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### SECTION 6. Metallurgy and energy.

## CONDITION OF A CASTING MATERIAL OF A CYLINDER BLOCK OF A CAR AFTER CRYSTALLIZATION IN A SAND MOLD

**Abstract:** Condition analysis of a cast iron cylinder block of a car after casting in a sand mold was performed in the article. An assessment of effectiveness of a gating-feeding system and predicted casting defects of a casting material after crystallization is given.

**Key words:** a cylinder block, a sand mold, crystallization, grey cast iron.

**Language:** English

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### Introduction

Some parts of a car, having a complex configuration, are made by different methods. A cylinder block is the main part of an internal combustion engine of the car [1 – 3]. The cylinder block is made by the various casting methods (a sand mold casting, a free chill casting, the chill casting under low pressure, a die casting and molding), depending on material, accuracy of dimensions, surfaces roughness of the part. The most economical method of manufacturing of the casting is gravity casting so as the cylinder block is mainly made of gray cast iron (taking into account of high castability of melt) [4]. The casting of the cylinder block has mass of about 60 kg (without taking into account of a gating system) and walls of different thickness. Complete filling of gray cast iron melt into the sand mold is provided by a calculation of dimensions (number) of elements of the gating system. A computer simulation of a gravity casting process will allow to give an assessment of stress-strain condition of the casting material at calculated values of dimensions and the required number of the elements of the gating system of the sand mold [5 – 6].

### Materials and methods

The gravity casting process of the cylinder block in the sand mold was implemented by means of the computer simulation. The casting was made of gray cast iron EN-GJL-250. Quartz sand was adopted as material of the sand mold. Initial temperature of gray cast iron melt before filling of the sand mold

was 1290 °C, initial temperature of the sand mold was 20 °C.

The gating system of the sand mold consisted of a pouring basin, a downsprue, a vent, a slag trap and three feeders [7]. Probability decreasing of occurrence of casting defects (for example, incomplete filling in the casting) [8 – 9] is provided by the careful calculation of dimensions and shape of the gating system of the sand mold. The model of the gating system was built according to the results of the calculation of the gating system of the sand mold for casting of the presented cylinder block: alloy density – 7012.4 kg/m<sup>3</sup>; weight of each casting – 66.87 kg; number of the castings in the sand mold – 1; weight of all feeders connected to one casting – 0.1 kg; dominating wall thickness – 10 mm; total average height of the casting in pouring position – 549.6 mm; height of the casting in a cope – 274.8 mm; the downsprue length – 649.6 mm; number of main runners connected to the downsprue – 3; average length of each main runner – 400 mm; suggested approximative pouring time – 11.18 s; selected pouring time – 17.52 s; pouring rate – 3.8 kg/s; a pouring box, an inner section area – 10900.3 mm<sup>2</sup>; width – 85.2 mm; length – 127.9 mm; height – 85.2 mm; weight – 5.75 kg; the downsprue weight – 1.15 kg; upper diameter – 26.7 mm; lower diameter – 9.1 mm; total friction factor – 0.36; effective pressure height – 666.2 mm; maximum true velocity at ingates – 1299.1 mm/s; the total ingate section area – 419.5 mm<sup>2</sup>; the section area per ingate – 139.8 mm<sup>2</sup>; suggested thickness – 6.8 mm; suggested width



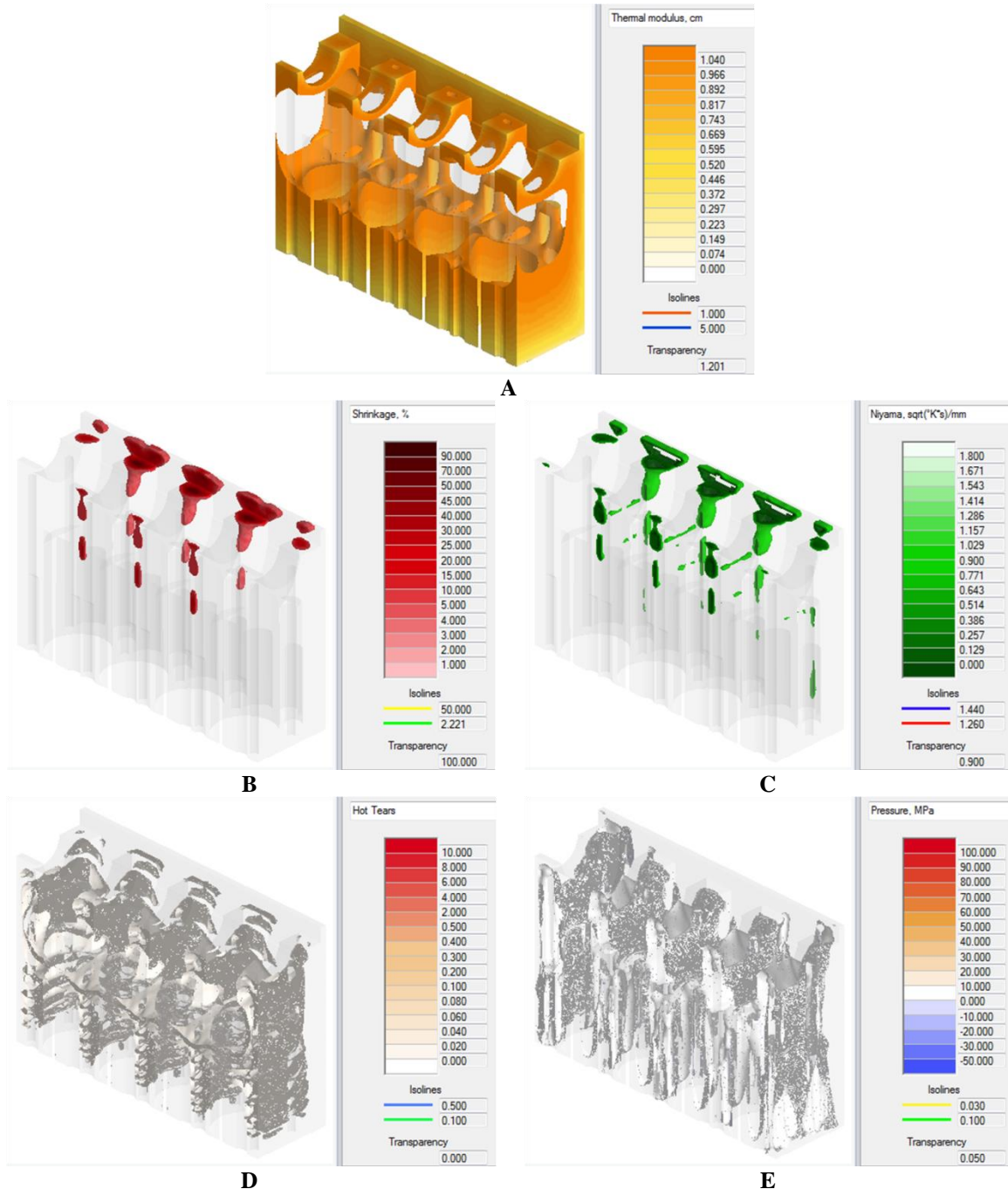
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– 20.5 mm; the total section area – 734.2 mm<sup>2</sup>; the section area per this runner – 244.7 mm<sup>2</sup>; suggested base and height (if the square section) – 15.6 mm; total weight of the main runners – 2.1 kg; total weight of the gating system including the feeders – 9.06 kg; casting yield – 88.1%.

## Results and discussion

Condition of the casting material after crystallization is presented by color contours on the three-dimensional model (the Fig. 1).



**Figure 1 – Condition of the casting material after crystallization:**  
**A – Thermal modulus, B – Shrinkage, C – Niyama, D – Hot tears, E – Pressure.**

Casting time of the cylinder block was 1321.457 s at calculated filling rate of the sand mold by melt of grey cast iron. Temperature of the casting material after crystallization was calculated in the range of 575...1129 °C, temperature of the sand mold

was calculated in the range of 20...1085 °C. The ratio of minimum temperature of the casting material to maximum temperature is approximately 1:2. A temperature change boundary is located on the thin-walled elements of the casting.

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The transparent areas of thermal modulus on the cylinder block model are material volume which crystallizes more slowly. This is due to insufficient feeding of melt at filling of the sand mold. Insufficient feeding is 35 – 40% of total volume of the cylinder block material.

Volume shrinkage of the casting material after crystallization was 0.24%. Maximum shrinkage of material is determined in a field of supports (for setting of root liners) of the cylinder block.

Porosity formation is also observed in the field of the cylinder block supports. This phenomenon, in the loaded fields of the casting, can lead to cracks and decreasing of an operation period of the part in an assembly unit.

Hot tears in material after crystallization are formed in the massive elements of the casting. Hot tears are practically not found in the thin-walled elements of the casting. Distribution density of hot tears in the casting material is high.

Material in a middle of the casting is exposed by tensile stress after crystallization. Residual compressive stresses of material were defined in surface layers and at bottom of the cylinder block.

Maximum calculated residual stress in the casting material is 877.742 MPa.

### Conclusion

Thus, based on the performed analysis of the research results of the casting process of the cast iron cylinder block of the car in the sand mold, the following conclusions can be drawn:

1. The calculation of the elements dimensions of the gating system of the sand mold for casting of the cylinder block is proposed. Gravity casting is recommended to perform at pouring rate of gray cast iron melt of 3.8 kg/s. Predictable casting yield is 88.1% at the calculated values of the gating system parameters of the sand mold.

2. Slow cooling of material in the middle leads to occurrence of residual stresses of various kinds in total volume of the casting. The distribution ratio of hot tears in the thin-walled and massive elements of the casting is given. The dependence of porosity formation in material from volume shrinkage of the casting material is presented. The cylinder block supports are the most exposed by casting defects.

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