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Use of Microscopical Techniques in Failure Analysis and Defect Control in Automotive Castings

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The automotive industry has been the driving force behind a series of improvements in daily life. Stringent requirements for energy consumption have made lighter and faster cars that do not compromise safety regulations. These apparently contradictory requirements have been accomplished by the development of improved products and processes, among these are the ones related with the replacement of iron and steel parts with those made from lighter aluminum alloys, such as the extensive use of cast aluminum alloys for cylinder heads and engine blocks.

These pieces can be cast by gravity or either low or high pressure can be used to fill the mould or die. Different defects can be encountered while processing, some of them can be originated while pouring the liquid metal, whereas others can be due to solidification reactions, presence of exogenous inclusions, or by the way the pieces are treated during extraction or heat treating.

A series of cylinder block heads (CBH) were reported to leak while being tested under water. Visual inspection indicated that the origin of the problem was located towards the upper portion of the pieces, which were sectioned for their X-ray inspection and examination by optical microscopy (OM), the liquid metal was also tested for cleanliness. OM put in evidence the presence of thin oxide films within the cast pieces, Fig. 1, that are associated with the oxidation of turbulent flowing metal. Inspection of casting operation revealed that in some cases the metal was cascading into the mould, Fig. 2. Corrective actions were made in such cases and the defect was suppressed.

Some other CBH were found to leak when subjected to the water test. OM examination of these pieces indicated the presence of porosity close to the bottom portion of the piece, Fig. 3. Their roundness allowed to assume that these defects were caused by trapped gases, but the use of an image analyzer, in the false color mode, indicated the presence of sand grains within the pores, Fig. 4. It was concluded that the defect originated by sand that was carried away from cores and was trapped in thin walls. The grains did not allowed for the free flow of liquid metal into these walls and, the lack of adequate feeding, caused the occurrence of this defect. Actions were taken to assure the integrity of the cores, the use of higher resistant coatings and better care to the assembly of the moulds.

Some pieces were detected to be faulty while being machined, the pieces with the defect were sectioned to be analyzed by different techniques. It was observed that the defects appear towards the upper part of the piece. Microstructural analysis showed that some defects were caused metal flowing from different directions, whereas some others were associated with a series of bubbles caused by turbulence. This study resulted in the modification of the feeding system and in better care on the coating used to protect the mould.

The cases that are presented were solved with the aid of various metallographic techniques. Final solution of the defects was obtained when the causes producing these defects were known, and the shop took proper care.

Fig. 1 Fracture surface of the piece with the defect.

Fig. 2. Liquid cascading into the mould

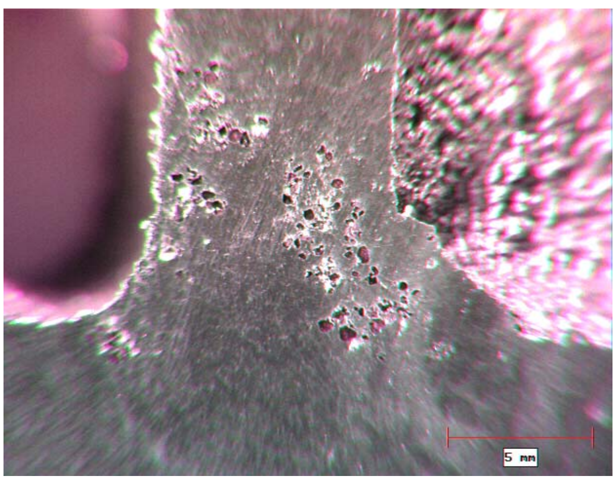

Fig. 3. Defects found in pieces.

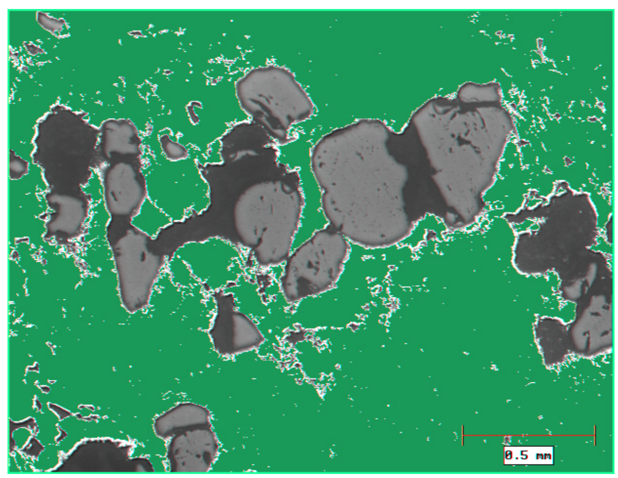

Fig. 4. Porosity detected in the piece.

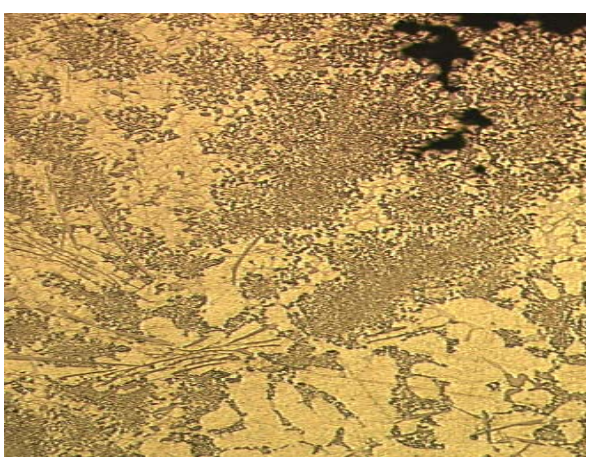

Fig. 5. Microstructure of the zone with the defect.

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