Characteristics of Brake Disc Castings Day by Day

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Abstract

In the paper are presented results of the project of Foundry R&D department made in Brembo. Present paper focuses on the changes of some characteristics of casted rotors with time and temperature. Possible correlation with other well-known parameters which are commonly used for daily castings quality measurement, like mechanical properties are also considered.

Keywords: Gray iron, Rotors, Natural frequency

1. Introduction

Everybody is well known about the goal to be achieved when we press the brake paddle in the car. Cast rotors are mainly responsible of this effect and they work in variable conditions due to different factors which include friction, load variation, shape and length of road pave [1]. Friction, which is the result of using brakes, put high demands for the castings which are used during the process for car stopping. It is very important to produce a material having a uniform, compact structure, the most wear-resistant thermal and frictional wear.

Gray cast iron, better than other materials, satisfy all the requirements necessary to work under such tough conditions. Cast iron has: high thermal conductivity, high scuffing resistance, high friction factor and strength, constant size in high temperature and low elasticity modulus [2].

A key indicator for final users, that is not so easy to measure, is comfort. Many parameters can describe this indicator but OEMs are mainly oriented to rotor natural frequency.

2. Description of the approach, work methodology

Since vibrations in the range of 20 – 20,000 Hz are audible by people; the natural frequency of the element is under strict control by OEMs.

The idea of the quality castings verification by sonic methods is quite old [3] and has been investigated in different devices [4] in many countries [5-8].

Natural frequency is determined by a number of factors:
1. Element geometry and shape
2. Size and mass of the element
3. Walls thickness
4. Elasticity modulus

All this characteristics except geometry and shape are determined by material texture and structure [9].

Due to all this factors frequency range is different for different rotors.

Investigation of natural frequency of fully machined ventilated rotors has been performed on parts casted with standard production process in Brembo Foundry in Dąbrowa Górnica.
Natural frequency was measured on stations specially designed for Brembo as presented on Figure 1, 2.

Non-destructive techniques, mandatory to check casting quality, can be classified according different criteria. These can be, for example:
1. Related to surface inspection, like magnetic flaw detection
2. Use of various penetrants liquid
3. Visual inspection
4. Volumetric methods:
   a. radiography
   b. thermography
   c. acoustic emission
   d. ultrasonic tests

3. Description of achieved results of own researches

Quality, besides life time, is castings main key performance indicator.
For natural frequency the measurement is based on the sound induced by inductor, as a result the screen displays graph with the ranges of natural frequencies.
Frequency controls were repeated for 30 days on daily base to evaluate the modification on machined rotors stored in ambient temperature. The results of the measurements are showed on Figure 3.

In the following chart it is visible that the dynamic rise of the frequency is through first 8 days, from 1082 to 1089 Hz. After that time results are more stable, next 12 days give us rise by 2 Hz only, and after that till the end of the period, natural frequency changed only by 1 Hz.
Rotors from the same production batch were also checked for natural frequency changes with the temperature.
The procedure was based on chilling rotor to –25 °C in dry ice and measuring the changes of frequency. Then rotors were heated to ambient temperature and frequencies were measured again. The result of the natural frequency measurements at different temperature is presented on Figure 4.
An important observation is that when rotor gets back to ambient temperature natural frequency come back to the previous, before chilling, level.
Not avoid important parameters which are commonly used for castings quality evaluation also mechanical parameters were measured:
1. tensile strength (Rm),
2. hardness (HB).
The methodology of measurement require to check characteristics in more spot of the rotor, see Figure 5.

HB was measured in points A, B, C, D. Rm on 3 samples cutted from A. The numbers of samples is limited by the fact that these kinds of check are destructive method.

In following chart (Fig. 4) results of natural frequency measurements for chilled castings are presented. It is visible that when rotors are at low temperature natural frequency rise. Measurement was done on both way: from ambient temperature to low temperature and coming back to the ambient temperature again. What is important is that when temperature gets back to ambient temperature also natural frequency come back to previous, before chilling, level.

Result of mechanical characteristics change in time are presented in following charts (Fig. 6).

Rm is not impacted by time at standard ambient condition; after first 2 days when Rm fall down then came back almost at the same level as was on the first day. HB shows a tendency to moderate increase, but the difference was within 5 points which is not significant and can be treated as neglectable.

4. Conclusions

Rotors natural frequency tendency is to increase during the first two weeks after production and after that time to get stable. In standard working condition temperature range there are no changes of rotors natural frequency while moderate increase takes place going down further below – 15 °C. Modification with temperature is completely reversible on the contrary of that happening with time, in reference to the natural frequency. Rotors mechanical characteristics don’t show sensible changes in time.
References