DEVELOPMENT OF CAD/CAE SYSTEM FOR MOLD DESIGN

Abstract: Development of CAx for numerical simulation of injection molding and mold design has opened new possibilities for product analysis during the design process of plastic products. This development contributed to higher quality performance as well as to lower cost of product. The paper presents developed integrated CAD/CAE software for mold design. This program solution presents integrated system with unique applications for mold parameters computations, verifies injection molding parameters and for final mold CAD modeling.

Key words: plastic injection molding, mold design, CAD, CAE

1. INTRODUCTION

Injection molding is one of the most important commercial processes for the production of plastic articles. It is the most important process used to manufacture plastic products. More than one third of thermoplastic materials are processed by injection molding. The injection process has in fact one major disadvantage, namely the high cost of molds, which is why manufacturing products by this process is ideally suited to manufacture mass-produced parts of shapes that require precise dimensions. This disadvantage led to the development of the numerical simulation techniques that have great implications for the design of molds. During the last decade, there has been tremendous development in CAE, which offers flexibility to determine the effect of different geometric futures and different molding conditions on the mold ability and quality of the final part [1].

During the last decade, many authors developed systems of mold design for injection molding. Todic et al. [2] have been developed system for automated process planning for plastic injection molds manufacturing. System is based on integration of CAD/CAPP/CAM activities without CAE calculations of parameters for injection molding. Godec et al. [3] have been developed CAE system for mold and injection molding parameters calculations. System used MS Access, MS Excel for thermal, rheology and mechanical calculation and material base management. Kovljenić et al. [4] developed model of CAD/CAM/CAE system for mold design using Pro/E for injection molding. Ren Jong et al. [5] have been developed a collaborative integrated design system for mold design within the CAD browser, using Pro/E module Pro/Web Link as the core tool. Providing both concurrent engineering and collaborative design functions, the navigation system is capable of assisting designers in accomplishing 3D mold development efficiently and accurately with the help of the standard component library and design decision-making system. Low et al [6] have been developed application of standardization for initial design of plastic injection molds. Proposed a methodology of standardizing the
cavity layout design system for plastic injection mold such that only standard cavity layouts are used. When only standard layouts are used, their layout configurations can be easily stored in a database. Bor-Tsuen Lin at al. [7] describes a structural design system for 3D drawing mold based on functional features using a minimum set of initial information. In addition, it is also applicable to assign the functional features flexibly before accomplishing the design of a solid model for the main parts of a drawing mold. This design system is integrated with a Pro/E. CAD system including feature selector, calculator, model generator, design coordinator, and user interface. Kong et al. [8] developed a Windows-native 3D plastic injection mold design system based on Solid Works using Visual C++. Other knowledge-based systems, such as IMOLD, ESMOLD, IKMOULD, and IKBMOULD, were developed for injection mold design. IMOLD divides mold design into four major steps; parting surface design, core and cavity design, runner system design, and moldbase design. Software uses a knowledge-based CAD system to provide an interactive environment, assist designers in the rapid completion of mold design, and promotes the standardization of the mold design process.

2. MODEL OF INTEGRATED CAD/CAE SYSTEM

Generally, plastic injection molding design includes plastic part design, mold design, and injection molding process design, all of which contribute to the quality of the molded product as well as production efficiency [9].

The developed program system makes possible to perform: 3D modeling of the parts, analysis and of part design, numerical simulation of injection molding, and mold design with calculation [10].

By realization of proposed informational system, this problem could be solved. Architecture of integrated CAD/CAE system for automation mold design presents in Fig. 1. System consists of four foundation modules. There are:

- CAD/I module for solid modeling of the part,
• CAE/I module for numerical simulation of injection molding process,
• CAE/II module for calculation of parameters of injection molding and optimization of mold design and,
• CAD/II module for final mold modeling (Core and Cavity design and design all residual mold components).

2.2 Numerical simulation of injection molding process (CAE/I module)

CAE/I module utilized for numerical simulation of the injection molding. After creation of 3D CAD model of plastic product, numerical simulation of injection molding process can be performed in the module Pro/E, Pro/Plastic Advisor. This application supports also other different CAD formats such as IGES, STEP, DXF, STL etc. It means that this module makes possible to carry out a simulation that is not designed in Pro/E. After importing the CAD model, material choice from the database (which can be permanently completed), and definition of injection molding parameters, system automatically applies the suggested parameters for chosen material, but there is a possibility to make subsequent changes and alterations. Date-Base of plastic materials included 6000 plastic materials. CAE/I module offers four different types of mold flow analysis. Each analysis is aimed at solving specific problems:

- **Part Analysis** - This analysis is used to test a known gate location, material, and part geometry to verify that a part will have acceptable processing conditions.
- **Gate Optimization** - This analysis test multiple gate locations and compares the analysis outputs to determine the ideal gate location.
- **Part Optimization** - This analysis test multiple thicknesses of the same part in order to reduce part thickness thereby minimizing cycle time and part weight.
- **Sink Mark Analysis** - This analysis detects sink mark locations and depths to resolve cosmetic problems before the mould is built eliminating quality disputes that could arise between the molder and the customer.

The part molding process is heavily affected by factors of the part design. If the critical parameters of a part are not set correctly, the part will have quality issues during the molding process. The most critical of these parameters is as follows:

- Part thickness,
- Part flow length,
- Thickness transitions,
- Part material,
- Location of gates,
- Number of gates,
- Mold temperature, and
- Melt temperature.

2.3 Special calculation (CAE/II module)

CAE/II module has been developed to solve problem of mold thermal, rheology and mechanical calculations for injection molding and optimizing mold design. Outcome CAE/I parameters like as (injection pressure, mass properties, maximal melt temperature, mold temperature, injection time...) must be inserted in to inlet form of the CAE/II module as presented in Fig. 2. After that, software leads engineer in to thermal, rheology and mechanical calculation. One of the
several forms for thermal calculus is presented in Fig. 3.

Fig. 2. Inlet form of CAE/II module

Fig. 3. Form for thermal mold calculation

One of the several forms for optimal wall thickness calculus is presented in Fig. 4.

Fig. 4. Form for optimal wall thickness calculation

After all thermal, rheology and mechanical calculations, user prefer choice of mold plates from mold base. Form for selection D-M-E standard mold plates is presented in Fig. 5.

Application load dimensions from date base and generating solid model of the plate. Dimensions of mold component (for example clamping plate) are presented in Fig. 6.

Outcomes results of CAE/II module are optimal parameters of injection molding, geometrical and technology specification of the mold.

Fig. 5. Form for selection standard mold plates

Fig. 6. Form for generating solid model of clamping mold plate

2.4 Mold design (CAD/II module)

CAD/II module used for final CAD modeling of the mold (core and cavity design). This module used additional software tools for automation creating core and cavity from CAD model including shrinkage factor of plastics material and automation splitting mold volumes of the stationary and movable plates. Additional capability of CAD/II module is software tools for:

- Apply a shrinkage that corresponds to design plastic part, geometry, and molding conditions, which are, compute in CAE/I and CAE/II module for automation core and cavity design,
- Make conceptual CAD model for non-standard plates and mold components.
- Design core and cavity inserts, sand cores, sliders, lifters, and other components that define a shape of molded part,
- Populate a mold assembly with standard components such as mold base (D-M-E, HASCO, Futaba, Strack, DMS, EOC, MISUMI, Meusburger, Strack, Pedrotti), and CAD modeling
3. CONCLUSION

In this paper process design of plastic parts production, by means of Pro/E and special application for mold design are presented. As the production results show the analyses, which have been performed during the process design, prove to be correct, e.g., integrated CAD/CAM system proves to be a confident software tool. All described modules of CAD/CAM system are 3D solid-based, feature oriented, associative and modular. Plastics flow simulation product in CAE/I that allows engineers to determine optimal critical parameters. CAD/II module also enables engineers to capture their own unique design standards and best practices directly within the mold assemblies and components. Module for calculation of mold specification and parameters of injection molding (CAE/II) improves design efficiency, reduce mold design errors, and make need fully information of geometry and technology for complete mold design. Of course, that standard components library (CAD/II) ensures the consistency of mold development and reduces the time and manufacturing cost of standard components. A design decision-making system assists the project leader in making key decisions quickly to guide designers via module.

The future work of this research can focus on two issues. The first one is an intelligent core and mold base with knowledge-based management for automatic parting surface creation, and components assembling through feature-oriented approach and development new high-tech formulas for mold calculation in CAE/II module.

4. REFERENCES


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