International Journal of Production Research
Vol. 49, No. 2, 15 January 2011, 553–567

Web-based navigating system for conceptual mould design with knowledge management

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(*Received 1 May 2009; final version received 7 October 2009*)

Efficiency and quality are essential demands in mould and moulding manufacturing. Most related enterprises have already expanded from 3C (computer, communication, consumer electronics) to 4C (3C, car) products, which is characterised by smaller quantities and more varieties. For many firms, the shortened life cycle of products presents an unprecedented challenge. This research aims at developing a web-based navigating system for conceptual mould design with knowledge management within the computer-aided design (CAD) embedded browser. This system integrates CAD and web-based management seamlessly by the dedicated application programming interface (API). Based on both customised and standardised procedures, not only does the system prevent probable engineering mistakes and accumulate valuable knowledge, but also generates consistent web reports and shortens mould-design processes from 1 ~ 2 days by senior engineers to a couple of hours normally. In the case study of this paper, using the web-based navigating system can result in time savings up to 66%. The results show significant time savings over the conventional design process.

Keywords: web-based; navigation system; conceptual mould design; knowledge management; Pro/Web.Link

1. Introduction

Moulds are essential components in the manufacturing industry; a notable example is that moulds have a vast variety of applications for plastic products. However, most enterprises in the plastic moulding industry face conflicting demands of advancing technology and declining costs. It is thus crucial to retain core abilities to support enterprise competitiveness. The current product life management (PLM) system on the market is largely based on the project management model, and merely provides tools for the management of information generated in the process of development, design, and manufacture. Not only is it unable to guide the designing process, but its ability to shorten the product development time is quite limited. Therefore, in order to enhance competitiveness in today's diversified and highly competitive knowledge-based manufacturing industry, shortening the product development time has become the goal of firms who realise that mould design and manufacturing determines the time-to-market and quality of products. In the current environment of the rapidly shortening product life

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ISSN 0020–7543 print/ISSN 1366–588X online

DOI: 10.1080/00207540903439830
http://www.informaworld.com

cycles, using conventional ways to complete the conceptual mould design does not guarantee timely success. On the other hand, web-based navigation with knowledge management is a better way to meet the demands of today's markets.

In previous studies, knowledge-based systems, such as IMOLD (Fuh *et al.* 2004, Lee *et al.* 1997), IKMOULD (Mok *et al.* 2001), and IKB-MOULD (Chan *et al.* 2003), were developed for injection mould design. IMOLD divides mould design into four major steps; parting surface design, core and cavity design, runner system design, and mould-base design. It also provides the ability to control and manage projects, and assists designers in completing projects correctly. IKB-MOULD was constructed using the experience and knowledge of product design and mould manufacturers; it uses a knowledge-based computer-aided design (CAD) system to provide an interactive environment, assist designers in the rapid completion of mould design, and promotes the standardisation of the mould design process. Turng *et al.* (1998) developed a knowledge-based online system for the design and manufacture of injection-moulded plastic products, which enables enterprises to preserve their knowledge. This system sorted information into five categories: designing, materials, processes, CAE, and issues to search the information. Chin and Wong (1996) developed a knowledge-based evaluation system for the conceptual design development of injection moulded parts (EIMPPLAN-1), this system obtains appropriate materials and generates the main features of the mould-design in a conceptual design. There is not much research being done on the initial (conceptual) design of plastic injection moulds, except for Ye *et al.* (2000), who presented an algorithm for the initial design. The researchers first determine the parting line for the plastic part, followed by the calculation of the number of cavities required. The cavity layout is created based on the input information of the layout pattern and the orientation of each cavity. The mould-base is loaded automatically to accommodate the layout. Alternatively, Low and Lee (2003a, b) proposed a methodology of standardising the cavity layout design system for plastic injection mould so that only standard cavity layouts are used. When only standard layouts are used, their layout configurations can easily be stored in a database for fast retrieval later in the mould design stage. Low and Lee (2004) further presented a methodology of rapid realisation of the initial design in 3D solid, based on the technical discussion checklist, which takes the role of the overall standard template. Information is extracted from databases and coupled with the basic information from the customer; this information is input into the technical discussion checklist.

The purpose of this research is to build a web-based navigation system for conceptual mould-design with knowledge management based on the mould design navigation system by Jong *et al.* (2009), which implements standard procedures, automatic operations, module design, project management, and seamless integration on a very popular CAD platform. The knowledge management modules are able to reduce man-made errors in mould development. Furthermore, the system not only does herein accelerate the design process for engineers and accumulates knowledge of conceptual mould design, but also prevents probable engineering mistakes and generates consistent web reports.

2. Conceptual mould design

In general, there are four major stages in mould-design: conceptual mould-design, core design, mould-base design and 2D drawing design. Conceptual mould-design, the first stage, is the most crucial procedure, so important that it must be carried out by experienced engineers. However, if such experienced engineers quit the job, the firm will lose valuable and intangible assets. The enterprise must then spend precious resources training the new employees. Moreover, most plastic moulding firms have not taken full advantage of the internet in managing daily operations. As a result, several months are required in order to complete mould design and manufacturing. In existing common mould-design procedures, each stage must be carried out in sequence. Not only is this inconvenient for saving information, but it is also difficult to refer into the as-is model.

3. Web-based navigating system

In the 21st century, most plastic mould and moulding enterprises industry face conflicting demands of advancing technology and declining costs. They are looking for new strategies to win more opportunities while maintaining profit margins, including computer-aided design (CAD), computer-aided manufacturing (CAM) and computer-aided engineering (CAE) technologies that are customised to assist mould design, automated for common tooling tasks and integrated across the suite of functionalities. Web-based application is already a quite mature tool for navigating design. It is thus crucial to build a web-base system for retaining core abilities to support enterprise competitiveness. As such, the project procedure can be monitored anywhere and anytime.

The conceptual mould design is to evaluate the design of a new product and to propose the concept of mould design. This work integrates the navigating procedure, web report and historical knowledge database together for conceptual mould design (Figure 1). The engineer will be guided by the navigating procedure to accomplish each step of conceptual mould design automatically. The components of historical database are to assist the navigating procedure of conceptual mould design. The web-based report can then be generated automatically with the work done by the engineer through the navigating procedure.

4. Integration of knowledge management

Conceptual mould-design consists of the mould-split reference and the mould-design epitome. This stage of the design process must be performed by engineers who have professional mould knowledge and abundant experience. If such engineers quit the job, they take away with them their intangible assets, which might inflict serious harm on the firm. Thus, enterprises need a knowledge management system (KMS), in order to codify and accumulate valuable knowledge.

This system is supported by historical knowledge-management systems (Figure 2); it accumulates previous and ongoing design knowledge, including issues of part design (thickness, draft angle, mechanism), material properties (shrinkage rate, viscosity, material flow index), mould design (parting lines, inner/outer undercuts, insert positions, ejector pins), moulding conditions (mould/melt temperature, cooling system, cycle time), and moulding machines (types, tons, shot speed). After the categorisation of product types, in order to enable the user to find desired product information, the system offers five major functions.

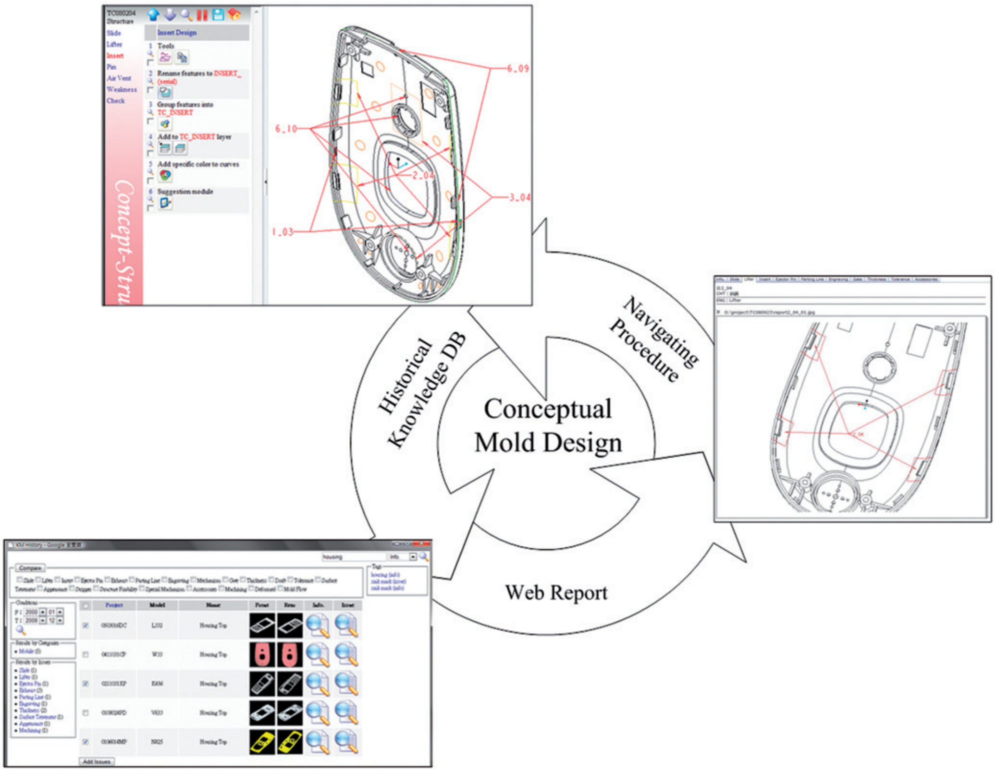


Figure 1. Integrated system for conceptual mould design.

4.1 *Categories and site-map*

This function offers dynamic tiers categories, which can be expanded easily. Each tier shows current and the next category information (Figure 3), thus, users are able to find the product information accurately in the shortest time. Moreover, according to different tiers, the site-map function shows the hierarchical position on top of the webpage (Figure 4). Also, users can click the text links of the map to go into the specified tier directly.

4.2 *Compare*

The user can investigate and compare the mould and moulding characteristics by selecting the similar products (Figure 5). The mined information is very helpful during the design process and is available whenever needed.

4.3 *Search and results list*

The users use the search engine to look for both products issues and information based on typical keywords (Figure 6). At the same time, keywords will be recorded to make it convenient to reduce the following searching time, and the results will be listed by categories and issues. Users can also find more detailed information from the results list.

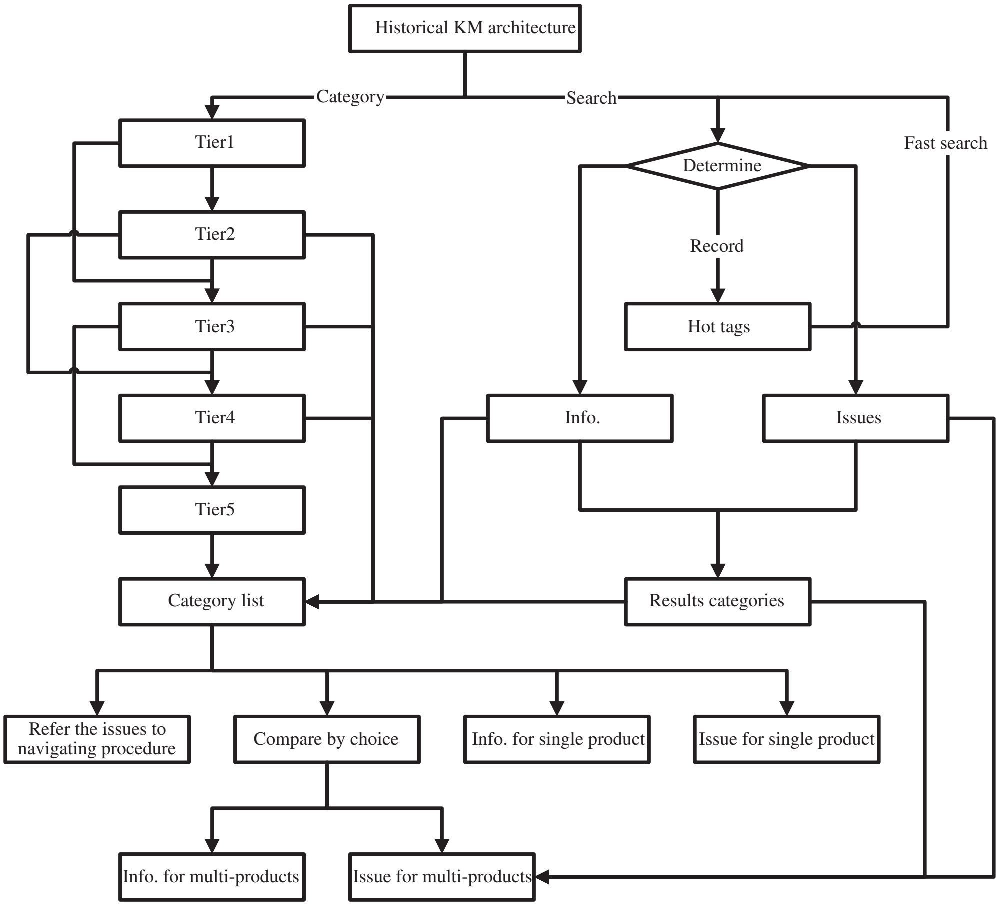


Figure 2. Historical knowledge-management systems.

4.4 *Reference*

Once the user selects the desired models for reference, the historical knowledge of these models will be accessible in each of the corresponding design steps which can effectively reduce the possible mistakes.

Commonly needed steps are implemented in the system, and each step is seamlessly integrated with the corresponding KMS. Dedicated enterprise processing sequences can be customised and integrated into the navigation process with built-in interfaces.

5. Results and discussions

In this section, some important functions of the web-based navigation system for conceptual mould design are demonstrated. The flip-front housing of a cell phone is used as the case study.

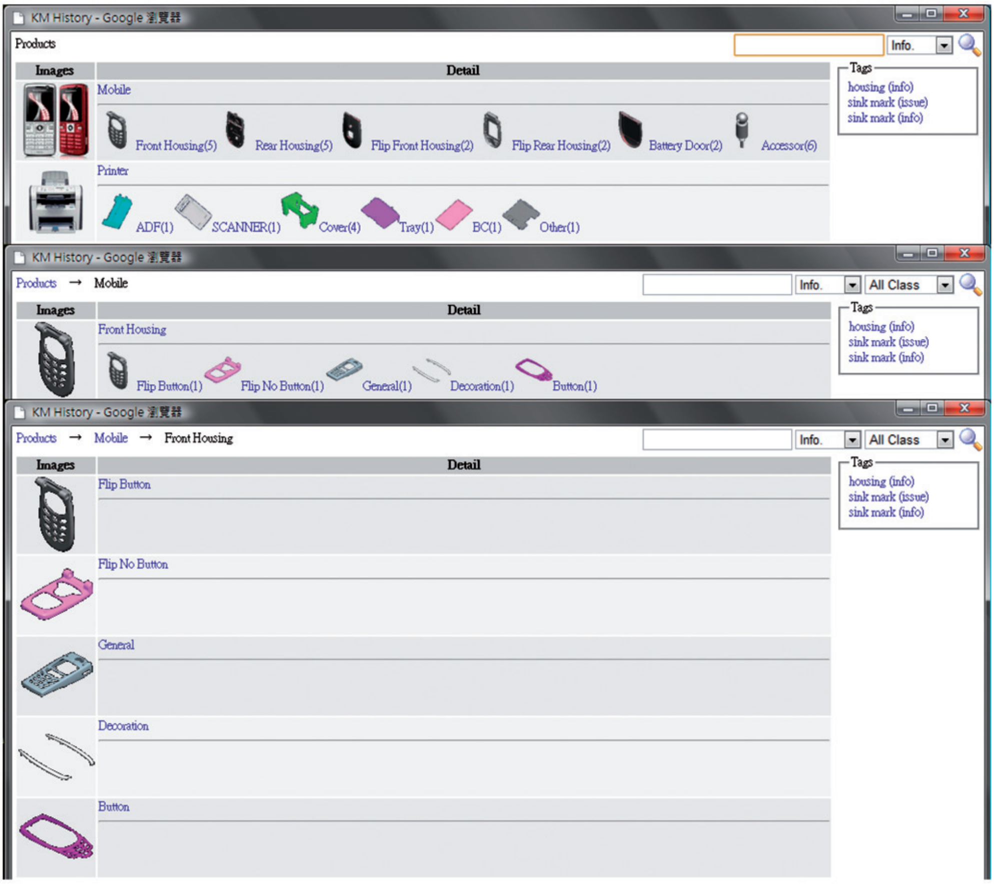


Figure 3. Categories list of historical products.

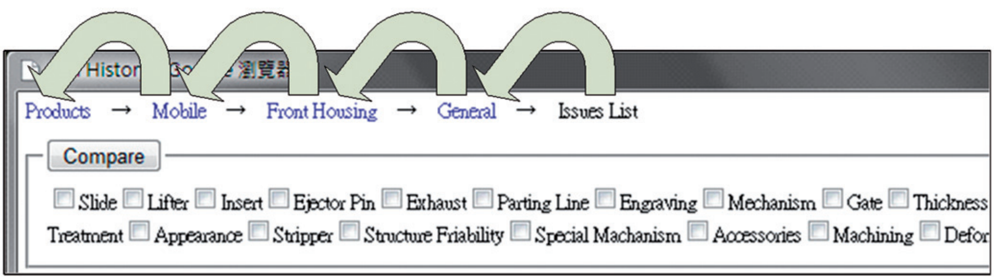


Figure 4. Site-map function of historical products.

5.1 *Model process and creation*

The customer's part model needs to be rechecked or redefined for quality which is very important for mould design. Since the conceptual and detailed mould design requires a solid model instead of a surface model, the system provides a function to check the status of the part model automatically (Figure 7).

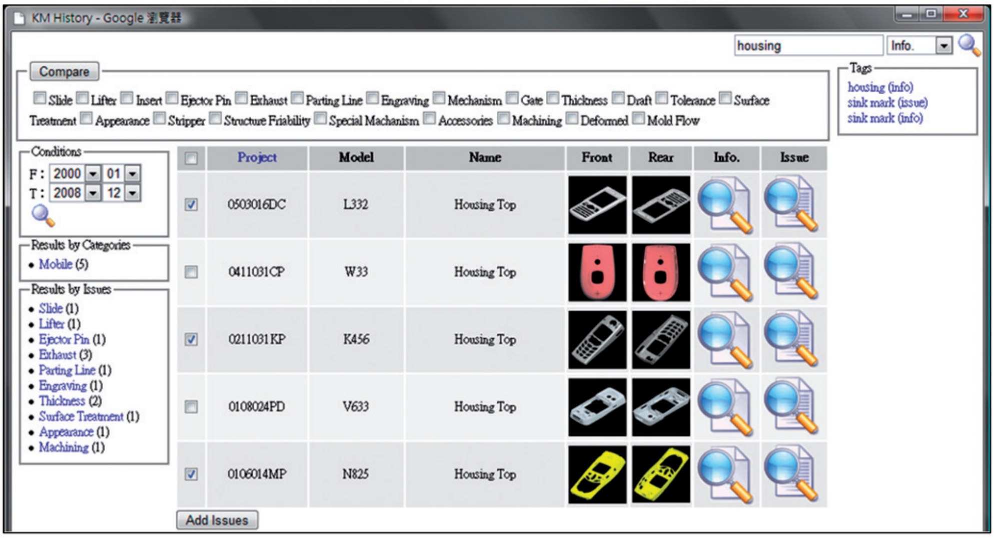


Figure 5. Compare function of historical products.

Figure 6. Search engine and results list of historical products.

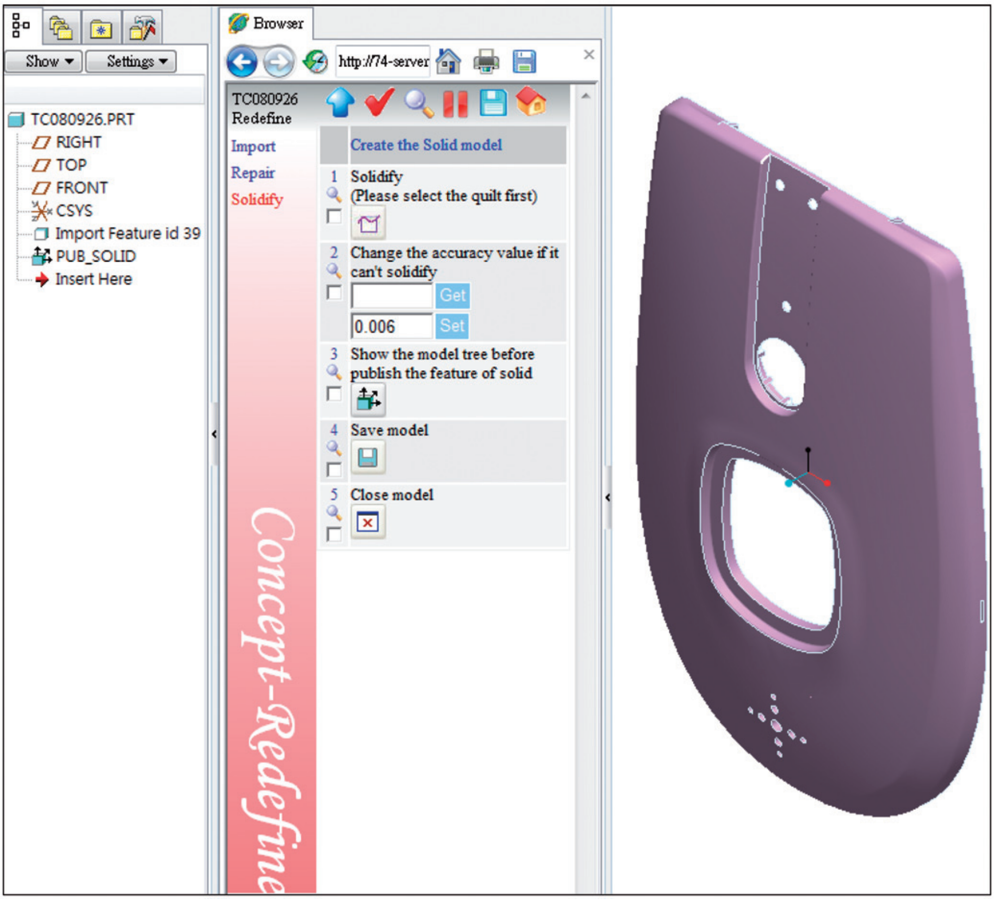


Figure 7. Model processing and creation.

5.2 *Layer functions*

Each model will create classified layers in order to organise and manage grouped features conveniently. Too many features on the screen not only cause confusion but also trigger interference very easily. The user can switch the layers on and off to clearly check the parting line and obtain pictures easily through the layer functions (Figure 8).

5.3 *Historical KMS interface*

The user can easily find similar designs based on categorised products (Figure 3). Users can also find products through the search engine. The result of each search is displayed, then the user can select similar models to investigate and compare their characteristics (Figure 5).

5.4 *Automatic functions*

This system also offers automatic functions to assist the conceptual-design process. For example, it automatically checks component interference and calculates the size of the model to further determine the size of the mould-base (Figure 9).

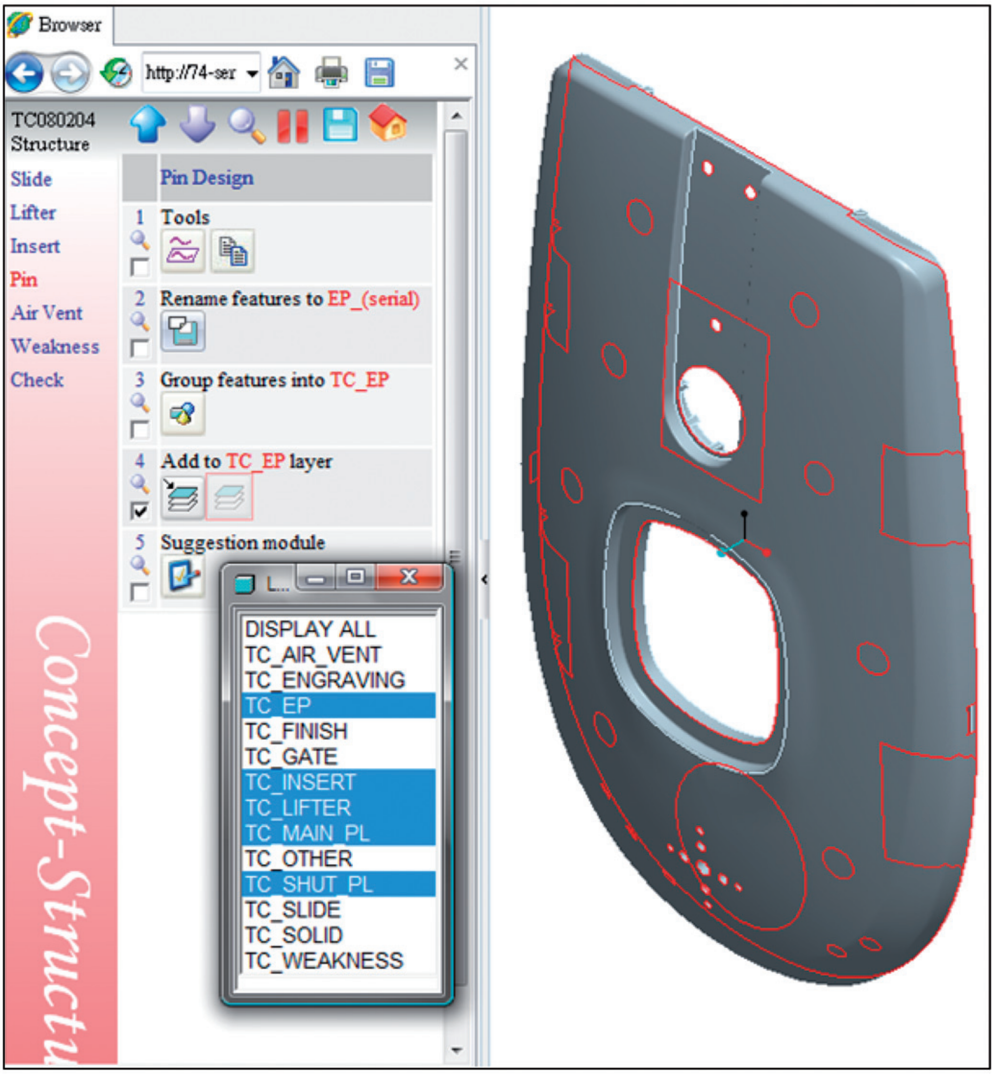


Figure 8. Layers functions.

5.5 *Moulding analysis and shrinkage*

Users select one of the available plastics from the database and define the gate location to perform the CAE moulding simulation (Figure 10). On the shrinkage page, the user can directly select the material and then shrinkage ratio will be recorded into the web-report and mould-design module automatically.

5.6 *Mechanism design*

After the draw direction has been decided, the parting lines for the parting surface and the inner and outer undercuts are required to be indicated for detailed mould

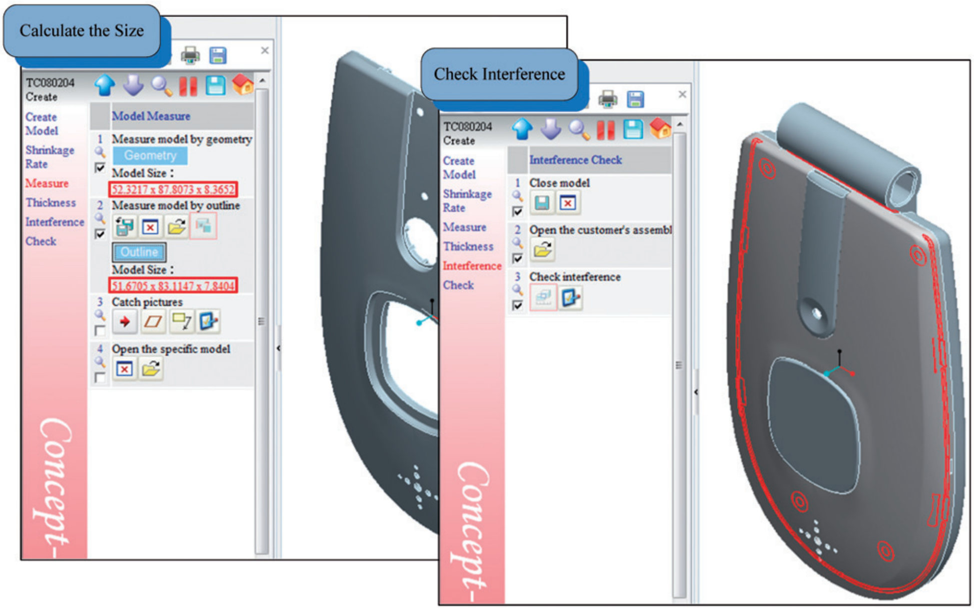
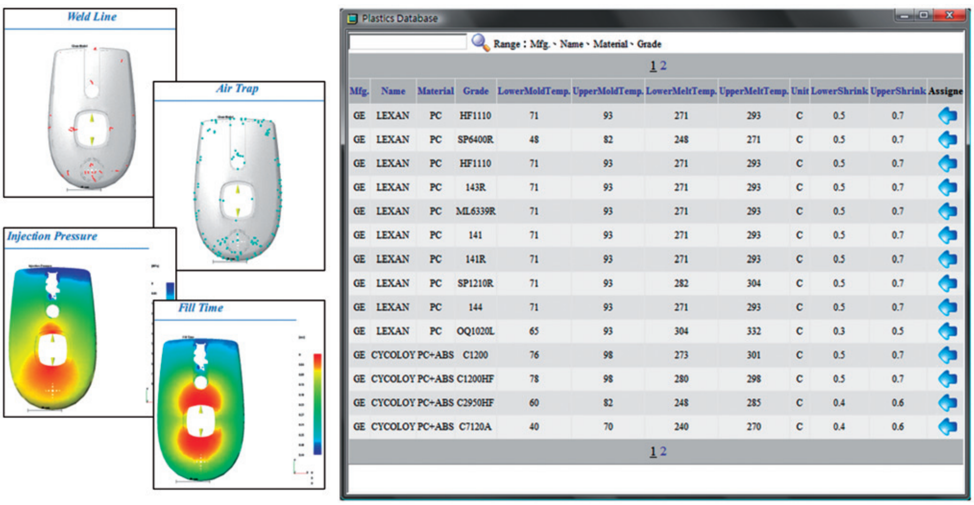


Figure 9. Automatic functions.



Mfg.	Name	Material	Grade	LowerMoldTemp.	UpperMoldTemp.	LowerMeltTemp.	UpperMeltTemp.	Unit	LowerShrink	UpperShrink	Assigne
GE	LEXAN	PC	HF1110	71	93	271	293	C	0.5	0.7	
GE	LEXAN	PC	SP6400R	48	82	248	271	C	0.5	0.7	
GE	LEXAN	PC	HF1110	71	93	271	293	C	0.5	0.7	
GE	LEXAN	PC	143R	71	93	271	293	C	0.5	0.7	
GE	LEXAN	PC	ML6339R	71	93	271	293	C	0.5	0.7	
GE	LEXAN	PC	141	71	93	271	293	C	0.5	0.7	
GE	LEXAN	PC	141R	71	93	271	293	C	0.5	0.7	
GE	LEXAN	PC	SP1210R	71	93	282	304	C	0.5	0.7	
GE	LEXAN	PC	144	71	93	271	293	C	0.5	0.7	
GE	LEXAN	PC	OQ1020L	65	93	304	332	C	0.3	0.5	
GE	CYCOLOY	PC+ABS	C1200	76	98	273	301	C	0.5	0.7	
GE	CYCOLOY	PC+ABS	C1200HF	78	98	280	298	C	0.5	0.7	
GE	CYCOLOY	PC+ABS	C2950HF	60	82	248	285	C	0.4	0.6	
GE	CYCOLOY	PC+ABS	C7120A	40	70	240	270	C	0.4	0.6	

Figure 10. Plastics material database.

design (Figure 11). The system offers automatic and semi-automatic functions to assist these design processes.

5.7 *Suggestions*

In each design step, the user may give suggestions to the original product design, based on accumulated mould-design experience. Users can select common suggestions from the

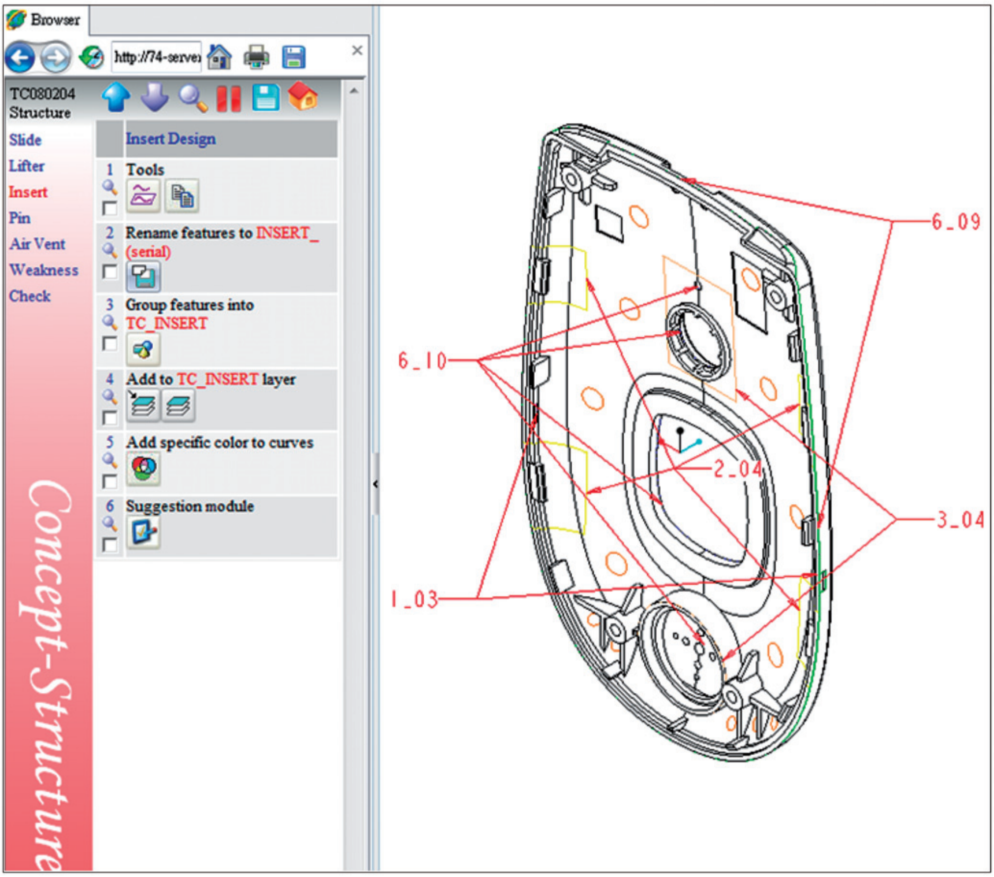


Figure 11. Mechanism design.

system or input new suggestions manually. The user can also edit or delete collected suggestions as desired (Figure 12).

If the explanation on the model is needed, suggestions should have the corresponding 3D notes on the part being designed. Then, this function can be performed automatically. In other words, the user only needs to select the position of the 3D notes, then the content of the suggestion will be added to the 3D notes and the image will be saved for the final web report.

5.8 *Web report*

After the user finishes the sequence of steps in the conceptual mould design, a web-based report will be generated automatically (Figure 13). Each tab will show the specific category from the suggestions. Users and customers can check and respond on this interactive platform.

5.9 *Case study*

This section uses a cell-phone model to present the case study for this system. When the user starts a project task in navigated process, the model needs to be rechecked and

Figure 12. Suggestions function.

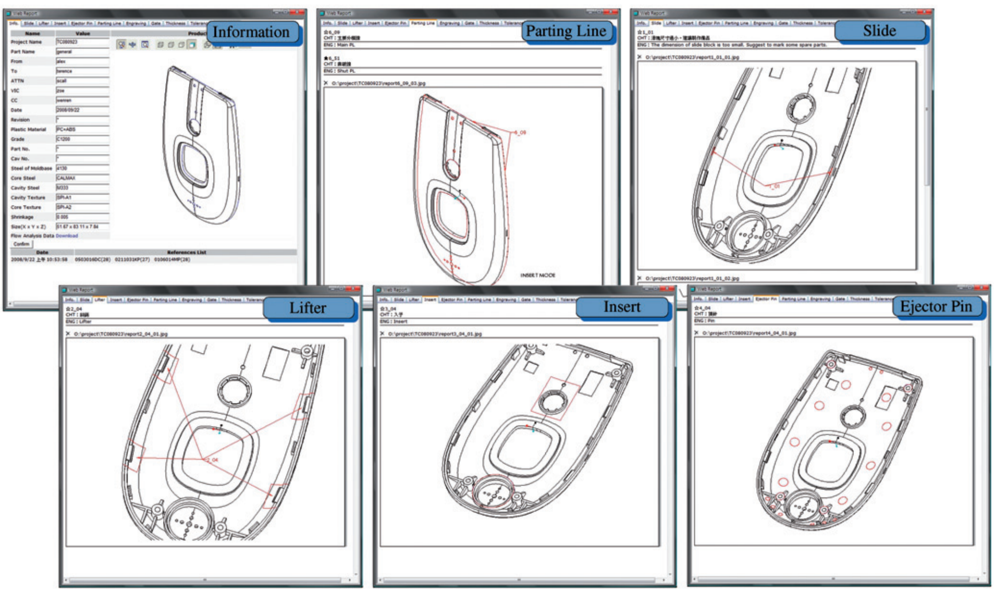


Figure 13. Web report.

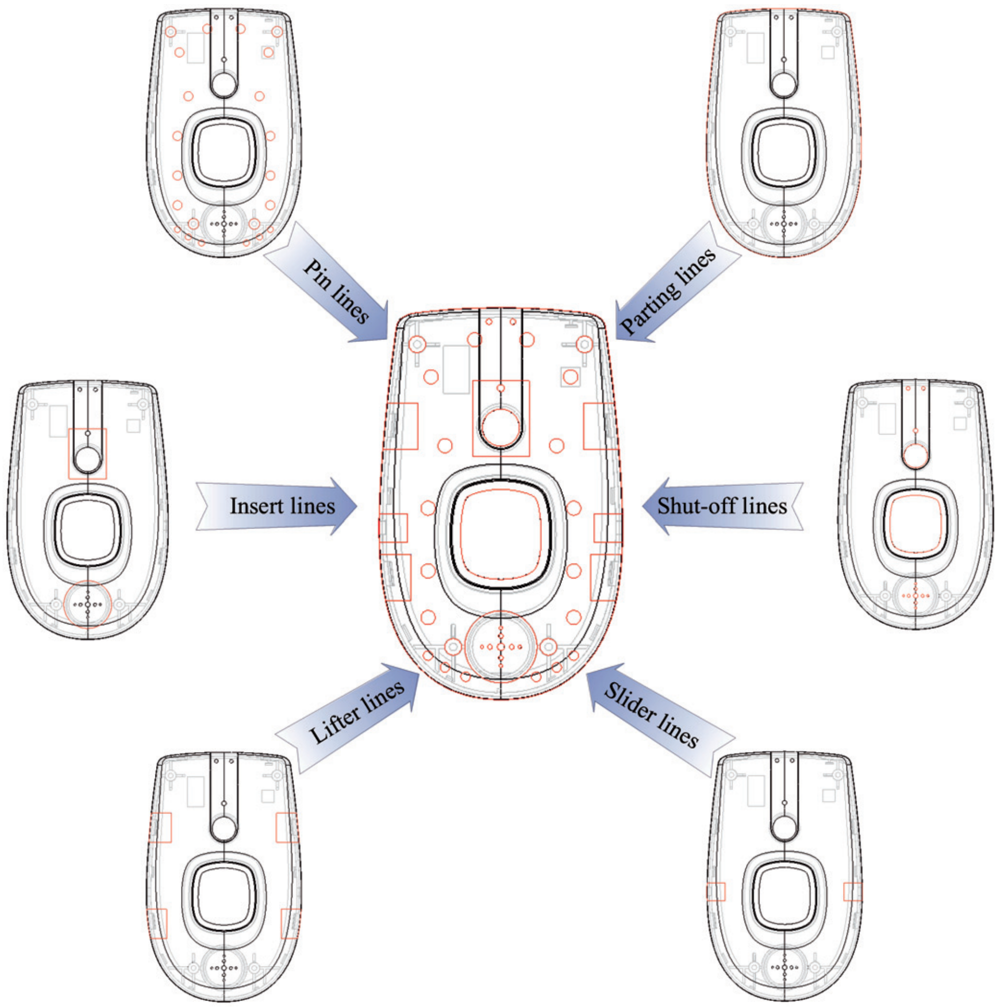


Figure 14. Finished model of conceptual design.

redefined first (Figure 7). The system offers related tools to assist the user in obtaining a solid model. Secondly, the classified and organised layers of the model will be created automatically in order to manage grouped features of geometry in the following steps (Figure 8). Furthermore, the user can designate the shrinkage ratio, estimate the model size, check the thickness of the model, and analyse the interference between components. These routine operations can all be accomplished by automatic and semi-automatic functions (Figure 9). Next, the parting-lines, shut-off lines, and the position of structure can be indicated via appropriate tools (Figure 11). Moreover, the user can highlight the specific features via layers management function and take the snapshots by suggestions module (Figure 12). The finished model in conceptual design is shown in Figure 14.

The time spent in conceptual mould design is then compared with a conventional CAD environment and web-based navigating system. A notable result shows, in the conventional CAD environment, they must spend more time to process models and to organise

Table 1. Comparison of conventional design and navigating design.

Items	Conventional design	Navigating design
Redefine and recheck the model	0.9 hour	0.6 hour
Create layers and organise features	0.5 hour	0.2 hour
Designate the position of mechanism	3.6 hours	1.5 hours
Give the suggestions and catch pictures	2.5 hours	1 hour
Explore the historical knowledge	1 hour	0.3 hour
Make the web report	3.5 hours	0.4 hour
Total times	12 hours	4 hours
Saving time	–	66%

each job, even check historical issues inconveniently. The web-based navigation system is clearly faster than the conventional CAD environment because the standard operation procedure was implemented and the complex operations are executed automatically. Moreover, when the user finishes the procedure, a web report will be created; in the meantime, designers and customers are able to communicate at the same time in this platform. The elapsed time for each of these two methods of case study is shown in Table 1; using a web-based navigating system results in time savings of up to 66%.

6. Conclusions

A web-based navigating system helps new products enter the market in the shortest possible time while meeting the individual demands of each customer; it effectively guides, helps and trains inexperienced engineers. It not only prevents possible engineering mistakes and accumulates valuable knowledge, but also shortens the conceptual mould design processes from 1 ~ 2 days to half a day normally. For the case study of this paper, using the web-based navigating system can result in time-saving up to 66%. Furthermore, the system offers a web-based collaborative platform for further detailed mould design and manufacturing, providing a complete solution.

The future work of this research focuses on two issues. One is an intelligent core and mould-base design with knowledge-based management for automatic parting surface creation and components assembling through feature-oriented approach; the other is the integration of mould design and a manufacture planning system to provide a complete total solution.

Acknowledgments

This work was supported by the Jabil Taiwan Green Point Enterprise Co., R&D Center for Mold and Molding Technology, Ministry of Education, Taiwan, and the National Science Council in Taiwan (grant no. NSC 95-2627-E-033-001).

References

Chan, W.M., *et al.*, 2003. A 3D CAD knowledge-based assisted injection mold design system. *International Journal of Advanced Manufacturing Technology*, 22, 387–395.

Chin, K.S. and Wong, T.N., 1996. Knowledge-based evaluation for the conceptual design development of injection molding parts. *Engineering Application of Artificial Intelligence*, 9, 359–376.

Fuh, J.Y.H., *et al*., 2004. *Computer-aided injection mold design and manufacture*. New York: Marcel Dekker.

Jong, W.R., *et al*., 2009. A collaborative navigation system for concurrent mold design. *International Journal of Advanced Manufacturing Technology*, 40, 215–225.

Lee, K.S., *et al*., 1997. Knowledge-based injection mold design system. *CIRP international conference and exhibition on design and production of dies and molds*, June, Istanbul, Turkey, 45–50.

Low, M.L.H. and Lee, K.S., 2003a. A parametric-controlled cavity layout design system for a plastic injection mold. *International Journal of Advanced Manufacturing Technology*, 21, 807–819.

Low, M.L.H. and Lee, K.S., 2003b. Application of standardisation for initial design of plastic injection molds. *International Journal of Production Research*, 41, 2301–2324.

Low, M.L.H. and Lee, K.S, 2004. 3D rapid realisation of initial design for plastic injection molds. *Journal of the Institution of Engineers*, 44, 15–30.

Mok, C.K., Chin, K.S., and Ho, J.K.L., 2001. An interactive knowledge-based CAD system for mold design in injection molding processes. *International Journal of Advanced Manufacturing Technology*, 17, 27–38.

Turng, L.S., DeAugistine, D., and Taam, B., 1998. A knowledge base system for the design and manufacture of injection-molded plastic products. *IEEE information technology conference*, September, Syracuse, New York, 95–98.

Ye, X.G., *et al*., 2000. Automatic initial design of injection mold. *International Journal of Material and Product Technology*, 15, 503–517.