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Casting Forming Process Simulation of Aluminum Flywheel

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Abstract

Simulating the forming process of casting in this paper, according to two kinds of analysis results of the designed model, the reasonable structure, pouring temperature and riser selecting of the flywheel are determined to ensure the quality of castings. The using of simulation software before the actual molding can get rid of the possible hidden danger, to shorten the product development cycle, save money, improve product quality.

Keywords: *flywheel, casting, numerical simulation, shrinkage*

1. Introduction

Rotary power transmission in the explosion stroke, the energy is absorbed and stored by the flywheel for the next stroke, make the crank shaft turning smoothly, outer ring gear is used for swinging the engine when it starting, the back of flywheel is contacted with the clutch disc, as a assembly component of clutch. After Ignition, the starter gear teeth meshing with the flywheel's, the piston is driven by flywheel - Spark ignition - fuel injection - began acting, in which the flywheel make a important role. The reasons for vehicle flywheel damage often caused by: 1\ the stiffness of pressure plate spring is not enough 2\ pressure plate bad contact or the gap is too large 3\ contact surface with oil or foreign matter 4\ long half-clutch state of the clutch, all of above may cause clutch slipping and causing flywheel death. The casting molding process of flywheel be simulated, numerous defects that are caused by the filling and solidification process can be predicted through the analysis of the filling and solidification process. Defects that can be generated during the filling and solidification process include faults where the casts are not completely filled, subsidence of air or gas and oxidation of molten surface metal due to errors such as unstable packing due to turbulence and air permeability faults in casts. Corrosion or breakdown can also occur due to high speed and temperature in the molten metal. To predict such defects, analysis of flow and heat transfer must be conducted during the packing stage of the cast.

2. The Design of Aluminum Flywheel

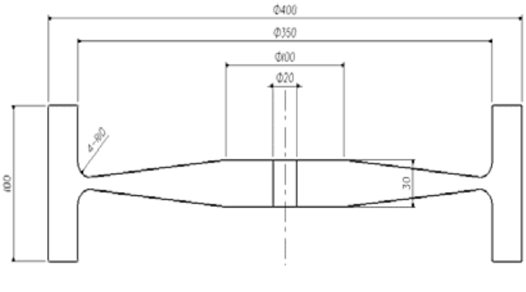

Figure 1. Geometry of Flywheel

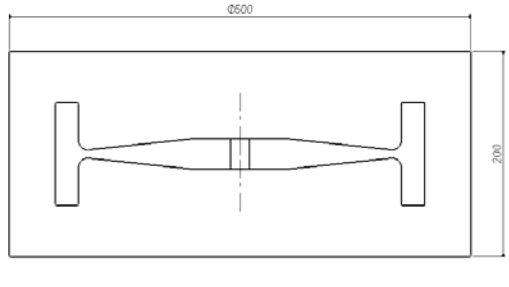

Figure 2. Geometry of Sand Mould

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The speed of flywheel can up to 6000-7000rpm (the same as engine speed), if the shock leading to flywheel flitting result of the enormous imbalance will cause the serious consequences of the engine and gearbox together with breakage. The flywheel is designed shown in Figure 1, the corresponding sand mold shown in Figure 2. The key part to the force of measure the distance of the end of S side, the absolute time T_0 for failure, T_1 fault initial line wave to reach the S side of the moment, T_2 at the point of failure reflection waves reach the S side of the T_3 is reflection-side bus wave to reach S end of time, L, for the Total length of transmission line, v The for Travelling Wave Speed. Displacement is equal to the velocity multiplied by time derivation is as follows flywheel are the external and internal hole, these parts should be given special attention in the casting process.

3. The Casting Process Simulation

3.1. The Choice of Casting Method

Sand casting is used as casting method, the dimensions of sand mould were: Height 20cm, radius 25cm, 750°C when aluminum liquid injects into sand molds. Sand mold initial-temperature was 25°C, the way of convection heat in the top and side of the sand mold through the free exchange. Ambient temperature was 30°C, the side heat transfer coefficient was 7.5 W/m2-°C, and the top surface heat transfer coefficient was 5.75 W/m2-°C. Casting model was axisymmetric. The thermal property of sand was assumed to be uniform, and the thermal property of aluminum was change over time. The characteristicals of sand model (constant): Thermal conductivity: 0.346 W/m-°C; Density: 1520 kg/m^3; specific heat: 816 J/kg-°C.

3.2. Simulation of Casting and Discussion

The continuous drive to improve product quality has motivated development of the associated manufacturing processes. This includes computational tools to assist with process development, such as CAD coupled with simulation techniques. For the casting process, significant achievements have been made. These have focused principally on filling and solidification simulations and, to a limited extent, on post-solidification evolution of mechanical properties and thermal stress. In each phase, knowledge of the relevant thermophysical properties together with parameters that are specific to the casting process that is being employed is required. Experiments for establishing these are either costly to perform or the procedures are still not sufficiently well established and reliable at this time. In spite of these difficulties, casting process simulation is gaining wider acceptance in both process design and development roles [1]. Because of the increasing maturity of basic simulation techniques for the casting process, the future drive will be towards exploring methods of process optimization using computational techniques, including numerical simulation. The principles illustrated the potential of the approach and this motivated the present investigation to explore and expandthese principles further. There are a wide range of applications for CAE technology in the casting process [2], the specific process was: Open the pre-processing module (anyPRE), import the three-dimensional model of STL files into the anycasting software, in accordance with parameters set above, and set the end of the simulation conditions, after done this, saved the file format with *.gsc, started anySOLVER calculation, opened module of anyPOST for the results analysis at last, including three parts of process data, a simple contraction and micro-structure prediction. Process analysis data mainly including filling time, solidification time, shown in Figure 3, the filling time was 0.2072 seconds. Casting center has a few isolated hot center in outside, the role of self-feeding is hard to working because the casting surface is not form a hard shell during the solidification, so in the vicinity of this region and the final solidification of the central region will likely have different size shrinkage or shrinkage which is negative for the dynamic balance, we can consider the pressure riser or non-riser design to removal [3, 4], while paying attention to the quality of filling and solidification of the force key part in the casting external; Riser and the middle part has a longer clotting time, two riser can be considered for part of the local heavy placed to ensure adequate hot metal give the feeding when the solidification, to prevent shrinkage [5]; simple contraction part mainly including the reciprocal interface moving velocity, cooling rate, as shown in Figure 4. The reciprocal interface moving velocity reflects the effects the location of solid – solid and liquid - liquid interface to contraction speed. The location of solid-liquid interface have a great affected on the drawing velocity, with the drawing velocity increases, the solid-liquid interface location moves down, we can carry out such process as directional solidification unidirectional [6]. Can be seen from the cooling rate of cooling more faster in the outer part, slower in the thick part, for a good cooling process, make sure the cooling rate as far as possible consistent. The solidification time is shorter in thin part compare with the thick part. Microstructure [7] for prediction aspects including nucleation density, grain size, the more adequate for filling the nucleation density larger but grain size smaller [8], directly determines the physical and mechanical properties of finished components.

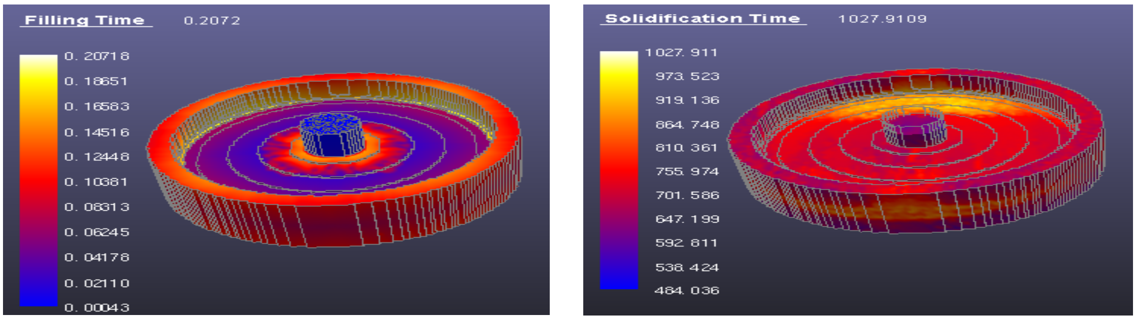

Figure 3. Simulation Results of Process Data

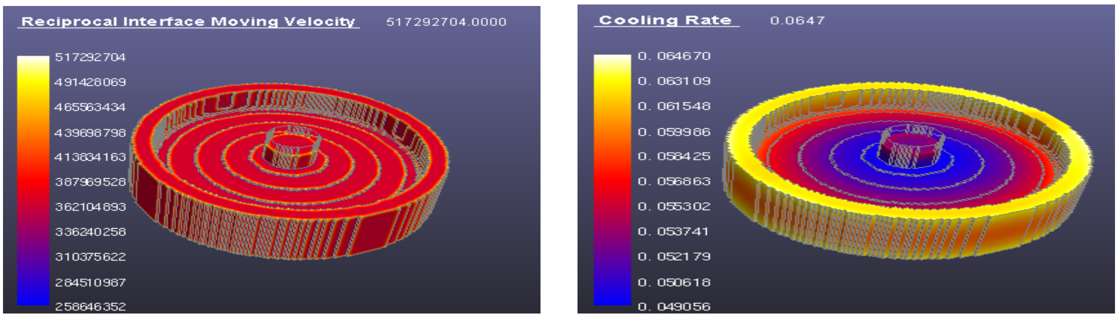

Figure 4. Simulation Results of Simple Shrink

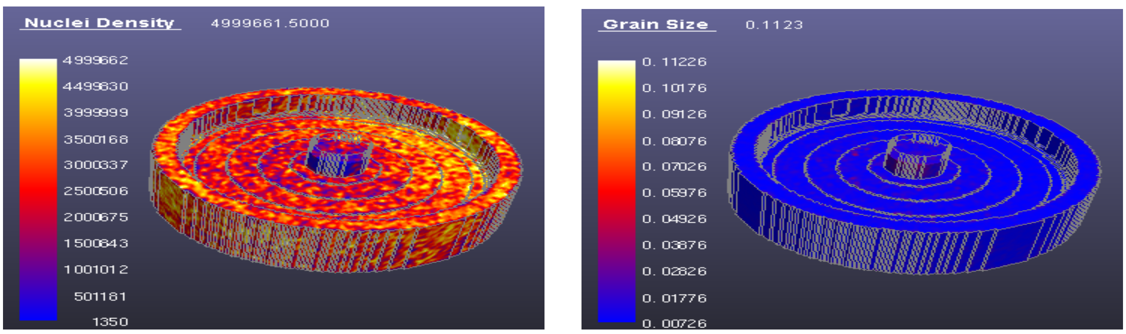

Figure 5. Simulation Results of Microstructure Prediction

Therefore, we can improve the mechanical properties of the final product by increasing the number of riser in the casting design to increase the adequacy of filling. Show as Figure 5.

4. Conclusion

This model uses a unit type: PLANE55, axial symmetry. Two materials: aluminum (with phase change) and sand (uniform material properties). Use static analysis to determine the initial temperature: the initial temperature of sand mold was 25°C, and aluminum's was 750°C. Anycasting software is used for flywheel filling, solidification simulation, to prediction the liquid metal filling, solidification time, temperature distribution; through the flow field and temperature field coupling calculations to predict the casting shrinkage, defects such as shrinkage and causes of the site. In this way that we can find the possible defects prior to actual casting. We can change the product design before hand, shorten the production cycle, access to qualified casting products.

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