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PRACTICAL ASPECTS OF INTEGRATION IN THE DEVELOPED MOLD DESIGN SYSTEM

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Abstract: This paper presents the aplication of a feature-based design features within simulation model development procedure. Based on a review of the feature technology and previous research work, paper focuses on the modeling of intricate relations among features of different design aspects. An example is provided to demonstrate our approach and to show its effectiveness in the integration of the modules. The authors propose a set of CAD-CAE features that are oriented to both the design and analysis processes in the developed an integrated CAD/CAE mold design system.
Keywords: mold design, numerical simulation, DB, CAD/CAE features

INTRODUCTION

Injection molding process is the most common molding process for plastic parts manufacturing. Plastic injection molding design includes plastic product design, mold design, and injection molding process design, all of which contribute to the quality of the molded product as well as production efficiency. The creation of feature geometry is dependent on the functionality of the CAx. If a CAD system supports feature-based modeling, as is the case, geometry will be referred to as 'CAD features'. However, these features are CAM-oriented too, but, in general, cannot be directly mapped into CAE-oriented features. These CAD features provide the geometry for the developed proposed CAD/CAE features. CAD/CAE system consists of four main modules [2, 4, 5, 6] such as CAD/I module for CAD modeling of the part, CAE/I module for numerical simulation of injection molding process, CAE/II module for mold design calculation and selection and CAD/II Module for mold modeling (core and cavity design and design all residual mold components).

The developed mold design system makes possible to perform: [2, 4]

- 3D modeling of the parts, analysis of part design and simulation model design,
- numerical simulation of injection molding and
- mold design with required calculations.

CAD/I Module

CAD/I module is used for generating CAD model of the plastic product and appropriate simulation model. The result of this module is solid model of plastic part with all necessary geometrical and precision specifications. Proposed precision specifications are: project name, number, feature ID, feature name, position of base point, code number of simulation annealing, trade material name, material grade, machine specification (name, clamping force, and maximal pressure). If geometrical and precision specification is specified (given) with product model, the same are used as input to the next module, while this module is used only to generate the simulation model.

CAE/I Module

Module CAE/I is used for numerical simulation of injection molding process. User implements an iterative simulation process for determining the moldability parameters of injection molding and simulation model specification.

INTEGRATION OF CAD/CAE

The authors propose a set of CAD/CAE features that are oriented to both the design and analysis processes. These include a part feature and a collection of wall, hole, rib, or slot features. These features can be decomposed into a number of sub-features because designers may need to specify *different non-geometrical information over different parts of a feature. The part feature contains the overall information of a plastic part. At the top of the feature tree is the part feature then simulation model features. The second level of the tree contains collections of non-geometric features and development simulation model features. The third level contains UDF with CAE text information. UDF contains design and analysis related data, which are called feature attributes. All features have a reference base point attribute, which describes the relationship between them. All design parameters have to be collected and managed in to model tree. With such conceptual features being specified by suitable parameters and values, the degree of uncertainty in the design problem will be reduced progressively in iterations. Finally, a well-defined simulation model, together with its important and influential features as well as potential options and configurations, is established and transferred to the next step of design. Next, along the stages of evolvement of detailing parametrically in the feature-based design approach, conceptual features are gradually enriched; and detailed features in individual components are constructed. Among these features, a hierarchical system of feature parameter maps can then be worked out. Further, the engineering analysis programming effort, with the support of a spreadsheet or a DB, can be carried out. After the previous steps of analysis, the design output parameters are defined into Pro/Table, and parameters are explicitly associated to important product modeling aspects and their relevant implementation features. In such a feature-enabled design environment, the product's geometry modeling makes use of those parameters of features calculated in the previous module as the input. In addition, at the CAD modeling, geometric constraints are imposed because component features are often affiliated to other advanced features, like conceptual features and assembly features are associated to the product design. Eventually, the final product is developed with all the detailed model features in to CAE/II and CAD/II module. In addition to engineering design equations and solutions, models, and documents, the useful information chains defined as design output 3D model. Within the design process, a constraint-driven design method can be applied, and at the same time, design can make full use of the advantages of feature-based technology. The potential goal is to achieve the information synchronization by production rules at different design stages such as concept design, detail design, or redesign. Flowchart of the integrated CAD/CAE features between module CAD/I and CAE/I is shown in Figure 1.*

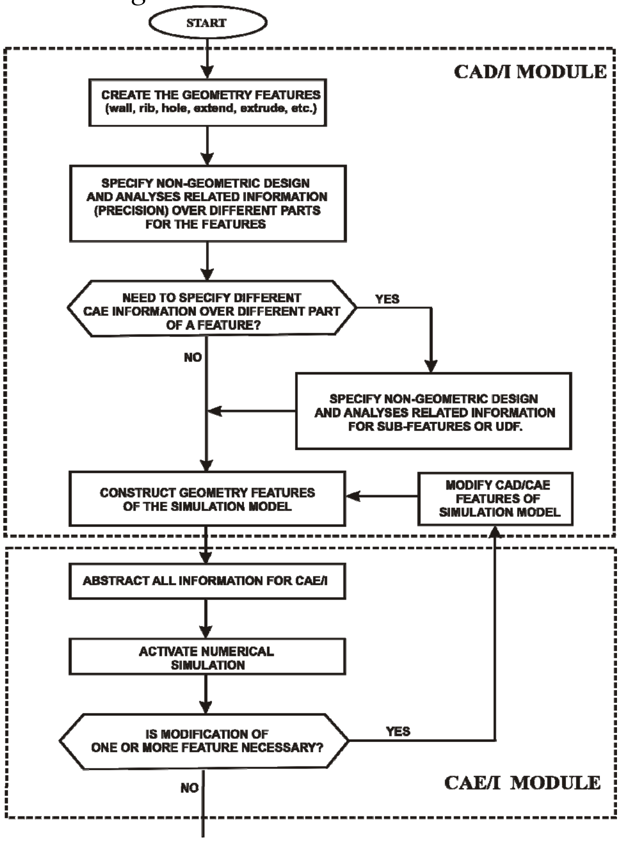

Figure 1. Flowchart of the integrated CAD/CAE features

CREATE CAD/CAE FEATURES

Assignment of CAD geometry to a CAD/CAE feature may involve selection of a complete CAD feature, combining several features, and/or decomposing a feature so part of it can be selected. After the geometry has been defined non-geometric as well as precision information can be added [2, 4, 5, 6]. Its geometry is assigned through the assignment of the constituent `optimal wall feature` in mechanical calculation (CAE/II module). Overall product information relating to design and analysis can be specified the simulation model and mold design approach. The abstraction process involves abstracting a geometric model as well as non-geometric analysis information, such *as material type, boundary conditions, several processing conditions and constraint information. With all of the information is available, the CAE/I system can be activated to conduct numerical simulation of injection molding process. The analysis results are then examined to check whether any of the pre-defined criteria – which are in the form of part feature constraints in the simulation model – are violated. If they are, then the CAD/CAE features need to be modified. After modification, a new model will be constructed and an analysis model abstracted, so that another CAE/I analysis can be activated. The process iterates until rules have been satisfied and simulation model is acceptable. The exact definition of thickness depends on the size and shape of the part. The following rules give satisfactory results:*

- *Consider the average of the length and width of a local region, and average wall thickness So < 1/4 of average of the length and width of a local region.*
- *Ensure the thickness is less than one quarter of this average.*

Off course for real parts, it is time-consuming to apply the above rule to each wall. However, it is often possible to look at the entire part or simulation model and decide whether or not it is suitable to be taken through the CAE/I module.

RESULTS OF CAE/I MODULE

Our research team used well known simulation model [2, 4, 5, 6], as concrete example to demonstrate the power of the first integration of the CAD/CAE integrated design system for mold design. The Gate Location analysis indicates a suitable location if the flow of material is balanced. Therefore, a blue region is shown in Figure 2. Dark blue indicates the best location to inject the material. The Confidence of Fill result is shown displays the probability of a region within the cavity filling with material. The Quality Prediction result measures the expected quality of the simulation model's appearance and its mechanical properties. The Fill Time result shows the flow path of the plastic through the simulation model. The Pressure Drop result displays the drop in pressure from the injection point to the selected point, at the moment that point was filled. The Injection Pressure result displays the pressure at the injection point at the moment each point was filled and the Flow Front Temperature result displays the material melt temperature at each point at the time it was filled. Sink mark estimate of the simulation model is also shown in Figure 2. The Confidence of Fill and the Quality Prediction results are good starting points when checking developed features. They will show designer where there may be problems. Table 1 presents some of expressions must be acceptable. An area of the Quality prediction result is green if all of these expressions are true.

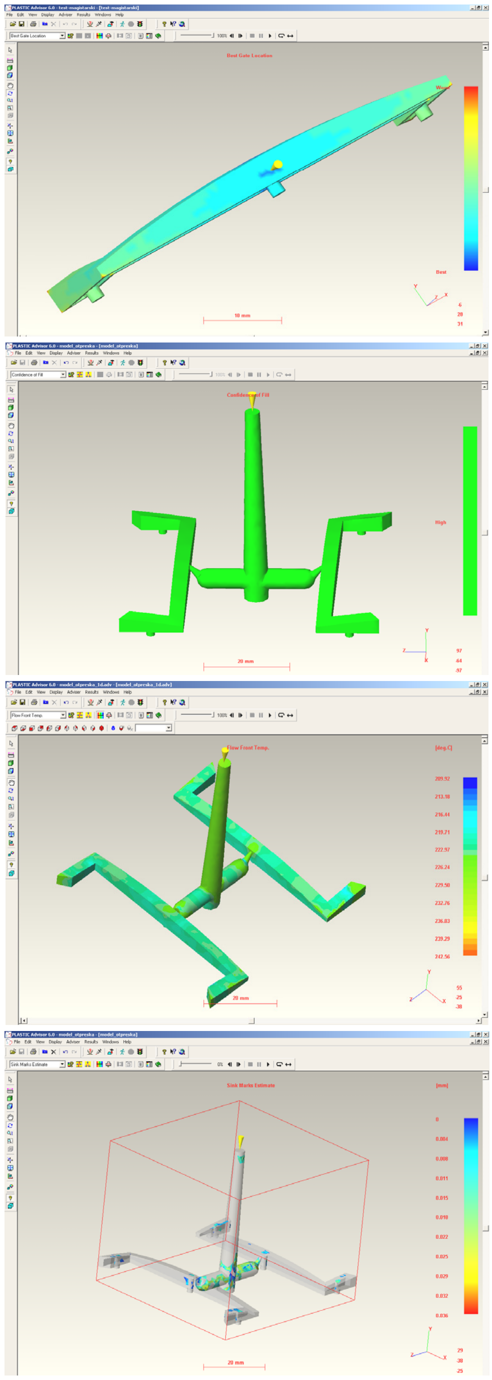

Figure 2. Few results of numerical simulation

Table 1. Expressions for green quality prediction

Description	Equation
The flow front temperature (T) is between the minimum (T_{min}) and maximum (T_{max}) recommended temperatures for the material in the DB.	$T_{min} < T < T_{max}$
The pressure drop (p_{drop}) is in the range between 0% and 80% of the maximum injection pressure (p_{max}).	$p_{drop} < 0.8\ p_{max}$
The cooling time (t) is less than 1.5 times the average cooling time for the part (t_{av})	$t < 1.5t_{av}$
The shear rate (τ) is less than the maximum recommended shear rate in the material record (τ_{max}).	$\tau < \tau_{max}$
The shear stress (σ) is less than the maximum recommended shear stress in the material record (σ_{max}).	$\sigma < \sigma_{max}$

The Quality is derived from combinations of the five results listed below. The five results are: Flow front temperature, Pressure drop, Cooling time, Shear rate and Shear stress. Only if all five results in an area are acceptable, the area is green.

CONCLUSION

Integration is achieved through a feature-based integration model and an iterative design-analysis process. The integration model consists of a number of CAD/CAE features and the relationships between them. The features capture both geometric and non-geometric information essential for CAE/I analysis and mold design in CAE/II module. By using existing software, development effort is reduced considerably and full advantage can be taken of the functionality of this software. A number of tools have been developed to assist in the integrated design-simulation process. With this model, designers can specify not only design information, but also CAE information. This is especially useful when a designer needs to specify mold design parameters intentions that are analysis-related, such as gate location constraints estimate in module CAE/I and for example „measuring wall distance" in module CAE/II. The case study also shows that the developed system supports iterative design-analysis process. The results of this research are limited to Creo Parametric and MPA. The future can be developing the integration model can be applied to other CAD and to other CAE/I software, if Serbian industry explicit need that. R&D of the integration process will continue in the future, especially interference engine using VBA and actual KBE techniques.

REFERENCES

[1.] Deng, Y.M., Lam, Y. C., Tor, S. B., Britton, G.A. (2002).: A CAD/CAE Integrated Injection Molding Design System, Engineering with Computers Vol. 18, pp. 80–92.

[2.] Hodolic, J., Matin, I., Hadzistevic, M., Vukelic, Dj. (2009). Development of Integrated CAD/CAE System of Mold Design for Plastic Injection Molding. Materiale Plastice. Vol. 46, No. 3, pp. 236-242.

[3.] Kennedy, P. (2008). Practical and Scientific Aspects of Injection Molding Simulation. University Press Facilities-Eindhoven, ISBN 978-90-386-1275-1.

[4.] Matin, I., Hadzistevic, M., Hodolic, J., Vukelic, Dj., Tadic, B. (2010) Development CAD/CAE system for mold design, Journal of Production Engineering, Vol.12, No 1, pp. 222-225.

[5.] Matin, I., Hadzistevic, M., Hodolic, J., Vukelic, Dj. (2011). An Interactive CAE/CAE System for Mold Design. Proceedings of 34th International Conference on Production Engineering, p.213-216.

[6.] Matin, I., Hadzistevic, M., Hodolic, J., Vukelic, Dj., Lukic, D. (2012). A CAD/CAE Integrated Injection Mold Design System for Plastic Products., International Journal of Advanced Manufacturing Technology Vol. 63, No. 5-8, pp. 595-607.

[7.] Nardin B, Kuzman K, Kampus Z (2002) Injection moulding simulation results as an input to the injection moulding process. International Journal of Material Processing Technology Vol. 130-131, pp. 310-314.

[8.] Zhou, H., Shi, S., Ma, B.: Virtual Injection Molding System Based on Numerical Simulation. International Journal of Advanced Manufacturing Technology, Vol.40, No.3-4, pp. 297-306, 2009.

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