IBM

Behr – Automotive Engineering.

Optimized 3D solid design engineering methods in a continuous process chain

The development of a company-specific and product-specific design engineering method is an essential requirement for the implementation of an efficient CAD process chain. Numerous studies, for example those of the Fraunhofer Institute, have shown that customization of this kind can drastically reduce throughput times. One of the leading automobile industry suppliers in Europe, Behr GmbH & Co., a globally active corporate group with its headquarters in Stuttgart, together with IBM, has developed a tailored method for full body modeling on the CAD system CATIA in the field of automotive engineering and defined this method in ten rules.

Behr: from a car radiatior to thermal management

Technology leadership is a decisive cornerstone of corporate strategy at Behr. Pioneering developments in vehicle climate systems – for example, the creation of a CO_2 refrigerant circuit, an independent air conditioner or an electronically controlled cooling circuit – in engine cooling and in the electronically activated visco fan clutch, document the innovative capability of the Behr Group.

Over the course of time, Behr has developed to an increasing extent from a manufacturer of components to a system integrator. In this context, the closely networked interplay of the individual components is at the forefront, to increase performance and reduce costs.

With the integration of climatization and cooling technologies into an overall system-thermal management – Behr has implemented the holistic coordination of all heat and material flows in the vehicle household. The result of this development is that to an increasing extent Behr is adopting the role of a development and system partner with overall responsibility. To preserve and extend the technology leadership, Behr runs highly modern development facilities. A new climate wind tunnel is currently under construction in Stuttgart, enabling Behr to extend market leadership in this technology segment in Europe. At the end of the 1999 fiscal year, Behr GmbH & Co. employed a staff of 12,500 worldwide, generating sales revenues of DM 3.4 billion.

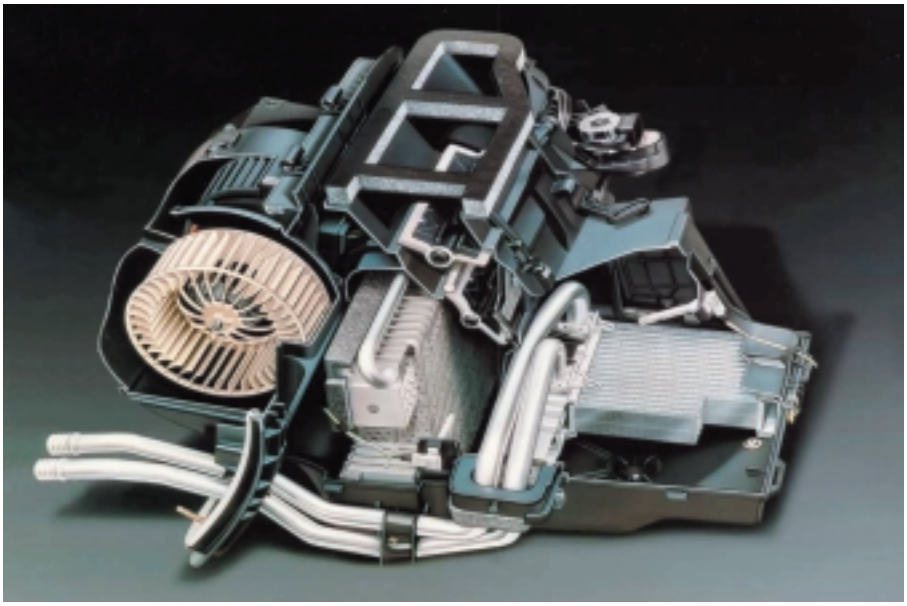
Positioning	• Corporate group worldwide in the field of vehicle and engine cooling • Preservation and extension of technology leadership • Use highly staff to develop and manufacture premium products • Process-oriented, group-wide provision of uniform IT development tools
Method	• Streamlined, deadline-oriented project management • Quality assurance by definition and optimization of process chains

BEHR

The innovative developments, but also the wishes on the part of the automobile industry to have continuous improvements in performance, reductions in volume along-side weight and cost optimization of the systems, made completely new demands on the product development process at Behr. The main focus of planning is the optimization of the entire development and engineering design processes, with the aim of reducing the innovation cycles and throughput times, even for highly complex assemblies. An efficient tool for this is 3D CAD design engineering, implemented at Behr using mainly CATIA – not least because of its widespread deployment in the automobile industry. This 3D CAD product, developed by Dassault SystËmes and sold worldwide by IBM, is used at Behr in Stuttgart in the automotive engineering divisions at around 150 workstations.

From area-oriented to solid design engineering

Initially, CATIA was used at Behr for area-oriented design engineering. For a wide variety of reasons – including optimization of simulation, simplification of the design engineering tasks, improved handling of the 3D data models, and increased efficiency of concurrent engineering options – the decision was made to switch to solid design engineering. Behr made a number of demands on the optimization of this design engineering method: first of all, a unified method concept was to be developed with the integration of new CATIA functions for the Behr-specific range of products. This method concept had to map out the entire process-oriented procedure. So as to enable implementation of this requirement as quickly as possible – and thus achieve rapid productivity on the basis of a process-oriented working method – workshops attended by all the relevant employees, including international employees, and important suppliers were run in cooperation with IBM, and these workshops continue to take place. Here, the objective of the design engineering method was precisely defined, namely: ease of change implementation, avoidance of redundant data, comprehensibility of design, low memory requirements, high visualization performance and adequate data quality.



Vehicle climatization at the highest level

"Our cooperation with IBM allowed us to implement the catalog of specifications for the creation of our method and to run the workshops very well. Our entire design engineering method has been given a completely new, application-specific and future-oriented basis,"

is the unanimous opinion of Jörg Göhler and Jörg Stenner, who are responsible for CAD technology support in the product area 'Climatization' at Behr. In order to create a method that was suited to requirements, Behr proceeded in two stages that were largely implemented in parallel: on the one hand, a unified method concept was drawn up on the basis of the Behr-specific range of products; on the other hand, the company's own models were processed to create workshop documents. The result was an individual training concept that was used to prepare the engineers for the new orientation of the design engineering method.

Solid design engineering in a closed process chain

With CATIA and solid design engineering, Behr has been able to implement a process chain that provides efficient support for the overall product development, from the initial idea to series maturity. The starting point of product development is the 3D geometry data of the space available for the assembly, provided by the customer together with a comprehensive catalog of specifications, including the specifications for connnection geometries and the performance profile. Based on this data, a model for the quotation is created in 3D, whereby Behr already applies the new solid design engineering method in these initial process stages.

… requires powerful 3D CAD systems such as CATIA.

"Before you start with the solid design engineering, you have to think about the base figures it makes sense to use and define the design engineering levels for the contours,"

advises CAD expert Jörg Stenner. This is required for the simple reason, among others, that the complex housing parts, whose modeling is very involved and complicated, also have a wide range of groove and spring connections with clips. Although housings are split, models reach sizes of 20 to 50 MB, which makes special demands on the individual design engieering stages as regards data handling. By splitting the housing components and applying the solid method, it has become possible to implement a closed process chain for the CFD and FEM calculations – which would not have been possible in area-oriented design engineering. The great degree of associativity that CATIA provides in solid design engineering has enabled significant optimizations of this method: for example, if the design engineer makes changes to the outer section of a housing, these are adapted to the inner section on a largely associative basis.

Based on this, the draft model is built. The geometry data of the draft model are used to generate the tool model – largely in parallel. Behr has cooperated with the CATIA experts at IBM to set up guidelines for the entire design engineering process; these are summarized in ten rules.

This document and the complete set of workshop documents have been published in the Intranet at Behr, both in German and in English, so that every design engineer has continuous access to information, content and background of the new design engineering method. Meanwhile all the related practice models are stored on the BEHR EDM system.

BEHR – Thermal Management in the Overall Vehicle

This enables every CATIA user to refresh their knowledge interactively at any time.

An essential element of the new design engineering method is the CSG (Constructive Solid Geometry) tree, that maps the Boolean operations. This achieves model structuring in which all design engineering stages are mapped, creating the requirements for optimum change management. The outer and inner figures are kept in separate branches of the solid tree and the add-on parts are only added when they have been unified. In this way, the design engineers create a CSG tree that is geared to the process and clearly structured. A contribution is made to the clear layout of the model structure by the specification that no DETAIL techniques are to be used for individual geometries.

"To simplify the tree SOLID/CREATE/ FEATURE/BRANCH makes more sense, as this generates a significantly smaller amount of data,"
says Mr. Göhler from CAD support.

The DRAFTS are applied to the base feature in the solid tree as early as possible, and designed before the FILLETS. That means that the FILLET operations in the CSG tree take place directly after the DRAFTS. This has the advantage of very much simpler and clearer filleting. In the design engineering process, the contours are spread across the smallest number of levels possible, as profile referencings are easier to handle in one level, and simultaneous profile changes can be made more efficiently. Moreover, the contours of the base figure are generated with sharp edges to ensure more flexible changeablity using the sketcher or parametrization. It is also specified that the drawing derivation for assemblies should be in a separate CATIA model. Firstly, this allows you to achieve smaller model sizes and secondly it enables temporally parallel 3D design and 2D drawing.

Factors for success of optimized solid design engineering
With solid design engineering, Behr has been able to implement a consistent, optimized development model that is ideally adapted to the process chain and the requirements of FEM and flow calculations. Important advantages here include greatly simplified and accelerated options for changes and optimization, and improved comprehensibility of overall CAD design engineering. The lowest possible memory requirement and best possible performance in visualization are other factors for the success of solid design engineering.

"By taking account of the shaping technique and tool parameters at an early stage in design engineering, it was possible to achieve significant reduction in throughput times, which gave us, among other things, the possibility, compared with before, to produce more variants within the same time,"

Ingo Putz, team head design engineering.

With the development of CATIA, new functions are to be integrated in the design engineering method in future. Here, however, it will not be that the design engineering is implemented – CATIA V5 is possible – prior to training, but there is a long-term plan to use the possibility of productive use of V5 for joint development with IBM of a customized method for Behr – i.e. employee training and the implementation of V5 in parallel. With a procedure of this kind, Behr creates the requirements for using a company-specific and product-specific customization of the design engineering method and integration of new CATIA functions to implement a continuous improvement of processes, and thus achieve even greater optimization of throughput times.

The 10 Rules of SOLID Design Engineering

Rule 1 "Structuring of the CSG tree that makes sense"
Outer and inner bodies in separate branches of the solid tree, add-on parts only after their unification!

Rule 2 "Only one detail level"
Each geometry model contains a maximum of one DETAIL level – no nesting!

Rule 3 "Contour levels"
The contours must be spread across as few levels as possible

Rule 4 "Sharp-edged contours"
The contours of the base figures are to be created with sharp edges. Exceptions are interdependent radii that are to be included in different contours.

Rule 5 "Prisms are better than cuboids"
Prismatic base figures are to be used in preference to cuboids.

Rule 6 "Drafts in the solid tree"
DRAFTS are applied as early as possible in the solid tree (CSG tree) directly onto the base feature, and designed before FILLETS.

Rule 7 "Fillets in the solid tree"
FILLET operations follow in the CSG tree directly after the DRAFTS.

Rule 8 "Avoid splits!"
Instead of several split operations, intersect solids are to be used or project solids drawn off. To be avoided absolutely are splits with planes!

Rule 9 "Sewing in the CSG tree"
SEWING elements are to be integrated in the CSG tree at as late a stage as possible.

Rule 10 "Drawing derivation and other definitions in a separate model"
The drawing derivation for assemblies should be in a separate CATIA model.

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