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Foundry quality control aspects and prospects to reduce scrap rework and rejection in metal casting manufacturing industries

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Abstract

Metal casting industries are actively involved to reduce the scrap rejection and rework during the manufacturing process of the components. To achieve this, the production concerns must follow the quality control procedures correctly and perfectly without any negligence. Timely implementation of the modified techniques based on the quality control research is a must to avoid defects in the products. In this review paper, some of the solutions and quality control aspects are explained in a simplified manner to eliminate the unawareness of the foundry industrial personnel who work in the casting manufacturing quality control departments. This review paper provides very valuable information to the young manufacturing and mechanical engineers who have interest to start their career in the manufacturing concerns of medium and large scale captive foundries. This paper discusses all about the general quality control aspects in a detailed manner. Besides, statistical quality control (SQC) is also highlighted to understand its recent application and techniques adopted in the developing metallurgical engineering foundries.

Keywords: Quality control; Statistical quality control (SQC); Quality circle; Quality assurance; Control charts; Captive foundries; Total quality control (TQC)

1. Introduction

Quality is defined as the fitness for use or purpose at the most economical level. It is an integral part of the process of design, manufacture and assembly. It can be assured by having effective procedures and controls at various stages. Manufacturing industries like foundries do not enjoy monopoly but they have to face competition. To overcome this problem and to retain the share of the market, it is necessary to constantly improve the quality of the cast product without the increase in the price of the products [1,2]. The price is influenced by the cost of production, which in turn is influenced by rework or rejection. Attention to quality assurance can reduce the wasteful rework. Aiming for quality in the first instance can reduce the cost of casting production. This quality production results in the company's growth and profitability. Quality in a product is difficult to define and invariably involves a consideration of the service environment. The most meaningful definition involves the concept of fitness for a given purpose or application at a prescribed life of number of hours, months or years in service. For a given set of service conditions, quality and reliability are interrelated to a certain extent. The minimum quality acceptable in any application is that level of quality necessary to ensure that the prescribed portion of the components will pass through the predicted service life without failure. If all the cast components survive the designed period of service under the given environmental conditions, then this constitutes 100% reliability [2]. The basic concepts of quality are that the finished cast products must meet established specifications and standards and hence customer's satisfaction will be derived from the quality products and services. Both of these can be attained by integrating quality development, quality maintenance and quality improvement of the product. These three aspects of a product can be achieved through a sound foundry quality control system [3,4]. The various meanings of quality are the fitness for purpose, conformance to requirements, grade, degree of preference, degree of excellence and measure of fulfillment of promises. The cast products should have certain abilities to perform satisfactorily. The factors governing are suitability, reliability, safe and foolproof workability, durability, affordability, maintainability, aesthetic look, satisfaction to customers, economical and versatility. The

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factors controlling the quality of casting design depends on the type of the customer in the market, profit consideration, environmental conditions and special requirements of the cast products. There exists a close relationship between quality and reliability. It is given as the sum of the quality now and quality later, which equals to reliability. The quality circles help in the improvement of product quality and productivity [5,6]. It implies the development of skills, capabilities, confidence and creativity of the people through cumulative process of foundry engineering education, pertinent training, work experience and participation [3]. A quality circle is defined as a way of capturing the creative and innovative power that lies within the work force and it is a group of employees, 3–12 doing similar work.

2. Emphasis of quality and quality control in foundries

The inspection of castings has the dual purpose of ensuring that the product confirms to design requirements and of providing information needed for quality control in foundry. Although foundry production and technical staff are concerned in many aspects of quality control, the systematic collection and interpretation of quality data is frequently channeled through an inspection department, which has a special responsibility for the administration of standards embodied in contracts and commercial relationships [7]. An outline chart for a foundry organization of inspection and quality control functions is illustrated in Fig. 1 [7]. The increasing weight given to the latter aspect, however, has led to new approaches in which a broader view is taken of the entire issue of quality design and management. A modern quality control foundry is thus concerned with a great deal more than the routine sorting of properties in relation to specified limits. Much data is obtained by the use of highly sophisticated equipment and techniques and more detailed treatment than simple go or no-go tests is required in interpreting the results. In the chart of Fig. 2 shown below, due to Quilter [29], this is formally recognized in the titles applied to the various functions and to the staff involved.

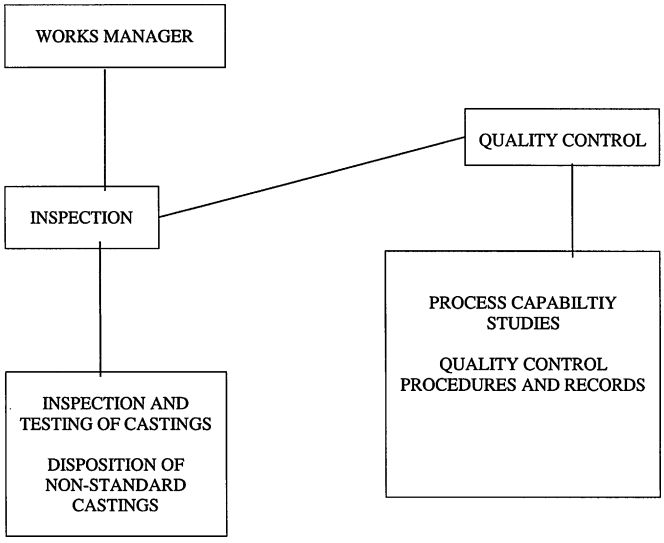

Fig. 1. Functional organization of inspection and quality control activities [7].

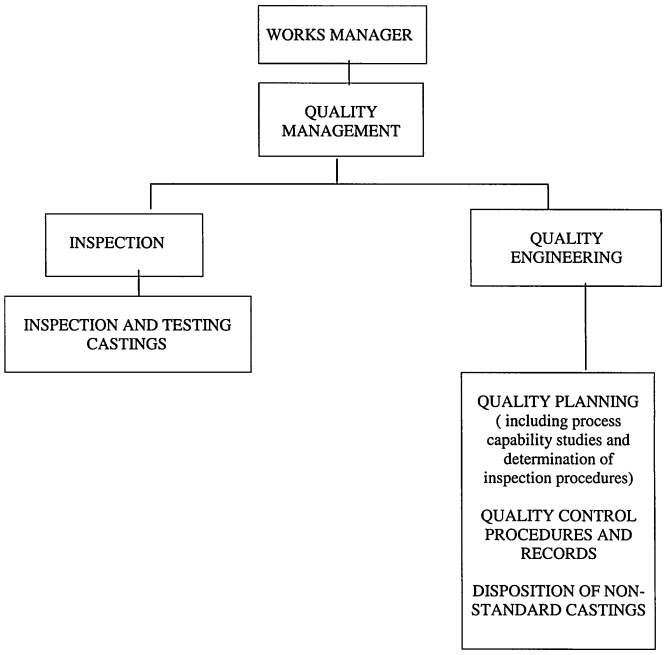

Fig. 2. Revised concept of foundry organization for inspection and castings quality [7,29].

3. Castings practice and quality control in foundries

Castings can be difficult to get right. Important rules are proposed as necessary and sufficient for the manufacture of reliable and quality castings [6]. It is proposed that they are used in addition to existing necessary technical specifications such as alloy type, strength and traceability via international standard quality systems, and other well-known and well-understood foundry controls such as casting temperature. The rules are summarized as follows [6].

- Start with a good quality melt.
- Avoid turbulent entrainment of the surface film on the liquid.
- Avoid laminar entrainment of the surface film on the liquid.
- Avoid bubble entrainment by properly designed offset step pouring basin and a well designed gating system.
- Avoid core blows by adequate venting.
- Avoid shrinkage.
- Avoid convection by absolutely reducing the convective loops in the geometry of the casting and rigging.
- Reduce segregation, particularly the channel segregation.
- Reduce residual stress by not quenching in water: the no water quench requirement.
- Provide location points for pickup for dimensional checking and machining.

4. Objectives of quality control in metal casting industries

The aims and objectives of foundry quality control are to improve the casting industries income by making the product more acceptable to the customers by providing long life, greater usefulness, versatility, aesthetic concepts, maintainability to