Optimize Molding Parameters to Improve Part Warpage through Moldex3D Expert Module

TAIWAN TECH NATIONAL TAIWAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

Customer: National Taiwan University of Science and Technology
Country: Taiwan
Industry: Education
Solution: Moldex3D Advanced & Expert Module

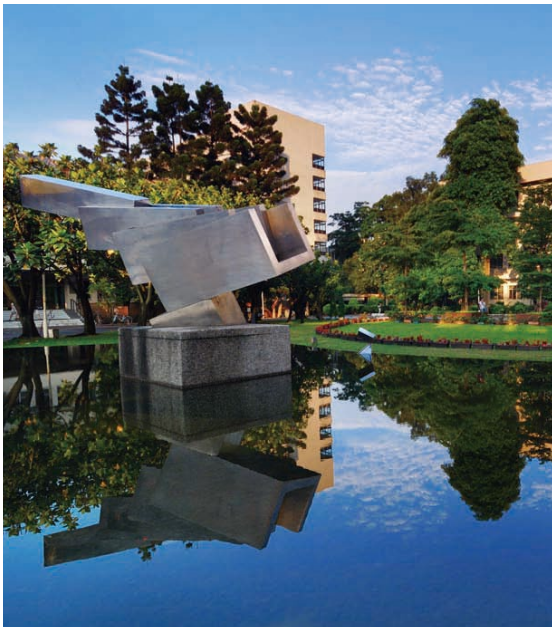


Image Courtesy of National Taiwan University of Science and Technology

National Taiwan University of Science and Technology (NTUST) was established on August 1, 1974, as the first higher education institution dedicated specifically for the technical and vocational education purpose in Taiwan. By expanding the different course offerings since the foundation of the institution, their goal is to create an environment to nurture the next generation of highly skilled engineers and managers in order to meet the needs created by the rapid economic and industrial developments. (Source: www-e.ntust.edu.tw)

Executive Summary

Casting is one of the most common ways to produce contact lenses. Reaction injection molding technology is used as a process to prepare contact lenses including a front shell and a basic shell. The polymer injected between the two shells will solidify into a contact lens. Since the manufacturing standards of contact lenses require high dimensional accuracy, part warpage should be strictly controlled within a small and acceptable tolerance. Thus, the researchers at NTUST have turned to Moldex3D's simulation technology; they utilize Moldex3D's Expert Module to simulate the molding process, and is able to attain optimum process settings in order to conduct design changes to successfully improve the warpage problem.

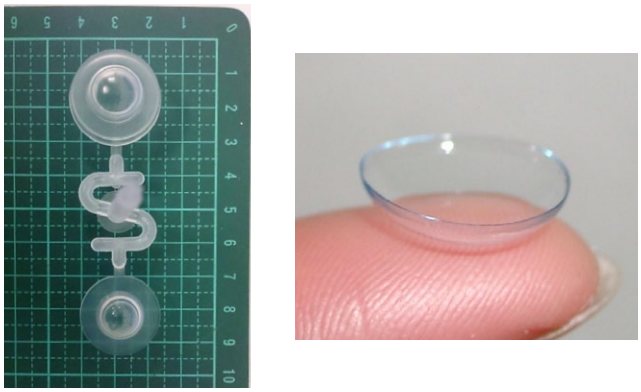


Fig.1 The Front shell and basic shell of a contact lens

Challenges

- Limited control on the product dimension because of using the multi-cavity manufacturing method for mass production.
- The molded parts require high geometrical accuracy, and they need a secondary processing to get the final optical products, so it is necessary to minimize the warpage in the processing stage.

Solutions

Utilize Moldex3D Expert Module to obtain optimum process settings in order to successfully improve the product's warpage problem.

Benefits

- Boosting educational research and helping NTUST researchers and students to gain a hands-on experience to use CAE software to visualize the filling behavior
- Reducing mold trial time and risks as well as saving labor cost.
- Attaining the total improvement rate on part warpage by17.28%.

Case Study

This is a perfect case that demonstrates how NTUST researchers evaluate and identify the most appropriate molding conditions for manufacturing contact lenses to save mold-repairing cost by utilizing Moldex3D CAE simulation software. First of all, Moldex3D Expert Module is used to measure the shrinkage variation. Then, optimal parameters can be acquired for carrying out design changes, thereby enhancing the final product quality.

The main purpose of this case is to reduce the warpage, making the total displacement as the quality factor that influences the part quality. Then, choose other four significant parameters to be the control factors which will affect the warpage condition in Moldex3D's Expert Module setting. Control factors, shown in Fig.2, are mold temperature, melt temperature, packing pressure and cooling time. CAE design of experiment method is applied to analyze the effect of each influential factors. The direct effect of each factor has the mold computed and shown on the factor response plot (Fig.3). From Fig. 3, control factor B (melt temperature) is being identified as the most important factor.

No.	Quality Factor	Characteristic	Target Value	Weighting
1	Total Displacement	Small the Better		100%

Control Factor : 4

No.	Control Factor	Level 1	Level 2	Level 3
1	Molde Temperature	30	50	70
2	Melt Temperature	190	210	230
3	Holding Pressure	15	20	25
4	Cooling Time	6	8	10

DOE Analysis Setting

- Mold temperature is to consider cooling effect first
- Runner effect is to be considered

Fig. 2 The quality and control factors of Moldex3D's DOE Module

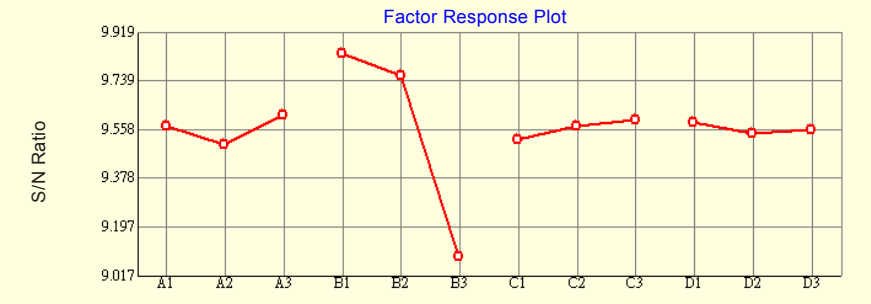


Fig.3 Factor response plot

In addition, according to Moldex3D's analysis (Fig.4), an imbalanced flow behavior is detected in the original design. When the filling at 80%, the basic shell is already completely filled while the front shell is still only less than half filled. As a result, the gate size of front shell is widened to facilitate a faster filling (Fig5.). With the new design change, Moldex3D simulation is applied once again to test the performance. From Fig.6 we can see a significant improvement on the flow balance. Due to the fact that this case is only for the purpose of academic study that aims to help students to understand how to use CAE simulation tool for predicting and improving molding issues. If a few more design changes had been tested and implemented, the improvement of the filling performance could have been more significant.

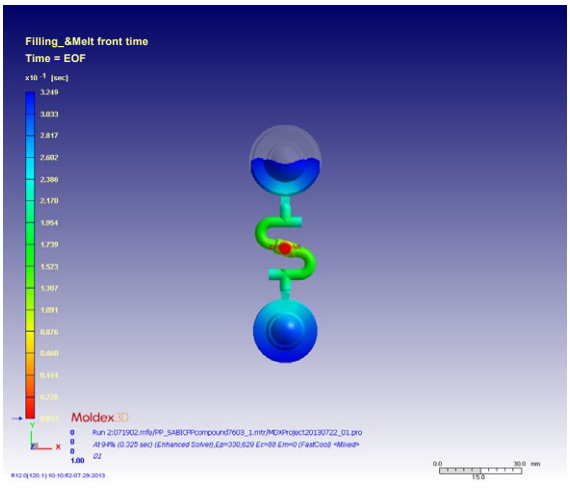


Fig. 4 The original design

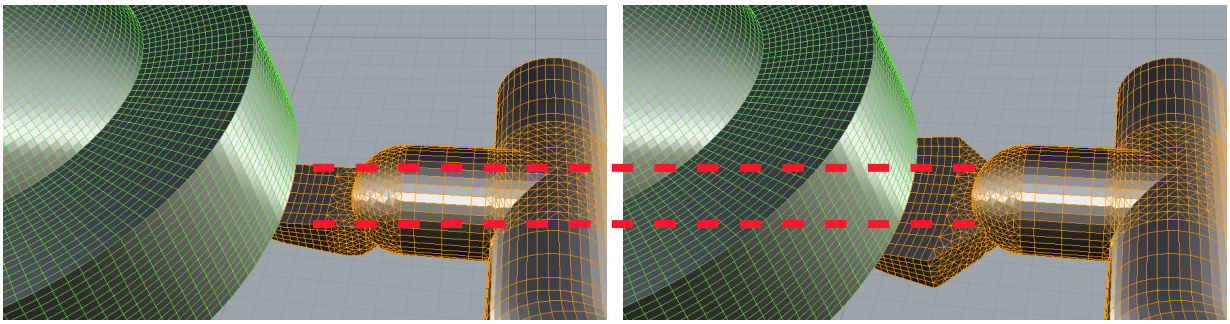


Fig. 5 The design change

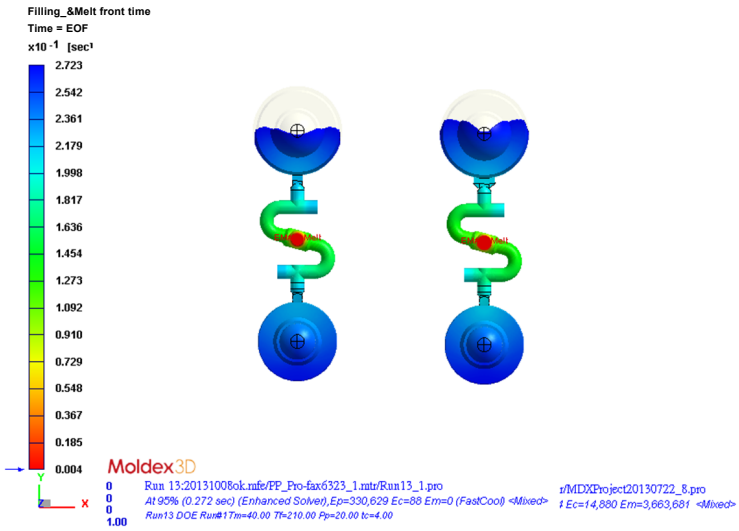
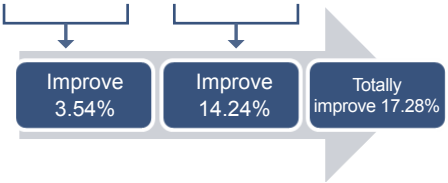


Fig.6 Melt front time analysis after applying the design change

The following table (Table 1) shows the simulation results of the original design, DOE (the optimum) and the design change. Through the help of Moldex3D's Expert Module and an effective design change, the total improvement rate is expected to reach 17.28%; thus, the displacement problem will be improved significantly (Fig.7).

Unit: mm	Original design (the best and the worst)	DOE (the best)	Design change
Moldex3D simulation results (total displacement)	0.32409 (The best)	0.32092	0.2752
	0.35588 (The worst)	N/A	
Average	0.3327	N/A	
Real measurement (Z displacement)	0.08 (The best)	0.0858	N/A
	0.1047 (The worst)	N/A	

Table 1 The comparison table



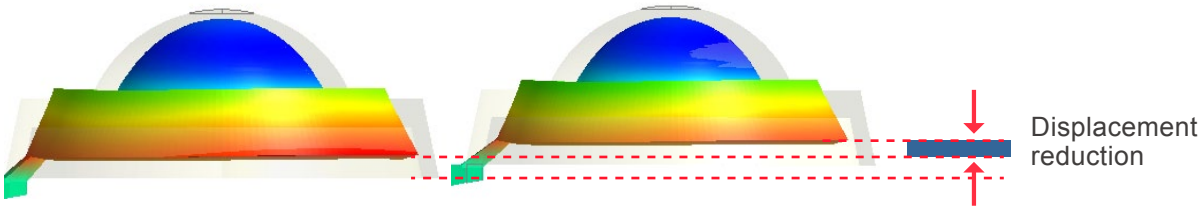


Fig. 7 Warpage variation

Results

Moldex3D's Expert Module not only can help researchers at NTUST visualize the molding process, but also help identity the most important influential factor effecting the part quality in order to adjust the process settings effectively to improve the warpage problem. Moldex3D also offers researchers and students at NTUST a hands-on opportunity to gain a real-world experience and learn how to use CAE simulation software to reduce the manufacturing risks and avoid trial-and-error effectively before starting their career in the industry.

Image Courtesy of National Taiwan University of Science and Technology

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