WEB-BASED COLLABORATIVE ENGINEERING FOR INJECTION MOLD DEVELOPMENT

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Keywords: Collaborative engineering, Injection mold, Injection molding flow analysis, Molding trial.

Abstract: Injection molding is one of the most important manufacturing processes enabling present mass-production. The recent evolutions of technology related to injection molding result in the difficulties in developing the molds. As a result, a higher level of engineering technology should be considered for the developmental stage. This paper presents the web-based engineering collaboration among mold makers, experts, and product makers. Pre-examination and post-verification in the moldmaking process were investigated carefully and implemented in the web environment. Hundreds of engineering collaborations were conducted via developed systems. Surveyed results show that these collaborations help small and medium sized moldmaking enterprises reduce cost and delivery time, while they increase the quality of molds.

1 INTRODUCTION

Injection molding is one of the most important manufacturing processes enabling present mass-production. After a product is designed, molds are made by a moldmaker from metal, usually either steel or aluminium. Molten plastic is injected at high pressure into the molds, resulting in a solidified plastic that is generally the final part without further process.

Injection molding process has been developed considering the process itself, the injected materials, and the utilization of products. In the case of process, new and novel methods were introduced and applied in the field, such as gas-assisted injection, co-injection, etc. The evolution of materials extends the utilization of the plastic in the fields of optics, bio, nano/micro, etc. These evolutions of technology related to injection molding result in the difficulties in developing the molds. In addition, globalization has created a situation of increased international competition, so the higher quality products at low cost and with quick response times to market demand are the common goal of all manufacturers in the world.

In order to survive in the present competitive environment, enterprises that produce finished products are attempting various strategies including product standardization, securing of multiple part suppliers, parts modularization, expansion of parts outsourcing, and fostering of collaborative companies which have core technologies, etc. These strategies naturally yield the needs for collaboration between internal and external organizations, and many researchers have studied these topics in the view of strategy, methodology, and real implementation (Li, 2005 & Molina, 2005). In the case of injection mold making industry, a framework of collaborative design environment was proposed (Chung, 2002). Web-based collaboration system especially for SMEs (small and medium sized enterprises) was proposed in the name of 'e-Manufacturing' and the idea of 'engineering collaboration hub' was expressed. (Ryu, 2007)

This paper presents the web-based engineering collaboration among relevant parties when developing injection molds as the case study of 'e-Manufacturing'. Lots of stakeholders participate in each stage of injection mold development, from the part designer to the injection molding machine

Lee D., Song K., Lee S., Choi H. and Ryu K. (2009).
WEB-BASED COLLABORATIVE ENGINEERING FOR INJECTION MOLD DEVELOPMENT.
In *Proceedings of the 11th International Conference on Enterprise Information Systems - Software Agents and Internet Computing*, pages 159-162
DOI: 10.5220/0001990601590162

operator. Chapter 2 describes the necessity and importance of the collaborations in the present competitive environment and introduces the engineering collaboration for pre-examination and post-verification in the moldmaking process. Chapter 3 details the web-based visualization and conference function, which plays major roles in the web-based engineering collaboration.

2 COLLABORATIVE ENGINEERING

In order to survive in the present industrial environment, large enterprises producing finished products should focus on the more crucial stages in the development of a product, like prerequisite technology research, product planning, assembly design, and marketing, etc. Most of the general manufacturing stages, like mold fabrications and part manufacturing, are conducted by the collaborating enterprises. But, from the viewpoint of large enterprises, most collaborating enterprises are small-scale, with only low levels of manufacturing technology.

In the case of mold fabrication, especially in Korea, the mold makers are smaller-scale and are struggling to meet the requirements of their customers, which are generally large enterprises. Large enterprises want collaborating enterprises to invest in man-power and equipment, but small-scale enterprises cannot afford to possess such expensive equipments. Even worse, the most difficult problem is to locate and maintain experts who can operate the equipments. These kinds of equipments can be different according to the characteristic of the industry and the level of required technology, and in the case of mold fabrication, these equipments are CAE (Computer Aided Engineering) tools for injection molding flow analysis and the 3-dimensional inspection systems for measuring the manufactured products. In order to cope with this problem, we suggest the engineering collaboration model in which 3 parties playing important functions in developing molds, that is to say, mold makers, mold purchasers, and expert engineers, work together in the web environment. Three parties can share important information such as drafts and documents, and can also have conferences with faraway co-workers while seeing the same screen via the Internet. When the mold maker or the mold purchaser requests technical assistance, the expert engineers assist them according to their request. The pre-investigation shows us that the injection molding flow analysis and the 3-dimensional inspection are the most important, but these are difficult engineering techniques for small-scale enterprises making molds, therefore we made them our focus when designing and implementing the engineering collaboration system.

2.1 Process of Mold Development

The process of mold development begins with mold design and ends with molding trial through machining and assembly processes. In the stage of mold design, the recent immense development of rheology and computation enables us to estimate the flow of resin in the mold and the deformation of solidified resin before making the real mold. As such, the majority of mold purchasers order important and high value-added molds from the mold makers who can provide them with these CAE results – injection molding flow analysis. After designing the molds, mold makers complete the molds by machining the parts and assembling them. Molding trial is the last stage just before delivery. If the results of the molding trial do not meet the required specifications, the mold is moved to the factory where it is disassembled and repaired in the proper process according to the cause of defects. These molding trial and repairing processes are repeated until the mold passes all the required specifications. In the molding trial stage, 3D inspection is not only one of the most important criteria, but also the evidence that helps engineers to analogize the causes of defects and find counter-plans. The following 2 subsections present more detailed process and function of the developed collaboration system (Engineering Collaboration Hub).

2.2 Injection Molding Flow Analysis

Figure 1 demonstrates the process for collaborating with faraway co-workers in the stage of injection molding flow analysis (CAE Analysis). The related parties need not gather in the same location and time.

Large enterprises or those performing product design transfer design information to the collaborating moldmaker. If the enterprise requests the engineering collaboration hub to provide a CAE analysis based on this information, this request is transferred to the PM (Project Manager) at KITECH (Korea Institute of Industrial Technology) by e-mail and SMS (Short Message Service for mobile phone).

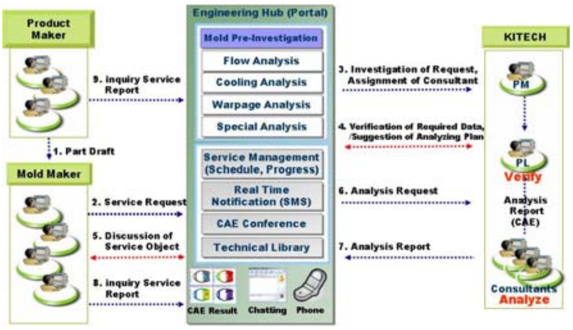

Figure 1: Process of CAE analysis in engineering hub.

The PM checks the requested project and assigns a consultant team. The PL (Project Leader) verifies the required data for CAE analysis and discusses the project considering all aspects from the due date to the objective. When the PL and requester agree to progress the project, a consultant begins to analyze the project. When the consultant completes the analysis, he or she makes a report and the report is verified by the PL before it is uploaded to engineering collaboration hub. Then, the product maker & mold maker can download the report. The most important aspect of this system is that the entire process is conducted via web environment and all the information is stored automatically to the DB system. When an important event takes place, such as analysis request, model change, or report uploading, the SMS automatically forwards it to the related person in order to obtain a proper and immediate response.

In the developed collaborative system, the injection molding flow analysis was categorized properly in order to meet the diverse requirement of each enterprise. At first, CAE analysis was divided into two categories, short delivery or normal delivery, on the basis of analyzing term. If an enterprise wants a fast CAE analysis result, the basic analysis is executed and it provides a brief report which contains the smallest pieces of information such as flow pattern of resin, injection pressure, clamping force, etc. Normal delivery CAE analysis is classified into 3 categories, 'flow' analysis for shrinkage estimation, 'cool' analysis for cycle time estimation, and 'warp' analysis for deformation estimation. Table 1 shows the classification of injection molding flow analysis available in the developed engineering hub.

Table 1: Classification of injection molding flow analysis.

Period	Class	Output
Short	Basic	flow pattern of resin, filling time, injection pressure, clamping force, location of weld line and air trap
Normal	Flow (Pack)	(+Basic) solidification time, shrinkage rate solidified resin
	Cool	(+Flow) temperature of cooling water, cycle time estimation
	Warp	(+Cool) deformation of part

2.3 Molding Trial Analysis

The molding trial process is located at the end of the mold making process and verifies the quality of manufactured injection molds just before delivery. Despite their important role in determining the quality of molds, due to low degree of interest, the molding trials are managed carelessly and as a result the similar defects, which can be eliminated easily if the cases of solutions to the mold quality problems through molding trial are managed carefully, are repeated.

The molding trial stage generates lots of technical information, because it involves mold, resin, injection molding machine, and the injection operator. The process of the molding trial consists of the following 4 stages: injection of a product with the proper molding conditions; inspection of defects; analysis on the defects; and derivation of the method to modify the mold to correct the defects. One of the most important outputs is the injected product itself. The injected plastics are generally the final goods, and in order to be assembled accurately, the shape accuracy must meet the desired specification. In addition to this basic functionality, as the aesthetic appearance of the final goods is becoming more important, the injected parts should meet the designer's requirements.

The result of 3D shape measurement is the beginning of the inspection of the injected parts. Like the aforementioned CAE analysis, molding trial analysis is started in accordance with the request of the mold maker or mold purchaser via the engineering collaboration hub. The analysis process is almost identical, but in the case of molding trial analysis, the expert engineer visits the field at the scheduled time and gathers the information related to the molding trial such as injection molding condition, mold and product temperature captured by thermal imaging camera, and field operator's opinion about the trial products. The expert engineer also brings the trial products and measures them with expensive equipment such as a 3D scanning device. He or she analyzes the gathering information and produces the report containing the cause of defects, counter-plan, and proposal of mold modification.

3 CAD/CAE/CAI VISUALIZATION AND WEB BASED CONFERENCE

Because analysis reports are printed materials in general, mold makers cannot understand the exact phenomena of resin injected into the molds. In addition, because all steps from requesting the analysis to receiving the results are conducted via the Internet, there might be a communication limitation between requesters and analyzers. In order to cope with these problems, CAD/CAE/CAI visualization and a web based conference system was implemented in the engineering hub.
The common data format which supports the CAD/CAE/CAI was designed and implemented. General CAD data such as UG, CATIA, and Pro/E can be translated to the developed common data format and visualized by an exclusive viewer which can be downloaded anywhere and anytime. The analysis model created through the CAE analysis tool and the result data are converted to the data for the visualization of the CAE. In addition, the results created from the product inspection equipment (3D measurement equipment) and analysis tool (Inspection S/W) are also analyzed and converted. That is, users can see the designed data, the result of injection molding flow analysis such as resin flow pattern, and the result of 3D inspection analysis using the converted data for visualization regardless of the CAD/CAE/CAI tools and equipment. This system also allows a conference to be held between expert engineers and mold designers or between product designers and mold designers, helping them to communicate clearly and to jointly review questionnaires. The modified and discussed items are stored in the database automatically during conferencing. Figure 2 is an example of the developed common viewer, which shows the result of the injection molding flow analysis.

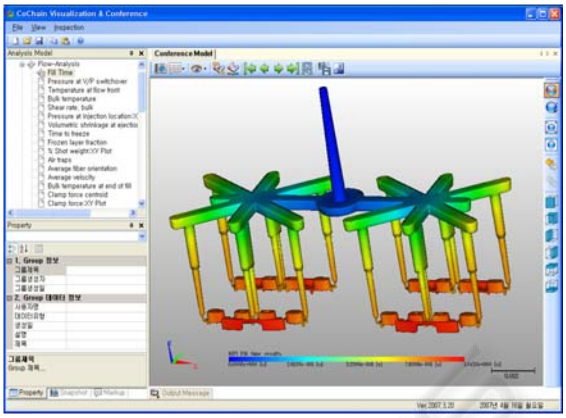

Figure 2: CAE Visualization.

4 CONCLUSIONS

The engineering collaboration hub was constructed from 2005 in a step by step manner and numerous collaborations were executed. For example, in the case of injection molding flow analysis, 407 analyses were progressed by using the engineering collaboration hub for 33 SMEs for about two and a half years and among them, 42% is the “Warp” analysis and 21% is the “Basic” analysis. Complete collaborative projects were surveyed as to which kinds of experts’ suggestions were helpful to moldmakers, and the accepted suggestions lied in the order of gate location, runner balance, and warp, etc. As a result, the average number of molding trials was reduced by 1 and total direct economic effect is estimated to be 2 million dollars. The main cost reduction comes from the reduction of the number of molding trials and accompanying fast deliveries. It also includes the material cost reduction due to decrease of resin consumption and the change of resin type, as well as the operation cost reduction due to injection cycle time.

ACKNOWLEDGEMENTS

This research has been conducted as a part of the project “i-Manufacturing” supported by the Ministry of Knowledge Economy, Republic of Korea.

REFERENCES

Li, H., Fan, Y., Dunne, C., Pedrazzoli, P., 2005. Integration of Business Process in Web-based Collaborative Product Development. International Journal of Computer Integrated Manufacturing, 18, 6, 452-462

Monila, A., ACA, J., Wright, P., 2005. Global Collaborative engineering Environment for Integrated Product Development. International Journal of Computer Integrated Manufacturing, 18, 8, 635-651

Chung, J., Lee, K., 2002. A Framework of Collaborative Design Environment for Injection Molding. Computers in Industry, 47, 3, 319-337

Ryu, K., Lee, S., Hong, W., Lee, D., Choi, H., 2007. Business Innovation via Collaboration - e-Manufacturing: Web-based Collaboration Systems for SMEs. Proceedings of ICEIS 2007, 198-201