ANNEALING OF THE ALUMINIUM ALLOY TURBOCOMPRESSOR CASING IN THE GAS FURNACE

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Abstract
An annealing furnaces play important role in the thermal treatment of various metal castings for the automotive industry. Their thermo-technical characteristics have a great influence on the product quality and costs.

In the frame of our investigation work we have performed control thermo-technical measurements in the annealing process of the testing charge of the aluminium alloy AlSi9Cu3 turbocompressor casing in the gas furnace Cimafond – Global, installed in the Cimos foundry.

For the purpose of thermo-technical measurements we designed a measuring system consisting of three basic elements: coated Ni-NiCr thermocouples, data acquisition modul, and PC computer which recorded the results of the measurements.

At the same time, the measurements of temperature of the testing charge and the temperature of the atmosphere in the furnace were carried out.

1. INTRODUCTION
An annealing furnaces play important role in the thermal treatment of various metal castings for the automotive industry. Their thermo-technical characteristics have a great influence on the product quality and costs.

Figure 1. Furnace Cimafond – Global, installed in the Cimos foundry, and basket with the turbocompressor casing No. 434-8071.
In the scope of the research, we carried out the control thermo-technical measurements in the annealing process of the testing charge of the casting of turbocompressor casing No. 434-8071 in the gas furnace Cimafond – Global.

The gas annealing furnace Cimafond – Global was manufactured by an Italian company Cimafond.

The furnace is practically new with the year of production 1999, and was first installed in the Cimos foundry in Roč (Croatia). The maximum heating temperature of this furnace is approximately 600 °C, which is fully satisfactorily in the case given.

2. TECHNICAL DATA ON THE CASTING
The material of the casing is aluminium alloy AlSi9Cu3 [1], with well known mechanical and thermal characteristics (easily found in technical literature, catalogues and data bases). The weight of the casting is 0.65 kg, the total weight of casting and feeder is 0.82 kg, the weight of the core amounts to 0.30 kg. Hence, total casting weight including the feeder and core comes to 1.12 kg.

The basket holding the castings that are inserted into the furnace for annealing, has the form of a block, of dimensions: length \( l = 250 \text{ cm} \), width \( w = 120 \text{ cm} \), and height \( h = 100 \text{ cm} \). The basket can hold approximately 2000 castings, which results in the whole charge mass of some 2250 kg.

3. THE ANNEALING PROCESS
The prescribed time schedule of the annealing process is devided into the three phases:
- heating,
- superheating, and
- cooling down phase.

The first phase in the annealing is an even heating of the charge up to the temperature 500 °C (the prescribed time of heating ranges from 2.5 to 3 hours). The temperature homogeneity of the atmosphere in the furnace and of the charge must be in the interval of \( 500 \pm 10 \text{ °C} \). For this purpose it was necessary to preliminary calibrate the furnace and perform the measurement of temperature of the atmosphere [2] and the temperature on the castings [3] at the same time. The time set for superheating of the charge in the furnace is 5.5 to 6 hours. The cooling-down process of the whole charge follows in the ambient temperature (ca. 2 hours).

For the purpose of thermo-technical measurements we designed a measuring system [4] consisting of three basic elements:
- even coated Ni-NiCr thermocouples,
- data acquisition modul ADAM – 4018, and
- PC computer which recorded the results of the measurements in 30-seconds time intervals.

Table 1. The positions of thermocouples (testing charge) in the basket.

<table>
<thead>
<tr>
<th>No. TC</th>
<th>No. MC</th>
<th>Series</th>
<th>l (cm)</th>
<th>w (cm)</th>
<th>h (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>Series 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>Series 6</td>
<td>25</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>Series 7</td>
<td>25</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>Series 1</td>
<td>125</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>Series 4</td>
<td>250</td>
<td>120</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>Series 2</td>
<td>225</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>Series 3</td>
<td>225</td>
<td>60</td>
<td>100</td>
</tr>
</tbody>
</table>

TC – thermocouple ; MC= measuring channel
The seven testing castings were bored. Ends (tips) of thermocouples were inserted therein and fixed with wire. Then, in the filling of the basket with the castings of the seven testing castings were put on precisely defined, pre-selected places in the basket [5]. Their positions are shown in Table 1 with locating coordinates of length (l), width (w), and height (h), provided that the coordinates of the left lower margin of the basket are 0, 0, 0 (see Fig. 1).

In the gas furnace Cimafond-Global, there are control Ni-NiCr thermocouples installed at six points for the purpose of temperature control of the atmosphere in the furnace which is divided in two zones (Fig. 4).

![Diagram of furnace setup](image)

**Figure 2.** The positions of control thermocouples in the furnace.

The temperatures of atmosphere in individual points in the furnace (TC I-VI) and average temperatures in zones 1 and 2 are displayed digitally on the control panel of the furnace and can be directly read; the recording of the values is only possible manually. For the recording of results we selected a 15-minutes time interval. The ambient temperature ca. 1.5 m from the furnace was measured with the thermometer Gulton Testotherm D 1200.

4. RESULTS

The results of thermal-technical measurements performed in annealing of the testing charge of castings of the turbocompressor casing 434-8071 are shown on the graphs in Figs. 3 and 4.

![Graph of temperature profile](image)

**Figure 3.** Measured temperature profile in the furnace; thermocouples: TC I - TC VI.
In the course of measurements of temperature atmosphere in the furnace, the prescribed temperature of 500 °C was achieved after some three hours. In the course of superheating, in the part of the furnace where the thermocouple TC II is applied to measure temperature, a declination of temperature outside the tolerance area toward the positive direction (+) (maximum measured temperature was 541 °C) occurred at certain time intervals. The heating time of the testing charge to the prescribed temperature value of pre-heating (500 °C) was some 6 hours (see Fig. 4) and exceeds the prescribed time (2.5 to 3 hours) for heating at least by 100 %. In the course of superheating of the charge at temperature 500 °C, there were from time to time only slight deviations outside tolerance values 500 ± 10 °C (by max. to + 4 °C).

Figure 4. Measured temperature profile in the basket holding castings; thermocouples: TC 1 – TC 7 (measurement errors eliminated)

At the beginning of measuring and in the time between the 5th and 7th hour of temperature measuring, the measurements led to technical problems on TC 1 and TC 2, or measuring channels 5 (Series 5) and 6 (Series 6). As the measured results for certain time intervals are not accurate, we disregarded all these values in the analysis. The view on temperature movement in the basket holding test castings on the measuring channel No. 1 (see Tab. 1 and Fig. 4) that shows the temperature in the central point of the basket (at the point of intersection of its diagonals) is of special interest.

5. CONCLUSIONS
In the annealing process of the test charge of the turbocompressor casing No. 434-8071 in the gas furnace Cimafond-Global, we also measured the time course in the temperature of atmosphere in the furnace and of castings, at the same time. The results of temperature measurements showed a certain deviation from temperature values prescribed in the time schedule diagram of the annealing process.
In further work on the problem described here, the reasons for this deviations need to be
analysed and the process has to be optimized.

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