

Technical Paper

The Effects of Process Variables on the Dimensional Variation of Intermediate Spacer Castings Used in the Cement Mills - A Case Study

A. Chennakesava Reddy*, K. Siva Reddy** and Ch. Rajanna***

The present work highlights the application of statistical quality control (SQC) techniques to improve the quality of intermediate spacer castings used in the cement mills. Variation of dimensions on castings was analyzed using \bar{x} and R - charts. The number of defective castings were identified with the aid of P - chart analysis. C-chart was employed to count the critical defects, which are very serious with respect to quality of castings. The comprehensive analysis of this work led to the decision of changing or updating the moulding and heat treatment procedures.

INTRODUCTION

The need for maintaining and improving quality standard is growing with increasing competition. Every manufacturing organization is concerned with the quality of its product. Stiff competition in the national and international level and consumer awareness requires production of quality good and services for survival and growth of the company. Quality and productivity are more likely to bring prosperity into the country and improve quality of work life. The cement companies are widely spread throughout India. The cost, quality and durability of the parts being used in the cement mills as shown in fig. 1 influence the cost of the cement.

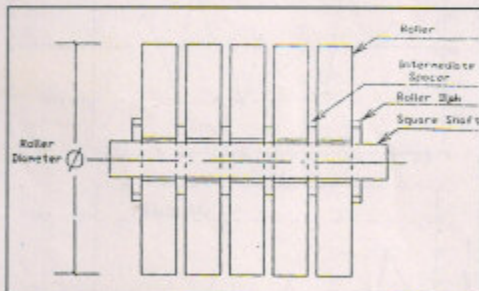


Fig. 1 : Cement mill

* Associate Professor and Life Member of I.E. (India), Department of Mechanical Engineering, Vasavi College of Engineering, Ibrahim Bagh, Hyderabad - 500 031

** Manager, Hyderabad Castings Pvt. Ltd., Hyderabad.

*** M. Tech student, JNTU, Hyderabad.

The present work is a case study, which focuses on controlling defects and dimensional variations in the intermediate spacer castings (fig. 2) of cement mills by SQC.

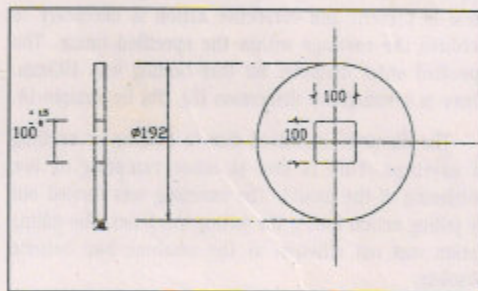


Fig. 2 : Intermediate spacer casting.

(All dimensions are in mm and tolerances as per IS:4879, CL. 1)

EXPERIMENTAL PROCEDURE

The green sand moulding process manufactures the intermediate spacer castings, which are being used in cement mills. The material used for intermediate spacer castings is cast Mn-steel of grade - 1 quality. The intermediate spacer castings are usually subjected to wear and tear during the manufacture of cement. During the production of intermediate spacer castings, the following dimensions were affected.

- Thickness
- Square hole
- Diameter of the castings

SQC techniques were adopted to solve these problems. The intermediate spacer castings were tested for the defects by the dye penetrant, X-ray and ultrasonic tests 200 intermediate spacer castings were tested to obtain the statistical data.

RESULTS AND DISCUSSION

The effects of the manufacturing process on the dimensions of the intermediate spacer castings, the number of defective disks and the number and type of defects are discussed.

Dimensional variation of intermediate spacer castings

Fig. 3 shows the variation of average dimensions of the intermediate spacer castings. The control chart shows that the points corresponding to the sample-2 and 8 are outside the control limits. Extreme variation is recognised upto the sample-9. Two points are falling outside the upper control limit; it means some assignable cause of error is present and corrective action is necessary to produce the castings within the specified limits. The specified outer diameter for this casting was 192mm. There is a sub-group dispersion (fig. 3b) for sample-14.

The diameter increased due to bulging or swelling of castings. This is due to loose ramming or low hardening of the mould. The ramming was carried out by jolting action (using the jolting machine). The jolting action was not efficient as the machine had become obsolete.

Variation of square hole dimensions is shown in fig. 4. The control chart for mean (fig. 4a) reveals that the samples-6 and 15 are outside the upper control limit and the sample-12 falls outside the lower control limit. Erratic fluctuation, which is characterized by ups and downs, can also be seen. This may be on account of single or group of causes affecting the process level and spread. The causes of erratic fluctuations are rather difficult to identify. It may be due to different causes acting at different times on the process. But the range of readings is within the control limits except for sample-13 as shown in fig. 4b. The causes of erratic fluctuations are:

- Frequent adjustment of moulding machine
- Change in operator or testing equipment
- Improper cores
- Change in chemical composition of metal owing to melting and pouring on different days.

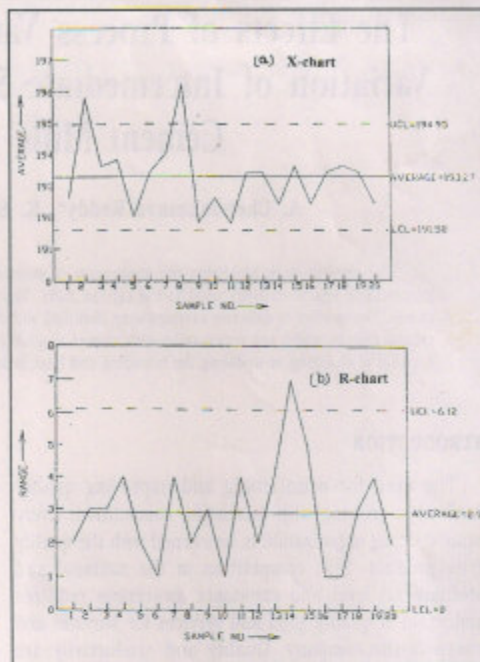


Fig. 3 : Variation of average outer diameter Intermediate spacer.

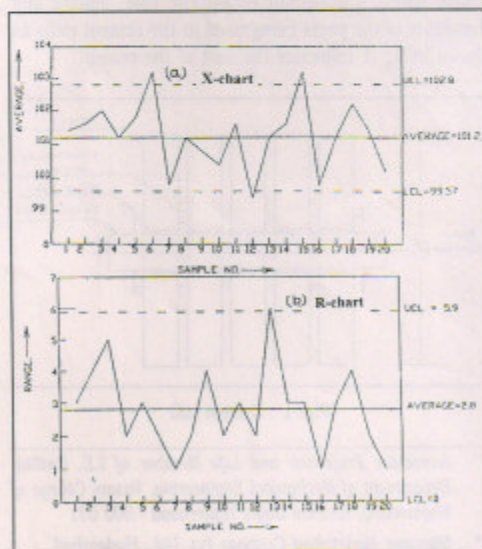


Fig. 4 : Variation of square hole dimensions of Intermediate spacer.

The variation of thickness of intermediate spacer castings is shown in fig 5. The charts for mean and range show that the process is under control, but the points are falling near to the control limits. Most of the castings were having greater thickness. The increase in thickness of the intermediate spacer castings is due to:

- Mould wall movement on account of improper ramming
- Metal-mould reactions
- The scale formation due to oxidation heat treatment. The scale formation was more particularly for these castings when they were heated to high temperature or soaked for excess time.

Fraction defective (P-chart) analysis

Fig. 5 shows the P-chart for intermediate spacer castings. The point corresponding to the sample-4 falls out of the upper control limit of P-chart. Discarding this sample, the revised estimate of the population proportion (P) is 0.12. This new value of P is taken as the standard fraction defective for future control. The assignable causes of variation are as follows:

- Heavy sand inclusions on the surface of the castings
- Bulging of castings
- Metal-mould reactions
- Insufficient fluidity of liquid metal in the moulds

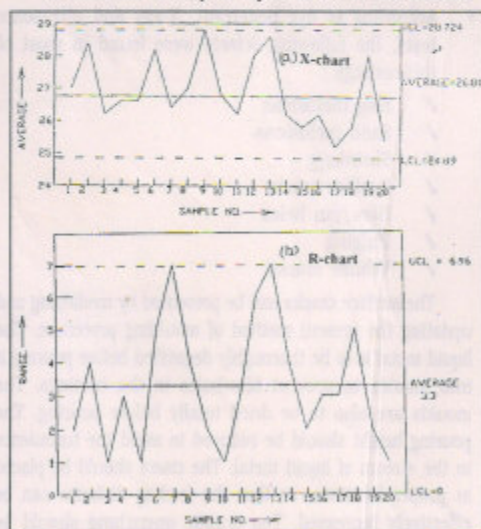


Fig. 5 : Variation of thickness dimensions of Intermediate spacer.

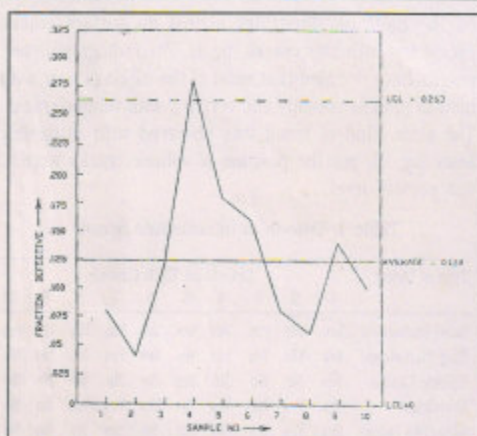


Fig. 6 : P-Chart analysis of Intermediate Spacer.



Fig. 7 : Intermediate Spacer castings with defects.

Two defective intermediate spacer castings, which were rejected from the sample-4 are illustrated in fig. 6. The castings (fig. 7) were rejected due to the metal-mould reaction and bulging.

C-chart analysis

The castings may contain number of different kinds of defects. These defects were identified through dye penetrant, X-ray and ultrasonic tests. All types of defects are not of equal importance to accept or reject a casting. Some defects are more serious than others. C-chart for intermediate spacer casting is shown in fig. 7. The process is well under control. The type and number of defects are given in Table- 1. The most common defects were sand and slag inclusions and shrinkage in the casting. The dye penetrant test, which was conducted

on the castings, illustrates almost no surface cracks except few with hair cracks (fig 8). The radiographic test results have revealed that most of the castings were with blow or pinhole porosity and very few with volume cracks. The same kind of trend was observed with ultrasonic tests (fig. 9), but the position of volume cracks were at sub-surface level.

Table 1: Defects in Intermediate Spacer

Type of Defect	Defects on Each Casting									
	1	2	3	4	5	6	7	8	9	10
Sand Inclusions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Slag Inclusions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Volume Cracks	Yes	No	No	No	Yes	No	No	No	No	No
Shrinkage	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No
Blow/Pin Holes	Yes	Yes	Yes	No	Yes	No	Yes	No	No	No
Bulging	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No
Surface Cracks	Yes	Yes	Yes	No	Yes	No	No	No	No	No
Piping	No	No	No	No	Yes	No	No	No	No	No

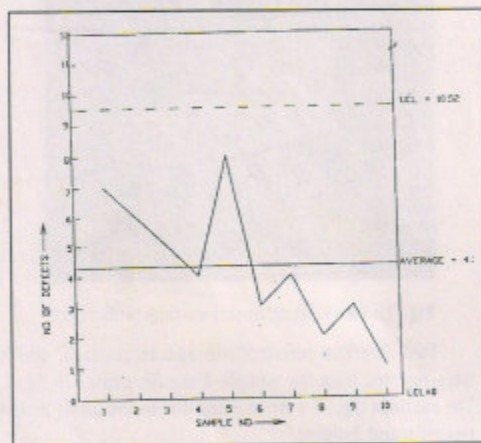


Fig. 8 : C-chart analysis of Intermediate Spacer.

CONCLUSIONS

The following conclusions were made with comprehensive analysis of intermediate spacer castings :

- The variation of dimensions on the castings was mainly due to sand and slag inclusions, mould wall movements and bulging during the process.
- The number of defective casting rejected was low. This is because most of the defects were restricted to the surface of the castings.

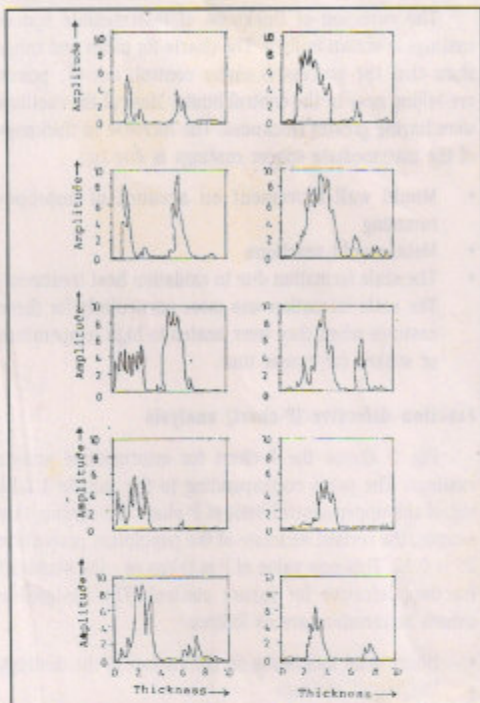


Fig. 9 : Ultrasonic test results of Intermediate Spacer Castings.

- According to dye penetrant, X-ray and ultrasonic tests, the following defects were found in most of the castings :

- ✓ Slag inclusions
- ✓ Sand inclusions
- ✓ Shrinkage
- ✓ Surface cracks
- ✓ Blow/pin holes
- ✓ Bulging
- ✓ Volume cracks

The surface cracks can be prevented by modifying and updating the present method of moulding procedure. The liquid metal is to be thoroughly degasified before pouring it into moulds to prevent blowholes in the castings. The moulds are also to be dried totally before pouring. The pouring height should be reduced to avoid the turbulence in the stream of liquid metal. The risers should be placed at proper locations, so that the feeding distance can be effectively increased. Too drastic quenching should be avoided during the heat treatment of castings.