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Auteur : Altemirov, Aimourza
Promoteur(s) : Bruyneel, Michael; 7312
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Modelling of the braiding process based on analytical and kinematic approaches

Aimourza Altemirov

Academic supervisor: Michael Bruyneel
Master in Aerospace Engineering
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Abstract

Composite materials are increasingly used in the aerospace, automotive, biomedical and many more industries as substitutes to their conventional metallic counterparts. One particular kind of composite materials are the braided composites that have become the subject of great interest in recent years. Interest in these materials is justified not only by their excellent mechanical properties and behaviour, but also by the cost and time effectiveness of the braiding process.

One aspect of the braiding process that is still generally lacking and needs improvement is the control of the machine, i.e. the correlation between the machine parameters and the geometry of the resulting braid. Experienced machine operators are able to manufacture desired, or acceptable, preforms but excessive trial and errors are usually needed, especially when complex shapes are required. As a result, the manufacturing process can be inefficient. To overcome this limitation, numerical models predicting the braid parameters, on which the mechanical properties of the material are directly dependent, are developed. In this work, two such models are implemented and used to analyse the braid structure for different mandrel shapes in the case of 2D biaxial braiding. Both are kinematic models which, although not as accurate, benefit from short calculation times compared to the more detailed finite element approach. Also, the models contain hypotheses such as the neglect of yarn interaction and yarn slip on the mandrel as well as the assumption of straight yarns in the convergence zone, which could lead to systematic errors.

The first model that is implemented was developed by Du *et al*. This model allows to predict the braid parameters, such as the braiding angle and the cover factor, for centered mandrels with circular cross-sections. The braid angle distribution is then analysed for cylindrical and conical mandrels, while the cover factor is briefly discussed for a conical mandrel. The correct implementation of the model is proved by comparing the results with those published by Du *et al*.

The second part consists in the partial implementation of the model developed by van Ravenhorst *et al*. This model is not limited to mandrels with circular cross-sections and is suitable for any complex shape mandrels. In this case, the braid angle distribution is analysed for cylindrical, conical and rectangular mandrels. Moreover, the braid geometry for a complex shape mandrel from real practice is studied and the numerical results are compared to the experimental results. Additionally, for this last mandrel, the local cover factor in certain key areas is determined and discussed.

Finally, a small part is dedicated to the braiding machine located at the research center Centexbel. First, the way this machine is operated is explained. The adaptation of the model by Du *et al*. to this machine is then performed through two practical examples.