INTENSITY AND HOMOGENEITY OF INITIAL TEMPERATURE FIELD ON THE ACTIVE WORKING SURFACE OF ALUMINIUM DIE CASTING DIE

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ABSTRACT

Die casting is the most economical process of casting very sophisticated and precise aluminium products in big-scale series. From the aspect of economical production of aluminium die castings it is very important that the dies have a long working life, because the replacement of a die is expensive in both: money and production time.

On the active working surface of the observed aluminium die casting die cracks appeared after less than 1000 shots and caused in imprints castings. The cracks on the surface are visible by visual and magnifying glass observation. Die design, material selection and thermal stress fatigue due to the cyclic working conditions, as well as to low and inhomogeneous initial die temperature contribute to cracks formation.

In the frame of our investigation work the intensity and homogeneity of the temperature field on the active working surface of the fixed die half during preheating process were checked through thermographic measurements.

1. INTRODUCTION

For economical production of aluminium and its alloys die castings it is important that the dies have a long working life. The replacement of a die is expensive in both money and production time.

The most frequent failures of aluminium die casting dies are: 1. heat checking, 2. gross cracking or cleavage cracking, 3. cracking in corners, sharp radii, or sharp edges, and 4. wear or erosion [1]. It is generally agreed that one of the principal causes of termination of die life is heat checking [2], which occurs through a process of crack initiation and propagation from the thermal stress fatigue [3] induced on a die surface.

Some of the factors that affect die failures may be controlled to some extent by the die casting experts (designers, manufacturers and operators).

These factors include [4]: 1. design, 2. materials selection, 3. heat treatment, 4. finishing operations, and 5. handling and use.

When hot aluminium strikes the active working surface of the die, the die expands and then contracts during cooling, as the heat in the casting is conducted into the steel bellow the surface of the die. The greater difference between the temperature of the die and that of the hot aluminium shot into the die, the greater will be the expansion and contraction of the die surface, and sooner the die surface will be heat check.

Since the stresses produced on the die surface are inversely proportional to the die temperature, it is good practice to run the dies as hot as is practical and economical. Aluminium die casting dies should be preheated to approx. 260 to 315 °C. Experience has shown that by increasing the die operating temperature from 205 to 315 °C, die production may be doubled [5].
2. EXPERIMENTAL
The discussed aluminium die casting die has been manufactured from well known BOEHLER W300 ISODISC hot work tool steel [6] which has frequently been used for similar dies and tools.

![Figure 1. Fixed half of the die casting die.](image)

On the active working surface of the fixed die half (Fig. 1) thermographic measurements have been carried out in the preheating period of the die to its initial temperature (240 °C - homogeneous through the whole active working surface of the die) [7]. The required initial temperature was a little lower in comparison to the before mentioned reference values from the literature.

By thermographic measurements the required intensity and homogeneity of the initial temperature field on the active working surface of the fixed die half have been examined. Testing thermographic measurements on the chosen die have been carried out due to the relatively simple geometry of the discussed die, so the simple heat images (thermographs) analyses have been performed. For each thermograph the time (Tab. 1) of formation of image print is very important [8].

Table 1. Preheating process.

<table>
<thead>
<tr>
<th>Time (hour:min)</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:50</td>
<td>start of preheating</td>
</tr>
<tr>
<td>11:30</td>
<td>start of measurements</td>
</tr>
<tr>
<td>11:32</td>
<td>calibrating of thermographic camera</td>
</tr>
<tr>
<td>11:50</td>
<td>opening of the die No. 1</td>
</tr>
<tr>
<td>12:20</td>
<td>increase of heating oil flow (for 100%)</td>
</tr>
<tr>
<td>12:45</td>
<td>start of the heating by increased oil flow</td>
</tr>
<tr>
<td>14:00</td>
<td>opening of the die No. 2</td>
</tr>
<tr>
<td>15:00</td>
<td>opening of the die No. 3</td>
</tr>
<tr>
<td>15:05</td>
<td>end of measurements</td>
</tr>
</tbody>
</table>
Thermograph in Fig. 2 is presented in the temperature range between 90 and 161 °C, where uncoloured (black) regions are below 90 °C. Preheating times of similar dies are more than two times shorter than they should be during our testing (max. up to 2 hours regarding to more than 4 hours in the discussed case) [9]. Generally speaking, thermographs give us useful data for the correction of the old dies and/or development of new ones.

![Thermograph](image1.png)

**Figure 2.** Temperature field on the active working surface at the end of preheating process (initial temperature field).

![Surface cracks and pits](image2.png)

**Figure 3.** Surface cracks and pits on the active working surface of the die. SEM; Magn. 200x (left). Surface pits. SEM; Magn. 500x (right).

The cracks which appeared in sharp transitions between two planes of fixed die half (Fig. 3) after less than thousand shots were revealed and identified by the use of penetrants. Some of them were also clearly seen by the use of magnifying glass or even by naked eye. In the presented investigation also non-destructive metallographic examination by optical microscopy and by SEM (scanning electron microscopy) of polymeric replicas was applied [10].
3. CONCLUSIONS
The required intensity and homogeneity of the initial temperature field of the discussed case are not possible to reach without changing the design of die and the heating method. Cracking on and also in aluminium die casting dies is caused by a number of different and simultaneously operating stresses. The failures observed on the active working surface of the fixed die half for die casting of aluminium alloy belong to heat checking initiated at identification marks, and cracking in corners, sharp edges and transitions.

4. REFERENCES
1. W. Young, Precision Metal, 3 (1979) 28.