Abstract

Gray cast iron (GCI) takes part in a wide range of applications in industry especially automotive one due to its unique properties like castability, machinability, low melting point and low cost as well. It's used in manufacturing engine block, clutches, cylinder head, drum brakes, etc.

The cooling rate of GCI affects its microstructure. Consequently, mechanical properties of GCI show strong deviation with the change in the texture of its microstructure. The main challenge with GCI is that surfaces are section sensitive i.e. microstructures vary within the same product at different sections.

Standards have classified grades of GCI into five distinguishable grades that are distributed from A to E. Each grade is concerned with a certain shape of graphite morphology and distribution. The followed standard was offered by General Motors DAEWOO Auto & Technology Company (GMDAT) that was used to distinguish between GCI grades.

GCI grading is always held by visual inspection. Although manual assessment to images gives accurate results, it's susceptible to human error, lack of experience and variation of the operators' performance. Thus, automated image processing has a great contribution in this area. It reduces the amount of time required and increases the accuracy of extracted data.

In the presented research, A microscopic setup (IN-MM600) is used for image capture. The system consists of an inverted microscope, a CCD camera and a computer with compatible software ready for image capture. Specimens were prepared following the GMDAT standards and images were captured at a magnification of x100.

Due to local imperfections on sample surfaces, human error during light tuning of the microscope in addition to the probability of presence of dust in the image capture medium, image enhancement was needed to equalize the parameters of each image in a way that ensures fair neural network (NN) decision.

Statistical features were extracted from images using a textural analysis technique named gray level concurrence matrices (GLCM). These statistical features were then inserted to the NN as inputs.

Feed Forward Neural Networks (FFNN) were designed and trained on different parameters until two of best performance were chosen . average of output of both networks was used as the decision of the created software named Gray CIMA ; Gray cast iron multi-assessment.

Gray CIMA involves two modules of GCI assessment suitable for both professionals and non-professionals. Manual module requires users' previous knowledge of grades and categories of GCI. While the automatic one can validate GCI images and guide the user about the sample's grades without much information from the user.

The trained neural networks have shown a total identification of samples of 98% with an error that varies between 3 – 4 %. Through samples identification testing, Gray CIMA has successfully distinguished between GCI images and images of other CI types and rejected images of ductile CI. On the other hand, Metavision, a commercial software used for validation, identified ductile CI to be more than 50% grade A GCI.