A CASE-BASED REASONING APPROACH FOR DESIGN OF TAILORED FORMING HYBRID MATERIAL COMPONENT

R. Siqueira[1], M. Bibani[1], R. Lachmayer[1] and I. Mozgova[1]

[1]*Intitute for Product Development, Leibniz University, Hannover, Germany*
e-mail: siqueira@ipeg.uni-hannover.de

1. Introduction

The development of new manufacturing technologies with new application possibilities requires components with properties more and more specific, being a challenge to design methodologies. One of these new technologies is Tailored Forming, which presents a process chain for the manufacture of hybrid components, aim of the Collaborative Research Project (CRC) 1153 established at the Leibniz University of Hannover [1]. This CRC has as main focus the study of the manufacturing process to join different metals, producing results that are mostly not optimal for the design point-of-view. Furthermore, the design stage has to consider all the strong manufacturing limitations involved at the same time that offers new optimized solutions. For that, an adaptive design process has to be developed, so that the manufacturing constraints are learned and new solutions are generated.

2. Method

The objective of the present study is to develop a systematic design method for Tailored Forming that can combine the manufacturing experience obtained with Computed Aided Engineering (CAE) approaches. The method here proposed is based on a Case-based Reasoning (CBR) [2]. However, two distinct features are implemented in the retrieve step: a parametric design and a geometry similarity analysis. In the first one, it is created a parametric analysis framework that generates a large simulated case-base. Here is where the best solution is searched based on user requirements. Since Tailored Forming is a technology still in research, the results collected in this first stage present also valuable information for the actual development course. The second part, the geometry similarity, is a comparison of this simulated case-base with a second case-base that consist on real results, manufactured and tested. The level of similarity performed in this step provides information about the manufacturability of the simulated geometries. Figure 1 presents the whole CBR cycle, showing the proposed model for the Retrieve phase.

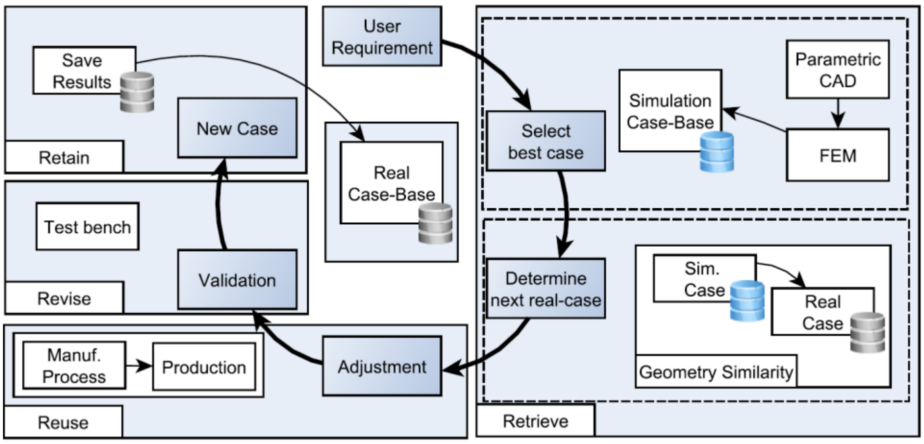

Figure 1. Diagram showing the proposed CBR.

To the end user, a mixed database is available, with simulated and real results. The best solutions are found according to user requirements in the simulated one, i.e. mechanical properties. Then, through the geometry similarity with the real cases, the results will be measured by the potential for manufacturing. So, by selecting a certain degree of manufacturability, the user will be able to find new improved solutions that are not so different from the current ones, but present improved performance. With all this collected information, the manufacturing process properties can be adjusted and validated, in order to generate new improved solutions that will be saved as a new case in the real case-base. The present study, however, focus on the method in the retrieve step, not getting into details with the manufacturing and validation side of the process.

3. Application Example

As application example of the method we take a hybrid shaft that is made of Steel and Aluminium, which is one of the demonstrators of the CRC 1153. The parametric generation system was implemented using the softwares Autodesk Inventor (2017) and Abaqus CAE (2014). Since the focus here is the performance of the connection zone, only this zone was parametrized. The CAD files with variated parameters were then submitted to a FE analysis, saving all the results in our simulated case-base. The parametric description is a critical step in the process, since it has to cover a large solution space and include the current real geometries.

Parallel, the cases already manufactured were saved in the real case-base, with all manufacturing parameters. With that, the CBR was ready to be started by the user, which may select specific or minimal properties as requirements. In Figure 2, we present the results for a case where the user requirement is the minimization of the maximal stress at the joining zone. Firstly, the geometry with the best solution was found. Next, we use Euclidian distance to find the most similar real geometry. All this information is then forward to the manufacturing side of the process, where the CBR cycle continues.

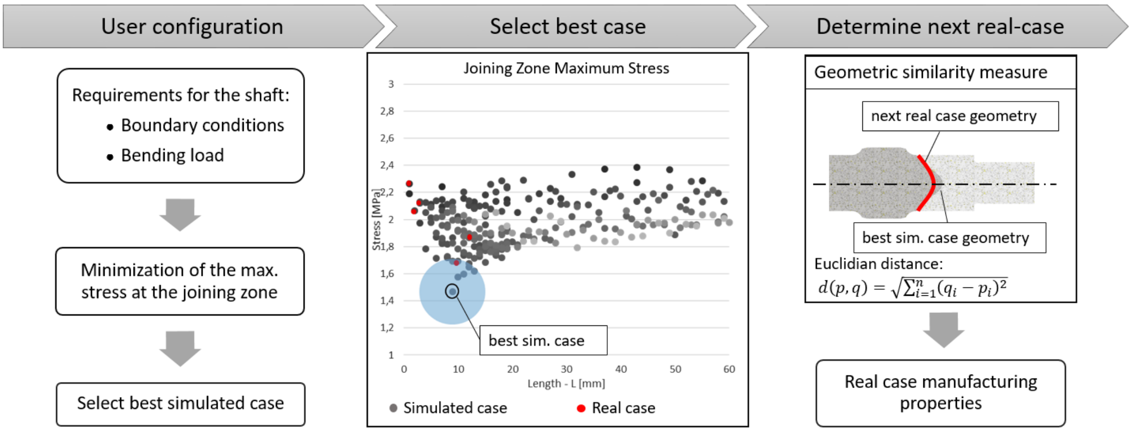

Figure 2: Implementation results until the retrieve phase for the hybrid shaft.

4. Conclusions

The method proposed in this study serve as tool not only for the current development of Tailored Forming, but also for industrial applications. The use of a simulated case-base has a positive impact on the initial research, since it measures the influence of each parameter on the design. The use of a real case-base in conjunction with the simulated one works as an efficient tool for the machine learning process. The proposed retrieve model is able to provide relevant knowledge for the next step of CBR, performed by the manufacturing side of the process. Thereby, the presented model can be here defined as a learning tool of the manufacturing restrictions, bringing new possibilities for the development of new technologies.

Acknowledgments The authors thank the German Research Foundation (DFG) and the CRC 1153 for its support.

References

[1] SFB 1153, Prozesskette zur Herstellung hybrider Hochleistungsbauteile durch Tailored Forming. [online] Leibniz Universität Hannover. Available at: https://www.sfb1153.uni-hannover.de/sfb1153.html (accessed 09.04.2018).
[2] Richter, Michael M., Weber, Rosina O., *Case-based reasoning*, Springer, 2016