Research theme	Design Engineering
Research title	*Where to put which material – A multidisciplinary design approach*
Researcher	Tim Terpstra
Research period	From 1 September 2014 to 11 January 2016
Company	University of Twente, Engineering Technology – Design, Production and Management
Supervisor	Ir. M. Schreiber & Dr. Ir. W.W. Wits

Background

The aim of this research is to establish a more efficient and effective way of concept generation in multidisciplinary settings. The conventional (industrial) way of designing products is done by executing the different phases of a traditional design cycle *(fig. 1).* This cycle aims to progress linearly with iterative loops within the design phases in which concepts and design knowledge are organized monodisciplinary. This thesis proposes a new approach *(fig. 2)* that is tailored to the advancements in manufacturing technologies, such as additive manufacturing. The availability of more computational power and improved design software in combination with e.g. additive manufacturing techniques, force engineers to think differently. This increases the design freedom dramatically and hence demands engineers to consider a far larger design space. However, are engineers creative and supported enough to turn these advantages into improved product performance?

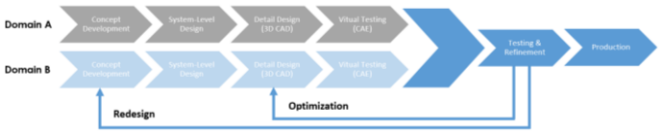


Fig. 1 Schematic representation of traditional design cycle.

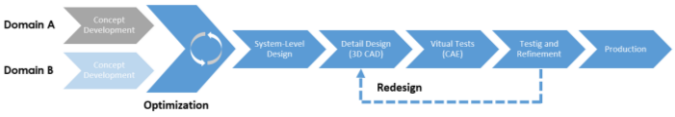
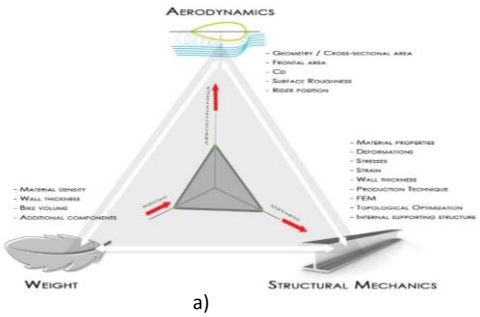


Fig. 2 New proposed design cycle

Assignment

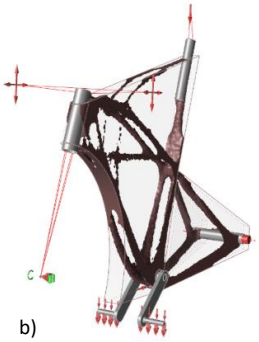
During the case study of ***improving the design of a bicycle frame with increased stiffness, while minimizing weight and drag*** the following main research question have to be solved:
Where to put which material in a multi-material, multi-disciplinary optimization problem?



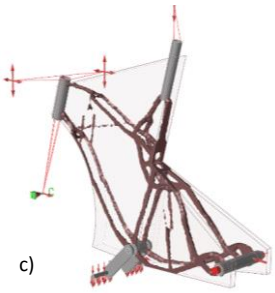
a)

Results

Finite element (Solidworks, ANSYS), topological optimization (SolidThinking Inspire) and computational fluid dynamics software (SolidWorks, ANSYS Fluent) is applied to generate the most optimal concept. However, the current available software offers limited options for multidisciplinary, multi-material optimization applications and generally still pointed on the conventional way of designing. Currently a gradual method, where there is interaction between the involved disciplines while iterating to an optimum, seems to be the most optimal design approach. Recent developments in multi-material additive manufacturing, multi-material topological optimization as well as functionally graded materials show promising features. Besides, new algorithms and efficient computational techniques such as parallel computing and cloud based optimisation software show possible benefits. However, most of these techniques are currently still in the development stage and only applicable for very simplified cases. If these techniques can be implemented in existing software or used in a combined way in the near future, the proposed new design approach seems to become more realistic. Therefore the development of a multidisciplinary syntheses tool, to provide insight in the interaction between the involved parameters and to support the engineer to come up with multidisciplinary concept design suggestions is recommended.



b)



c)

Fig. 3 (a) Schematic representation of the involved domains, (b) Topological optimization (*SolidThinking Inspire 2015)* for a bicycle frame optimising for stiffness and mass (c).

Personal experience

I really enjoyed the assignment due to the application of the new technologies like multi-materials combined with topological optimization and computational fluid dynamics to a practical subject like a bike. However, it was a challenge due to the high number of parameters involved by the multiple domains, which were often contradicting.