle assessment (LCA)

Description of work
By employing similar material properties in tool and part as well as the usage of curing simulation to predict the process induced deformations of the part, the present research project aims at producing rotor blades in the “first right” approach, without the expensive iterative tool remanufacturing currently used in the industry.

To further enhance the process and reduce the needed production energy, a new heating device is employed, which introduces the heat “where it is needed”. A carbon roving utilized as an electric conductor is stitched to glass fabric, which is then implemented in the tool layup. The carbon roving acts as a resistance heating, if attached to an energy source. Depending on the pattern of the roving the heat input can be adapted. To fully exploit its capabilities a new simulation strategy is implemented to achieve a customized heating strategy for said device.

With the extensive development and use of simulation regarding tool heating and process induced deformations throughout the entire project, a robust and reliable lay-out tool for mould design will be completed with this project. The supportive function for mould design will be beneficially utilized within the project and is hoped to be advantageous for future tool constructions beyond this project. The use of simulation is effectively reducing material and energy consumption for prototyping and increases confidence in new tool designs, especially when CFRP is to be used.

Expected results
The RTM tooling concept with innovative heating of LEEToRB for rotor blade production offers considerable advantages over conventional tooling made from metal or aluminum. The use of carbon fibre reinforced plastics as the base material of the tools allows the realization of much lighter tooling in combination with efficient heat-up and cooling.
Both aspects contribute to substantial savings regarding material and energy input, from tool manufacturing to the actual blade production. The new heating device will be integrated into the composite structure of the tool with a low distance to the cavity surface, accounting for the self-heating characteristic of the tools. The CFRP tool structure possesses a much lower thermal inertia compared to metal tools and therefore less energy in a shorter time is needed for heat-up. Furthermore, less energy is need for tool handling in serial production, since the total weight is a fraction with the same rigidity of comparable metal tools.
Project Summary

Acronym: LEEToRB

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Involved ITD: Green Rotorcraft

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