Master thesis project proposal:
Simulation-driven development of stronger tennis rackets (HEAD)

Tennis rackets are constantly under development and are today mainly consisting of fibre reinforced polymeric materials (such as carbon fibre composites). The use of these lightweight materials has led to that rackets have increased in stiffness while reducing in weight. A recent study[1] reports that modern rackets weighs approximately 250–350 g and have a moment of inertia about an axis through the grip, the so-called swingweight, of approximately 0.026–0.038 kg/m^2.

Image from www.pngguru.com

However, the introduction of more advanced, anisotropic composite materials also poses challenges. One such challenge is to understand the more complex failure of modern composite rackets, and how rackets should be designed to mitigate loss of stiffness or even compete failure while subjected to external loads.

The current project aims to support the racket development at HEAD tennis, by developing a finite-element based modelling approach of tennis rackets that can be used to assess racket performance and to predict the risk of failure and ultimate strength of the racket. You will be working closely with the development team at HEAD tennis, who will provide geometry, loads, material information and design requirements.

To be more precise, the task of the project team will be to:

- In ANSYS ACP develop a FE-based simulation model of a three-point bending test of a tennis racket, starting from a base model to be provided by HEAD.
- Define a procedure for tennis racket strength evaluation based on a chosen set of failure criteria that are able to predict both individual failure modes and critical load limits.
- Define a test matrix to be used for characterising the necessary strength parameters for the failure criteria
- Develop new innovative laminate designs, so-called “ply books”, for a tennis racket with significantly improved strength (under three-point bending).

The project is a collaboration between Chalmers Sports & Technology, the Division of Material and Computational Mechanics and HEAD, a world-leading manufacturer of sports equipment for e.g. tennis and alpine skiing. The work will be conducted at Chalmers, in close collaboration with the responsible senior development engineer at HEAD (in Kennelbach, Austria) who will provide experience, material data and experimental data from impact tests.

We are now looking for interested students with documented knowledge in solid and composite mechanics, the finite element method and material mechanics. You need to be motivated and self-propelled and to be able to take own responsibility for the progress of the project. During the project, you will be offered advice and support from experienced researchers in at Chalmers as well as from a company that is very active in the alpine world cup.

Interested, please contact **Martin Fagerström**, martin.fagerstrom@chalmers.se (Chalmers supervisor and thesis examiner)

[1] Allen, T, Choppin S, & Knudson D (2016) *Sports Engineering*, pp. 1–11.

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