Title:
A Feature-Based Engineering Methodology for Cyclic Modeling and Analysis Processes in Plastic Product Development

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Keywords:
Feature-based engineering, cyclic processes, CAD modeling, engineering analysis, specification model, injection molding

DOI: 10.14733/cadconfP.2014.193-195

Introduction:
Injection molding is a widely used automated net-shape manufacturing process for producing plastic parts having relatively complex geometries economically. However, designing plastic parts is a complex and tedious job involving many design-analysis-redesign cycles for counting considerations from other downstream product engineering aspects. It is important to check the designed part meets customer requirements, structural strength criteria, moldability, cost effectiveness etc [1]. Organizations have been using various computer-based tools to assist designers and analysts in performing different engineering tasks. Since the engineering aspects are inter-related and mutually constraining, information modeling and association in the cyclic processes are essential to maintain product information consistency by updating engineering models systematically [2]. A literature survey carried out in this regard reveals that although many researchers have done considerable works in product information sharing and integration [3,4], in-depth research is still required for product performance based cyclic process modeling among CAD design and engineering analyses, capturing engineering intents in the design process, and associating information across software applications. This research work is focused to developing a feature-based product engineering methodology in order to facilitate cyclic processes involved among engineering aspects during the development of an injection molding plastic product. The emphasis is on feature-based information modeling of the iterative process to evaluate product performance and manufacturability, and to generate updated cost estimation for changes of engineering models.

Main idea:
Since features have flexibility to capture non-geometric engineering information along with product geometric data [5], new feature types have been introduced to encapsulate attributes and behaviors of related engineering aspects such as structural analysis, molding simulation and cost estimation.

Fig. 1 outlines the framework of the proposed feature-based engineering methodology for cyclic modeling and analysis processes. The methodology starts with building product specification model based on specification feature that facilitates capturing design intentions such as customer requirements, technical specifications, engineering knowledge, performance criteria, and their relationships at the onset of new product development. Information about design process, structural analysis, molding process and cost estimation required for injection molding has been stored as data files, and new feature types and their attributes are connected with these data files for their parameter values.

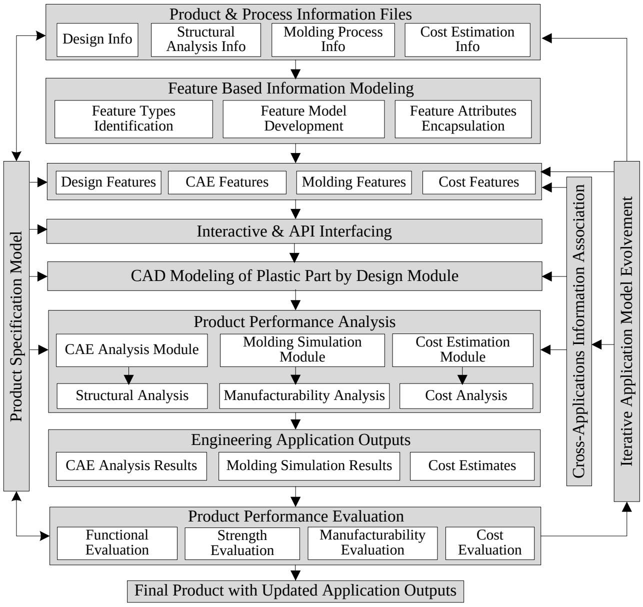

Fig. 1: Framework of feature-based engineering methodology for cyclic modeling and analysis processes.

Innovation Description

CAD model of the product serves as the master model and newly introduced features are connected with it using API functions. Product performance of the CAD model is then analyzed for its structural rigidity, manufacturability checks and updated cost estimation. Evaluation of the analysis results and verification against predefined criteria are managed by product performance evaluation process. Based on the evaluation feedback, CAD models or simulation models are modified iteratively through feature modifications. Existing feature attributes are modified or new features are created for the iterative design evolvement. Information sharing and dependency relations among CAD model and analysis models are modeled as cross-applications associative relations, and feature parameters are updated accordingly to generate updated product engineering models.

Product Performance Based Iterative Design Evolvement

A case study for design evolvement through feature modifications based on strength evaluation is shown in Fig. 2. The product is intended for carrying oil-drill pipes. It starts with building conceptual model by adding design features for satisfying designed functions derived from customer requirements captured in product specification model. The first figure is an intermediate CAD model and as checked by functional evaluation, it does not meet all the designed functions. As the design evolves, the second figure is the conceptual model that satisfies the functional requirements. The design model is then analyzed for its structural stability under static loading, vibration and drop-test scenarios.

The third figure shows that under the loading environment, its deformation and generated stress crosses the predefined criteria captured in specification model. The model is thus modified semi-automatically by introducing structural design feature known as ribs. As the design is modified progressively adding new ribs and evaluated by strength analysis, it reaches to the final model which satisfies all the functional and structural requirements.

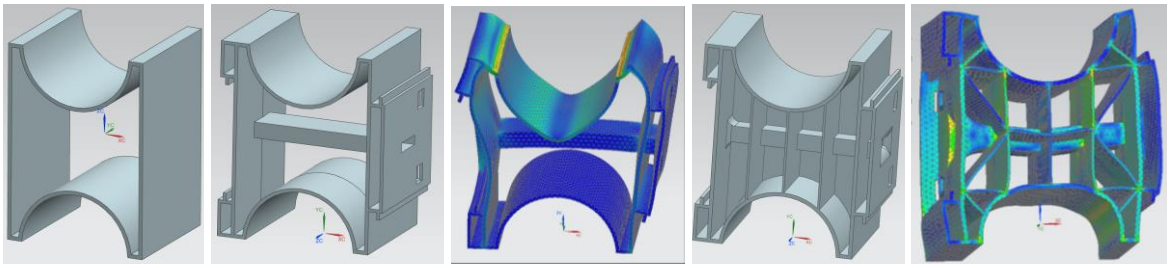

Fig. 2: Product performance based iterative design model evolvement through structural feature modification.

Conclusions:

This paper gives the overall framework for feature-based engineering methodology and a case study for iterative design model evolvement based on structural performance analysis. The modeling, implementation and tracking of the cyclic processes between CAD modeling and other engineering analysis aspects based on feature concepts ensures capturing design intentions earlier in the process, and guides the design modifications towards fulfilling preset criteria. Product specification model also acts as source of common information for all the engineering models and ensures information consistency.

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