DOI: 10.1515/amm-2017-0191

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STUDY ON EFFECTS OF MOLD TEMPERATURE ON THE INJECTION MOLDED ARTICLE

This is a study of the effects of temperature of injection mold on the injection molded article. By supplying water of the proper temperature in the cooling line of mold in the cooling process, the mold was the appropriate temperature, and the deformation of the injection molded article was examined according to the mold temperature. In this study, we conducted simulation analysis and experiments, and the results were analyzed. The minimum deformation of the injection molded article model obtained by supplying 50°C water in the cooling line is 0.003 mm, and the maximum deformation was 0.813 mm. Injection molded article models obtained by supplying 20°C water were found to be a minimum of 0.002 mm, with deformation of up to 0.761 mm. When comparing both conditions, the error rate of injection molded article obtained by supplying 20°C water in the mold cooling line was lower by about 0.18%.

Keywords: Injection molding, Mold temperature, cooling temperature, Molded article

1. Introduction

In modern industry, in addition to mass production, consumer preferences are diversified, and products have an important design element [1]. Many products are made using injection molded articles [2]. Injection molding is a process where by a thermoplastic resin is heated and melted in a cylinder and then injected into a mold where it solidifies to become the final product. Injection molding die is made of die steel, and mold temperature has an effect on the thermoplastic resin [3]. The temperature of the mold plays an important role in determining the quality of the molded products [4]. We are working on improving the quality of our products by changing the mold temperature [5]. In this study, by supplying water of the proper temperature in the cooling line of mold in the cooling process, the temperature of the mold is adjusted to a temperature suitable for injection, and the effects of the temperature of the mold on the quality of the injection molded article were analyzed. Modeling of the mold and mold injected articles was performed by creating 3D models using CATIA V5. The results of the experiment, which was conducted by injecting the obtained results and mold injected articles, were analyzed using a finite-element analysis program.

2. Simulation and Experiment

The injection mold industry endeavors to shorten the injection process time and eliminate deformation of the injection molded article. In order to eliminate deformation of the injection molded article, the cooling time and mold temperature are important factors. The models were composed of a lower die and an upper die. The injection product is shown in Fig. 1. The number of nodes of the model was 682,176 and the number of elements was 421,524. Width, height, and length of the models were 230 mm, 360 mm, and 960 mm respectively. The die of the models is composed of die steel, and the injection molded articles of the models are composed of ABS. The properties of ABS is shown in Table 1.

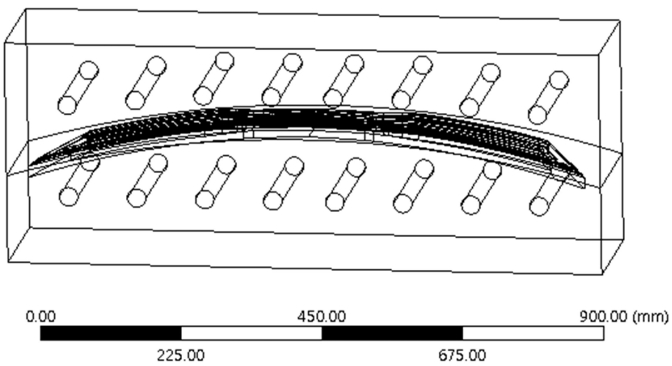

Fig. 1. 3D model for the analysis

To perform heat conduction analysis, as shown in Fig. 2, the outer mold was given a convective heat transfer coefficient through contact with ambient temperature air. It was set up

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TABLE 1

Properties of ABS

Property	Value
Young's modulus (MPa)	2100
Poisson's ratio	0.392
Density (g/cm^3)	0.93673
Yield strength (MPa)	41
Ultimate strength (MPa)	40
Thermal conductivity (W/m·K)	0.189
Specific heat (J/kg·K)	2342

under two conditions in order to change the temperature of the injection mold and the cooling time: (a) 50°C, 67sec and (b) 20°C, 46sec. The reason for changing the cooling time is that it's a condition set for reducing the cycle time by reducing the cooling time. Finite element analysis was performed under the above conditions. In addition, the initial temperature of the injection molded article was set to 200°C. The reason for this is that the temperature when ABS in melted and injected into the mold frame during the injection process is approximately 200°C.

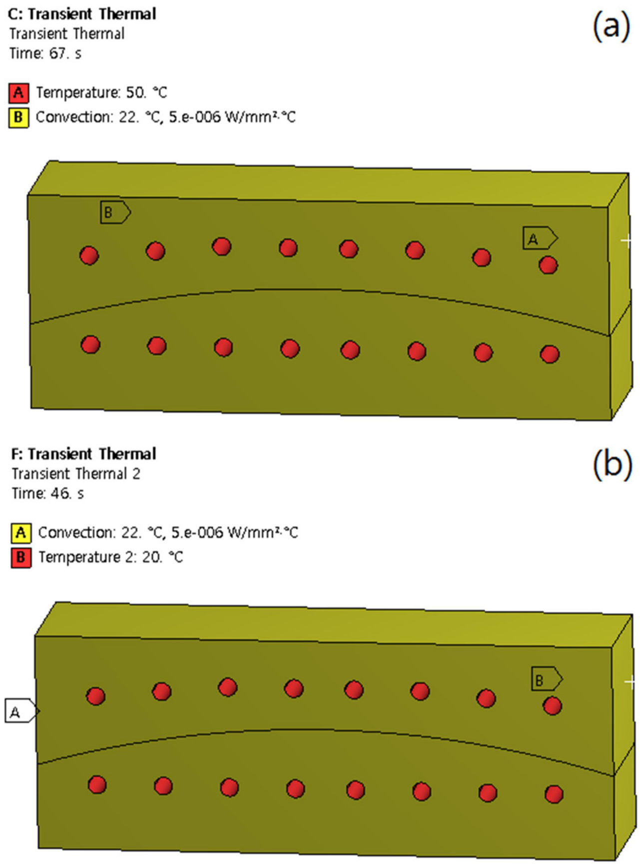

Fig. 2. Transient thermal analysis condition of model : (a) 50°C, 67sec and (b) 20°C, 46sec

Thermal structure interaction analysis was performed to investigate the deformation of the injection product. The thermal structure coupled analysis is conducted on the basis of the heat transfer analysis results. Constraint conditions of thermal structure interaction analysis were fixed to the upper and lower surfaces of the models as shown in Fig. 3. The reason for fixing the upper and lower surfaces of the models is that they are fixed with an injection molding machine.

Experiments were performed under the same conditions as the analysis condition (a) and condition (b). Experimental results were compared to the deformation of the injection molded article. A control module as shown in Fig. 4 was produced, and the condition (b) experiment was performed. Upon cooling to connect the injection molding machine and the control module, it was supplied with water with a temperature of 20°C. The cooling time was set to the same as that of the analysis condition.

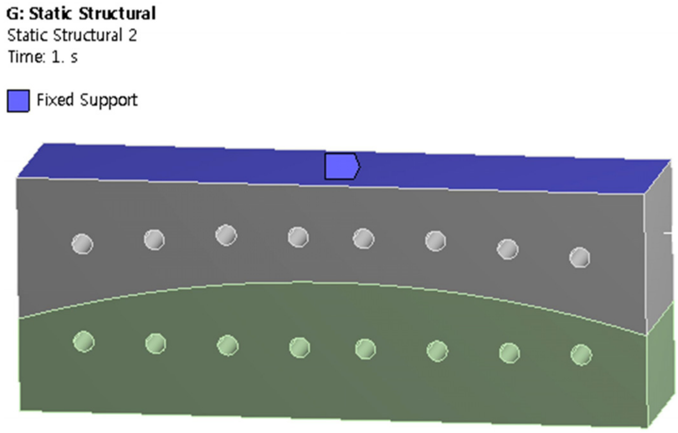

Fig. 3. Static structural analysis condition of model

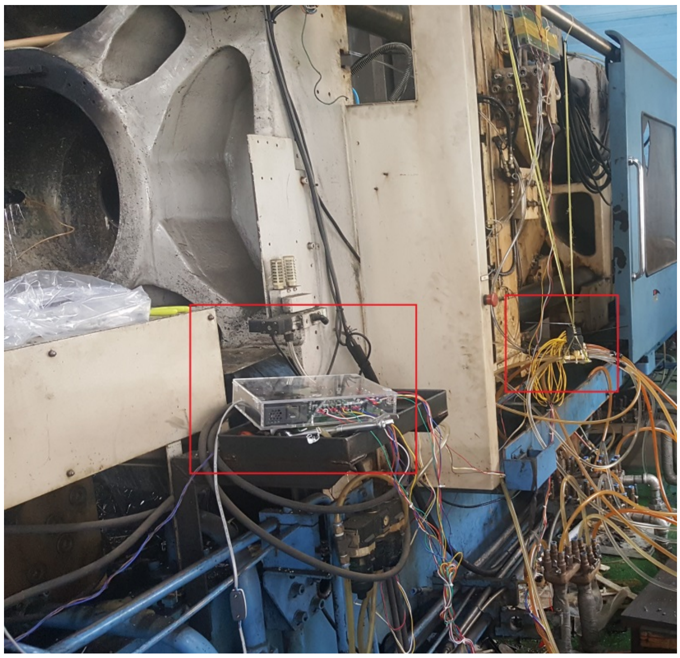

Fig. 4. The control module in conjunction with an injection molding machine

3. Results and discussion

The finite element analysis results of this study are as follows. The results of total deformation in condition (a) are shown in Fig. 5. The deformation of the model is small in Base, and it can be seen that the deformation at the corner is large. In addition, a minimum of 0.003 mm deformation is generated from the base, and a maximum of 0.813 mm deformation is displayed at the end portions of the edge. The reason for this is, as shown in Fig. 6, the stress on the corner is concentrated.

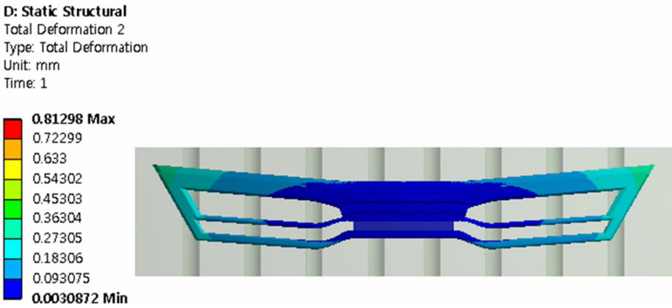

Fig. 5. Total deformation of model (50°C, 67 sec)

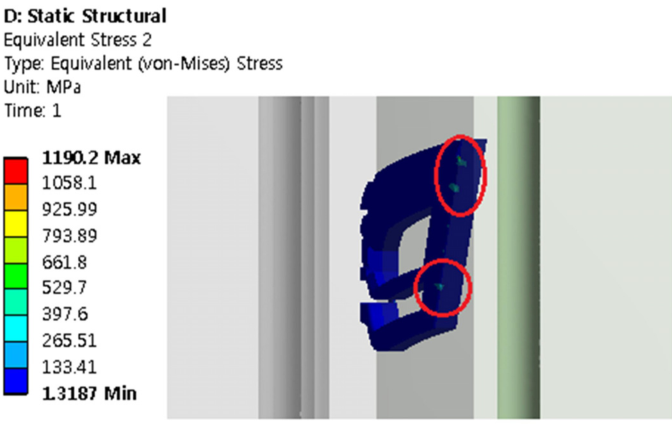

Fig. 6. Equivalent stress at the edge of model (50°C, 67 sec)

The total deformation results of condition (b) are shown in Fig. 7. The total deformation shows the same trend as in condition (a), and the minimum deformation at the base of the model is 0.002 mm. The maximum of 0.761 mm deformed at the edge of the corner is shown. The deformation at the corner is large, which is the same as in condition (a).

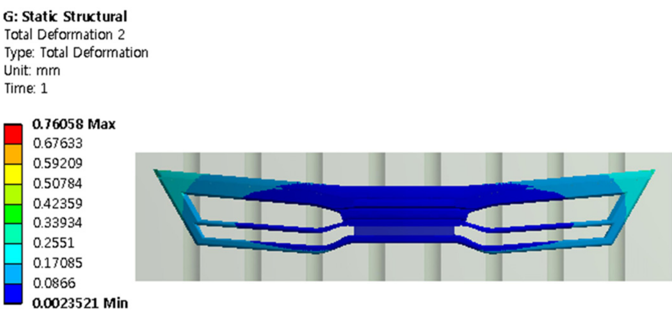

Fig. 7. Total deformation of model (20°C, 46sec)

The results of the experiment show the deformation of the injection molded product. The injection product extracted using molding machine is shown in Fig. 8. The measured displacement to measure the large deformation of the specimen is shown in Fig. 9. In Fig. 10, the injection product was measured using a vernier caliper. This is due to the large deformation of the injection molded article. This was obtained by measuring the error rate for 10 specimens compared to the reference displacement and the measuring displacement. The results are shown in Table 2.

Fig. 8. Injection molding product

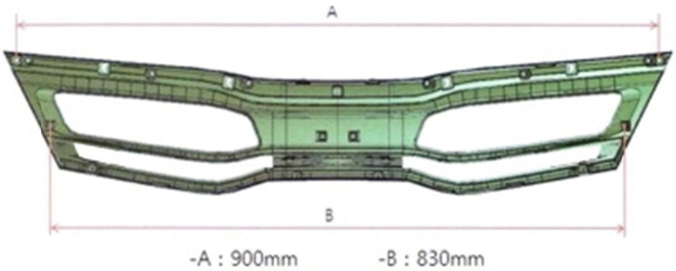

Fig. 9. Measuring the deformation of experimental model

Fig. 10. Measuring method of molded product

TABLE 2

Experiment results

	50°C	20°C
A	0.150%	0.097%
B	0.177%	0.149%

The average measuring efficiency for displacement A of the condition (a) is 0.150%, and the average measuring efficiency for displacement B is 0.177%. A mean measuring efficiency for displacement A of condition (b) is 0.097%, and displacement B is 0.149%.

From these results, it can be seen that the amount of deformation decreases when the temperature of the cooling water is set to 20°C. in the cooling process. It was found the curing process time speeds up the lower the temperature of the cooling water is, and deformation decreases. The error rate of the reference value was also found to decrease due to the above reason.

4. Conclusions

In this study, using finite element analysis and experiments, the temperature of the mold was found to have the following effects on the molded article. When comparing the simulation results of condition (a) and condition (b), it is possible in condition (b) to shorten the cooling time to 21 sec, and the maximum deformation is decreased to 0.05 mm, and the minimum deformation is decreased to 0.001 mm about total deformation result. In the experiment, the average error rate for condition (b) of displacement A is 0.053% less than condition (a) and displacement B is 0.028%. The following conclusions were obtained. The lower the temperature of the mold in the cooling process is, to the more reduced is the deformation of the injection molded article.

Acknowledgments

This work (Grant No. C0274508) was supported by Business for Cooperative R&D between Industry, Academy, and Research Institute funded by the Korea Small and Medium Business Administration in 2015.

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