Title:
A CAD-based Layout Environment for a Semi-automated Test-bench Assembly

Authors:
Christoph Gradwohl, christoph.gradwohl@tugraz.at, Graz University of Technology
Severin Stadler, severin.stadler@tugraz.at, Graz University of Technology
Mario Hirz, mario.hirz@tugraz.at, Graz University of Technology
Helmut Waser, helmut.waser@tugraz.at, Graz University of Technology

Keywords:
Knowledge-based design, automated assembly, functional integration, automated geometry creation, gear box test-bench layout optimization

DOI: 10.14733/cadconfP.2014.223-225

Introduction:
Besides extensive physical testing, virtual development methods represent an inevitable task in mechanical product creation. Automotive drivetrain components are typical examples for virtual and physical testing, when focusing a failure-free operation during their lifecycle. Exemplary, transfer cases or differential gears are checked in particular powertrain test-benches where they are loaded with predefined torque and rotational speed in order to simulate real-life driving conditions. Every time a new specimen has to be tested, a new test-bench layout has to be designed, which is performed within commercial 3D-CAD software beforehand. The required effort for the design primarily depends on the experience, know-how and background knowledge of the involved engineers, [3].

Engineers are responsible for building up virtual test-bench assemblies considering different functional and geometrical boundary conditions by using already existing, suitable and currently available test-bench components. Existing components that do not fulfill the specific requirements have to be created new. The creation of new test-bench parts is often a repetitive task, because frequently ordered elements, like shafts, are very similar. Typically the number of existing components within a CAD-based library is very large and supplied by product data management systems. In this way, it is a challenging and time consuming task for engineers to find and assemble correct parts efficiently. Furthermore, typical databases do not contain the required functional or geometrical metadata, [4]. This makes it nearly impossible to find proper components, especially if the components have been created by persons, who are not involved in the current project. An additional challenge is the management of availability of components. Particularly in case of multi-test-bench configurations, it is often not known, which components are already in use. In the end, the assembly of test-bench configurations within virtual environment includes the complete test-bench layout considering primarily already existing and available parts according to the functional requirements.

Main idea:
The main idea of the developed semi-automated test bench assembly method is to support the design engineer by providing smart applications, which use knowledge-based engineering methods of a commercial 3D-CAD environment, [2] [5]. These applications are able to support engineers to efficiently build up test-benches, considering above mentioned issues. The basic architecture of the method is shown in Fig. 1. It can be divided into three components, which are interlinked efficiently in order to guarantee a proper operation of the approach. The knowledge environment component contains all relevant meta-information to build up a powertrain test bench by use of the method. It consists of the product data management (PDM) system, where all necessary meta-information about already existing parts is stored, the supplier database, where functional and geometrical meta-

information about standard parts from suppliers (e.g. shafts) is stored and a layout database, which represents the actual build-up of the test bench within the 3D-CAD system, [1]. The semi-automated layout creation component supports and guides the user through the entire process of virtual test bench design by use of a graphical user interface (GUI). Within the GUI, various different implemented tools can be selected and applied by the operator. For example, there is a tool to build up basic functional layouts for standard powertrain test benches. It makes sense, that the pre-design of a functional layout takes place outside the 3D-CAD system at first. Crucial meta-information of functional parts is taken from the PDM system and automatically considered during the functional layout design process. During the process, engineers have the possibility to select from a pool of all suitable functional parts from the PDM system, which fulfill the requirements. After the pre-design of the functional layout is completed, the chosen functional components can be automatically inserted into the CAD system. Within the 3D-CAD system, parts can either be prepositioned or even coupled semi-automated by use of the method. Therefore, the respective tools recognize predefined reference elements within the selected parts. Parts, which transmit power in shape of torque and speed, like shafts or bearing blocks, are normally connected by different kind of flanges. In the proposed method, a flange is defined by a reference flange axis and by a reference flange plane. In the semi-automated positioning or coupling process, these reference elements are automatically recognized and aligned accordingly. By use of provided meta-information about the chosen flanges, a check for connectivity can also be performed automatically. When functional parts are inserted or coupled in the 3D-CAD environment, respective records are created in the layout database in order to represent the current test bench configuration. The database makes it possible on the one hand to easily analyze or adapt a test bench regarding its applied parts and on the other hand, to automatically perform feasibility checks regarding functional or geometrical boundary conditions. Finally, standard parts, which are often needed but are not yet available in required dimensions, can be designed semi-automated by the automated part creation component. In these cases, standard parts, like shafts, are easily and rapidly designed new from respective part templates. Necessary meta-information for a correct design is taken from the engineers as well as from the supplier database.

In case of unusual powertrain test bench configurations, the tool for semi-automated design of the functional layout may not be usable, but the method always enables an effective filtering and insert of selected components.

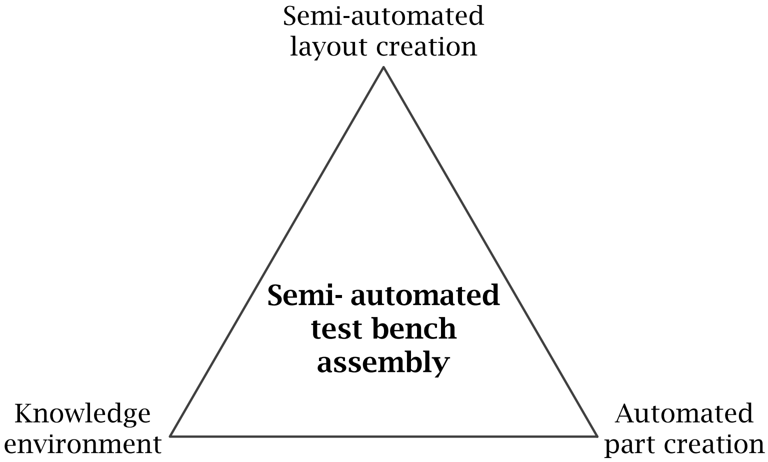

Fig. 1: Basic architecture of the semi-automated test bench assembly method.

Conclusion:

The conventional design of a test-bench for automotive powertrain systems is a rather time consuming and expensive task, which needs to be done by experienced and involved engineers. With the presented method, a collaborative solution for several powertrain test-benches has been introduced, which leads to a significant reduction of time and costs in the design process of industrial applications. The creation effort decreases significantly, because the semi-automated test bench assembly method considers all suitable, existing and currently available parts and allows a quick connection within the CAD-based assembly environment. Missing components, like shafts, are created automatically and are easily inserted in the required dimensions as well. Limitations for the semi-automated method are only given for very unusual types of powertrain test benches. Nevertheless, the user has always the possibility just to work in an advanced manual mode, where specific demanded components are selected and created in an effective way.

References:

[1] Catalogue Driveline Solutions UniCardan, http://www.gknservice.com, GKN Land Systems PowerTrain Systems & Services.

[2] Hirz, M.; Harrich, A.; Rossbacher, P.: Advanced computer aided design methods for integrated virtual product development processes, Computer-Aided Design and Applications, 8(6), 2011, 901–913. http://dx.doi.org/10.3722/cadaps.2011.901-913

[3] Naunheimer, H.; Bertsche, B.; Lechner, G.: Fahrzeuggetriebe - Grundlagen, Auswahl, Auslegung und Konstruktion, Springer, 2007.

[4] Rossbacher, P.; Hirz, M.; Dietrich, W.: 3D CAD parametric design strategies with interlinked CAE reference object creation for the overall vehicle layout optimization in the early automotive concept phase, Fisita World Congress, 2010, 1-10.

[5] Stadler, S.; Hirz, M.: An Application of Enhanced Knowledge-Based Design in Automotive Seat Development, Computer-Aided Design, 11(3), 2014, 335-345. http://dx.doi.org/10.1080/16864360.2014.863507

Proceedings of CAD'14, Hong Kong, June 23-26, 2014, 223-225