# Facilities of optimization of car parts in CAD system Pro/ENGINEER

**L. Ševčík**

*Faculty of Mechanical Engineering, Technical University in Liberec, Liberec, Czech Republic*

**ABSTRACT**: New methods covered in this contribution describe the behavior of modeling algorithms that can be added to the parts and their assembly in the input data dependents. These input conditions could be of various types – dimensions, forces, moments, temperature and friction. The method includes the setting of requirements, combination of requirements, test of feasibility and test of sensibility. For consideration of user defined conditions of geometric and mass optimization can be made. Behavior modeling is a new programming product, which can stay as a part of CAD systems.

**Keywords**: CAD system; behavior modeling; computer models; machine parts; optimization

A model of each element can be supplied with an algorithm, which describes its behavior in accordance with input conditions. Input conditions can be of various types – dimensions, forces, moments, temperature and friction. It involves ability of setting design requirements or of a combination of requirements and the display changes of the effect on the final product, which can be element or a group of elements. Following the user defined requirements on geometric parameters and mass parameters their optimization can be performed. Furthermore a feasibility test of design or tracking influence of specific parameter on the entire model can be made. Modeling conditioned by behavior and functionality is new program package, which becomes a part of CAD systems. Modeling conditioned by behavior and functionality is included in Pro/ENGINEER system, in which it was partially included from version 20 and implemented completely in version 2000i. Similar functionality can be found in AutoDESK Inventor 4 with MechSoft.com plug-in or in CAD program UNIGRAPHICS or Solid works with MechSoft-PROFI plug-in. Modeling is advantageous not only for studies, whose solution will require repeated searching and testing of changes in geometry of model – it means studies leading to maximization or minimization of mass, volume and length parameters, but also for designs, where we search for exact, specific parametric value (Vondřich, Jirků 2000). Another usage examples are geometric analysis of surface and spline torsion, group collision control and control of kinematics bindings. In connection with relations and parameters it is possible to use these methods in some detail for implementation of analytic dependence into model analysis. Using user defined analysis it is possible to create elements driven by specific parameter, which can be used repeatedly on other models. Modeling conditioned by behav-

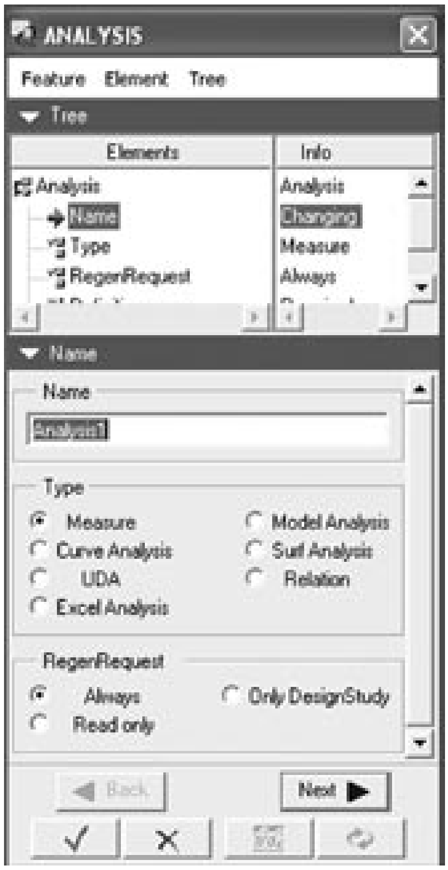


Fig. 1. Screen dump of Analysis element

ior and functionality of mechanical units means in final consequence for example to describe the gear unit, starting with gearing and ending with bearings. Once designed modifications can be made by redefining of input parameters. Also by performance, rotations or working load. The keystone of modeling conditioned by behavior is analysis element feature. Screen dump of Analysis element can be seen on Fig. 1. It is an element of type date. Analysis element is composed of one or more parameters or auxiliary elements, which are linked to model analysis. This analysis can be a measurement, model analysis, torsion analysis, surface analysis a relation setting, user defined analysis (UDA). Analysis elements (analysis and dependent parameters) are from that moment dependent elements and will be automatically updated to changes in design.

Analysis element enables to implement designed aims directly to the model in system Pro/ENGINEER. This makes possible to count changes of the effect of design in previously designed models (study of sensibility) and is a base for retrieval of appropriate values for the design change, with the aimed at reaching optimal characteristics (feasibility and optimization). It is possible to use these methods in many areas of design and machine computation. In most cases only one criterion is used in computation. For example: minimal surface of plastic reservoir in dependence on liquid of glass washer for the given liquid volume and change of dimensions. As more difficult case, an example of more criteria will be solved. Complex spatial tasks had currently to be solved in automobile industry. Experimental solution is very time wasting and does not necessarily lead to optimal variant of results. Following what Fig. 2 shows, the task was to find optimal tube positioning in engine area of suction and exhaustion or tubes in heat exchanger. Positions of input and output tubes are given generally in space, shown on Fig. 2. Next given value is type of controlling curves (tube center lines) – general spline vertical in starting points on input walls.

Goal is to optimize the tube shapes to answer these requirements:
- Minimization of tube length.
- Minimization of distance given by tube spacing.
- Minimization of radius of inflexion – as straight as possible.

These requirements are contradictory and have more than one solution. It is necessary to create five analyse, as follow:
- horizontal tube DH analysis, given by length of spline type curve, connecting facing surfaces,
- vertical tube DV analysis, given by length of spline type curve, connecting the other two facing surfaces,
- length analysis of two points laying on curves, given by Cartesian coordinates,
- minimal radius of inflexion on horizontal curve MINR_H analysis,
- minimal radius of inflexion on vertical curve MINR_V analysis.

Considering the repeated computation with different dimensions, it is necessary to render entire model again. To reduce computing time, it is necessary to make the model as simple as possible.

A table of multi object design study is created, in our case titled "VARIANTY_POLOHY" (POSITION_VARIANTS). The range of model change is to be set in this table. Change range is set on parametrical elevations, point positions are set on the centers of tubes. Next step is to set, which values have to be counted and which to write to the table for next variant selection. Finally a count of computed variants is set for the most precise view of solution. The more variants you have, the more precise results you get, but they take more time to compute. In our cases 200 different ranges of combination were set. This results in stack of variants. Result values are displayed either in text way or in graphs.

With respect to feasibility of inflexions and denying of tube touch it is necessary to define limitations of stack variants. It means, that only appropriate solutions, according to the upper mentioned requirements, from stack are selected, see Fig. 3 row labeled C HODNOTY CILE (aim values). This reduces the results selection to 33.

Next selection reduction of displayed results is to search for tube axis local minimums. The possibilities of results variant retrieval is lowered to 4,

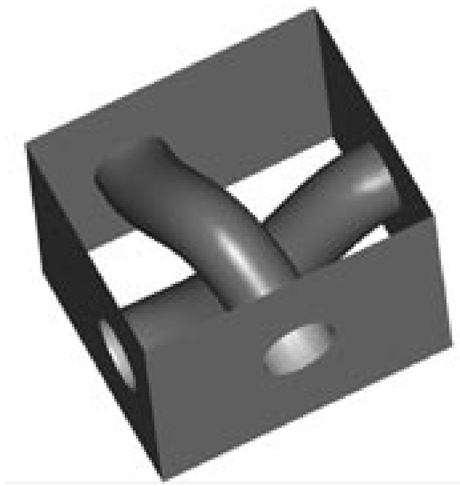

Fig. 2. Optimization of geometry of tubes in heat exchanger

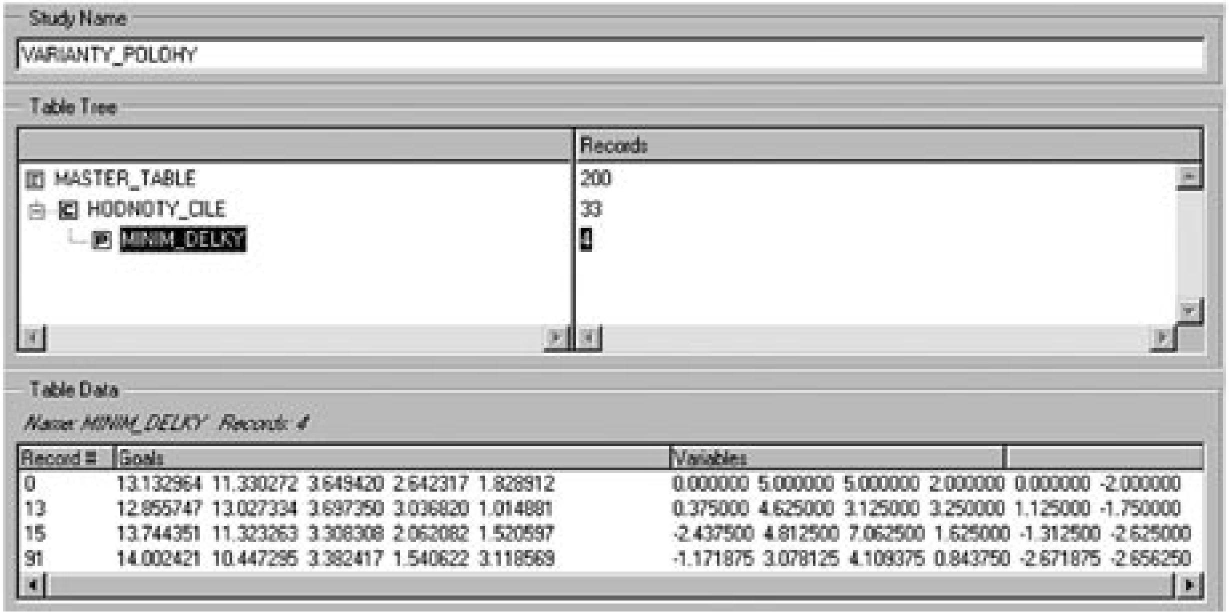


Fig. 3. Results of optimization

following raw labeled P_MINIM_DELKY (minimum of length).

In the lower part of Fig. 3 is a print-out of tracked values from analysis and coordinates of point positions laying on tube axes. According to given requirements four variants are displayed. It is a task of designer to choose the optimal one.

## RESULTS AND DISCUSSION

Using the method speeds up rapidly the design process of mechanical parts and is used mainly in automobile industry.

### References

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## Možnosti optimalizace dílů automobilů v CAD systému Pro/ENGINEER

**ABSTRAKT**: Model každé součásti může být doplněn algoritmem popisujícím jeho chování v závislosti na vstupních podmínkách. Tyto vstupní podmínky mohou být libovolného charakteru – rozměry, síly, momenty, teplota, tření. Zahrnuje možnost stanovení požadavků, kombinace požadavků návrhu a zobrazení účinků změn na výsledný produkt v podobě dílu nebo sestavy. Na základě uživatelem definovaných požadavků na geometrické parametry a hmotové parametry lze provádět jejich optimalizaci, zkoušet proveditelnost návrhu či pouze sledovat vliv určitého parametru na chování celého modelu. Modelování podmíněné chováním a funkčností je nový programový balík, který se stává součástí CAD systémů.

**Klíčová slova**: CAD systém; modelování vlastností; počítačové modely; strojní součásti; optimalizace

*Corresponding author:*

Doc. Ing. Ladislav Ševčík, CSc., Technická univerzita v Liberci, Fakulta strojní, Hálkova 6, 461 17 Liberec, Česká republika
tel.: + 420 485 353 316, fax: + 420 485 353 313, e-mail: ladislav.sevcik@vslib.cz