Analysis and Research on Molding Technology and Thermodynamics

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ABSTRACT
Injection molding technology forming the shape of a complex and precise size of products, suitable for high efficiency, high-volume production methods, has become part of thermoplastic and thermoset plastic molding process the most important. Moldflow software is based on the theory of injection molding technology finite element software. In this paper, UPS fan as an example, during the process of injection molding, the finite element model, gating system and cooling system layout, flow process analysis, the cooling process of analysis and warpage process analysis are expounded. And then on injection process causes of defects are analyzed, and finally through the optimization of process parameters the results have been satisfied.

Keywords
Injection; finite element simulation; shaping

1. INTRODUCTION
Injection molding of large deformation has been a problem for mold enterprises. With the development of finite element technology and computer technology, numerical simulation has become the effective tool for process analysis and optimization design. The injection mold CAE software to calculate the deformation result is true specific process conditions and provide products, injection molding process parameters optimization for injection molding. With the help of numerical simulation analysis results, the deformation of the reverse compensation to product model, will provide a new idea to reduce product deformation.

(1) Steady state problem solving
For steady state thermal analysis
\[
\begin{bmatrix} K_T \end{bmatrix} \{T\} = \{Q\} \tag{1-1}
\]
The steady state thermal analysis can be divided into linear and nonlinear problems. In the linear problem, the overall thermal conductivity matrix is a constant matrix with no relation to temperature. For nonlinear problems:
\[
\begin{bmatrix} K_T (T) \end{bmatrix} \{T\} = \{Q(T)\} \tag{1-2}
\]
In the steady state nonlinear problem, the overall heat transfer matrix and the thermal load matrix may no longer be a constant, but rather a function of the temperature T.
(2) Transient state problem solving
For transient state problems
\[
\left( \frac{1}{\partial t} + [K_T] \right) \{T_{n+1}\} = \{Q\} + [C] \left( \frac{1}{\partial t} \{T_n\} + \frac{1-\theta}{\theta} \{T_n\} \right) \tag{1-3}
\]
For formula (1-1), ANSYS only supports the full method solver. ANSYS uses generalized trapezoidal rule algorithm to solve, i.e:
\[
\{T_{n+1}\} = \{T_n\} + (1-\theta) \Delta t \{\dot{T}\} + \theta \Delta t \{\dot{T}_{n+1}\} \tag{1-4}
\]
In formula (1-4), \(\dot{\theta}\) is the transient integral parameter. The user can use the TINTP command input:
\[
\Delta t = t_{n+1} - t_n;
\]
\(\{T\}\) is the temperature of the node at time \(t_n\);
\(\{\dot{T}\}\) is the temperature change rate of the node at time \(t_n\).

At the time \(t_{n+1}\), formula (1-3) can be written as follow:
\[
\begin{bmatrix} C \end{bmatrix} \{\dot{T}_{n+1}\} + [K_T] \{T_{n+1}\} = \{Q\} \tag{1-5}
\]
Substituting Formula (1-3) into Formula (1-5):
\[
\left( \frac{1}{\partial t} + [K_T] \right) \{T_{n+1}\} = \{Q\} + [C] \left( \frac{1}{\partial t} \{T_n\} + \frac{1-\theta}{\theta} \{T_n\} \right) \tag{1-6}
\]
Formula (1-6) takes into account both linearity and nonlinearity in transient analysis. Once \(\{T_{n+1}\}\) is solved, \(\{\dot{T}_{n+1}\}\) is updated by formula (1-6). ANSYS defaults time integral parameter as \(\theta = 0.5\). The Crank-Nicolson method was used to solve (1-6) and it has second-order accuracy. When the time integral constant \(\theta = 1\), the solution method is the backward Euler method. For all \(\theta > 0\) cases, the solution is implicit. In addition, the available range of \(\theta\):
\[
0.5 \leq \theta \leq 1
\]
(3) The first law of thermodynamics
\[
\rho c \left( \frac{\partial T}{\partial t} + \{v\}^T \{L\} \{T\} \right) + \{L\}^T \{\dot{q}\} = \ddot{q} \tag{1-7}
\]
Notes: \(\rho\) - density; \(c\) - Specific heat capacity;
Injection molding process parameters selection: mould temperature using a default value of 90 °C, the material temperature using a default value of 300 °C, open time using the default value of 5S, injection and holding pressure and cooling time is 35S. Filling control adopts automatic filling control mode, velocity / pressure switch adopts filling volume percentage of 100%, holding pressure control adopts the relationship between pressure and percentage of time.

2.2 Simulation Result

(1) The filling time

From Figure 1, the melt filling of the UPS fan is completed in 1.177s time. From the filling time result, there is 0.1s difference at the outer end of the injection time of fan blade. The gate position should be adjusted appropriately, then the molten material can reaches the outer end of the blade in the equal time.

(2) Velocity / pressure pressure switch

From the results, the red oval logo can be seen, the pressure is 0MPa, showing that the melt without flow to it, as shown in figure 2. Therefore need to modify the injection molding process parameters or recreate the gating system to repair defects.

(3) Cavitation

Cavitation refers to the formation of gas mold cavity cannot discharge in time, direct damage to the appearance of the product quality, which should be avoided. Figure 3 shows the cavitation location UPS fan. Cavitation occurred mainly in the parting surface and the fan blade tip, so do not affect the quality of the products, can not be modified.
5. CONCLUSIONS

Injection molding based on UPS fan simulation, and the simulation results were carefully analyzed, the improvement measures of the following are put forward: (1) A gate settings from the initial plan, the four gates are redesigned which are evenly arranged in the circumferential direction. (2) Improving the cooling system, the distance between the center line of cooling water pipes and cavity obstacle of products should be changed from 20mm to 15mm. (3) The injection pressure should be up to 130MPa. (4) Extending the holding pressure time for a certain time, melt in the cavity can be pressured, compensating melt cooling shrinkage. (5) Increasing mold temperature can be more conducive to the melt in the cavity filling and solidification. Under the condition of improved scheme, simulation of the fan injection again, defects of the above five aspects have been reduced obviously.

REFERENCES

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