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Image-based classification of defects in frontal surface of fluted ingot

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Abstract

An image-based comparative study of different defect classification methods has been presented. Bayesian Network, Artificial Neural Network (ANN) and Probabilistic Neural Network (PNN) based classification techniques have been used for classifying the defects in frontal surface of fluted ingots, which are used for the production of locomotive wheels. The complete system has been implemented for one of the integrated steel plant of India.

Keywords: Fluted ingot; Surface defect classification; Bayesian Network; ANN; PNN

1. Introduction

The increasing demand for high quality standards, increased yield and higher productivity in manufacturing sector has necessitated the development of products and systems, which can provide a competitive advantage to business. Production of locomotive wheels is one of such sectors where hundred percent nondestructive testing is conducted for accepting the final product. Since inspection is carried out almost at the final stage of the manufacturing processes as depicted in Fig. 1, it is imperative that rejection due to any defect in the product incurs substantial financial loss. To circumvent this, it has been found useful to develop an on-line defect identification and classification system at the initial stage of the production cycle. Vision-based inspection [1,2] of industrial products offers low-cost, high-speed and high-quality detection of defects. Automated visual inspection of materials, woven or non-woven, such as paper [3], steel roll [4], wood [5,6], carpet [7], textile fabric [8], etc., has been used for defect detection and quality assurance.

In order to meet the stringent quality requirement of the product, an on-line image-based defect identification system for fluted ingots has been developed. The system has been implemented in the wheel slicing section i.e., band saw machine where the input (fluted ingot) of the wheel plant is cut into three pieces. These pieces are called

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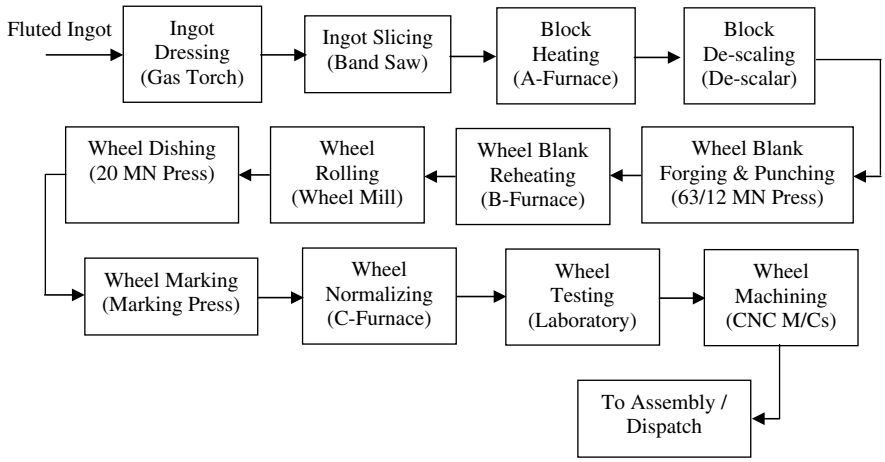

Fig. 1. Process flow chart of wheel shop.

cheese/block. The defects in the fluted ingots, which may in turn lead to the rejection, can be classified into broadly two categories (Fig. 2). These are:

1. Slant cutting of the cheese due to poor quality band saw blade, which leads to under/over weight of the cheese.
2. Metallurgical defects due to improper ingot preparation.

In making the input steel in the form of fluted ingots for bulk wheel production, it is normal that some deviations will occur as far as desired quality standards are concerned. However, to minimize these deviations, and once an unacceptable cheese has been produced, effort should be to segregate acceptable and non-acceptable materials effectively so that maximum number of ingot cheeses, which can be processed for further operations are available.

With the above objectives in view, it is necessary that the different defects associated with fluted ingots and their effects on subsequent processing are critically examined. Based on this, acceptable standards of different defects, with a view to stabilize rejection level of fluted ingots, are formulated. Accordingly, along with other parameters, the need for a judicious approach of rejection guidelines for defects arising in fluted ingots is felt essential. Therefore, in this work, an attempt has been made to detect the critical internal surface defect of ingots.

The system initially captures the image for defect identification. After necessary pre-processing, the image data are transmitted to the process control department for their scrutiny. If the captured image, after necessary analysis, is found defective only then the images of the same is stored for post-production study in order to initiate appropriate corrective actions. Since the system needs to cater the production rate of the plant to the level of 300 blocks per day, to avoid huge amount of storage space requirement, only images, which require post-productive study are stored. This post-productive study identifies the source of defects like mould preparation,

Fig. 2. Defective ingot blocks.