Analysis and Design of an Adhesive Joint in Wind Turbine Blades

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Creating a wind turbine blade which can be produced in sections and then assembled at the construction site is essential to further increase the length of blades and thereby also the power production. The dissertation shows that a very strong joint could be achieved, if designed properly, by using adhesives.

The demand for renewable energy is constantly increasing. To compete with other sources of energy the wind energy output has to increase. The power output from wind turbines are highly dependent on the length of rotor blades. Increasing the length of the rotor blades will increase the weight of the blades and introduce problems during transportation. Especially for land based wind turbine blades where the length of trucks are limited.

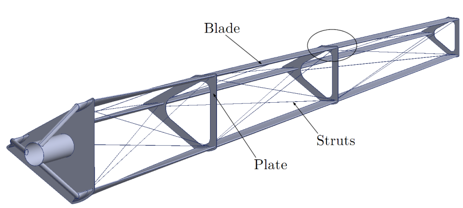

Figure 1: Triblade design with the connection in focus of this dissertation encircled.

These problems can be addressed by introducing a more lightweight material, such as carbon fibre, and by separating the blades in to smaller sections (modules). The company Winfoor has taken the lightweight approach even further. They have designed a truss structured 3-in-1 wind turbine blade called the Triblade seen in Figure 1. It is estimated that, through this design, the mass can be reduced by up to 80% and the cost can be reduced by up to 60%.

The connection between these modules, however, will be vulnerable and could very well be the weakest part of the blade. The connections therefore needs to be carefully designed in order to make them comparative with the remaining parts of the structure.

The carbon fibre manufacturer Marström proposed a design where the modules would be overlapping each other and bounded together using adhesives. The adhesive offers several advantages compared to mechanical fasteners. The solution is more lightweight and can distribute loads better since a larger area used to transmit forces between the bounded components.

The proposed design was investigated using the computer software Abaqus. Different geometric properties of the connection were considered to find a structurally efficient design which uniformly distributed the loads over the connection making it less vulnerable. It was found that the connected parts should have as similar geometric properties as possible, the overlapping section should be of sufficient length and a tapered design such that the thickness was reduced to zero in the overlapping section should be implemented. These solutions will make the structure very uniform and only small changes in cross-section geometry will occur over the connection.

The adhesive material was further investigated to determine which properties were of greatest importance when choosing the adhesive. It was concluded that the load capacity of the joint were highly dependent on two material parameters. The strength of the material but also its ability to deform under loading (ductility). It was shown that a higher load capacity was obtained when increasing etiher one of these parameters. It was also shown that a decrease in strength could be compensated by an increase in ductility and yield an even higher load capacity.

The conclusions drawn from this dissertation were made from the investigation of a very specific connection design. The results, however, can easily be transferred and applied on other adhesive joint designs and can therefore be very useful even if this specific joint design is not considered in the end.