Role of Quality Circles & Total Quality Management Practices in an Indian Public Sector Industry: A Pilot Research

Gopi S, Asher John Sathya, Abhinav Suresh

Quality Circle consists of a group of people, who are doing the same or similar work, who meet voluntarily and regularly to identify, analyse, discuss and solve problems in their work areas. Housing Accessory Cover (Rh) casting used in a critical helicopter component which is a magnesium alloy, thin walled casting needs special attention and careful control of all parameters. This casting has several contours with very close dimensional tolerance. Supply of housing accessory (Rh) casting for a critical helicopter component was delayed beyond the committed date due to high rejection (56%) at floor inspection & radiography. The goal of this pilot study was to examine the factors influencing the successful implementation of active Quality Circles to increase organizational productivity and establish processes to manufacture zero defect components. One such unit quality circles strives to achieve 100% radiographic quality housing accessory cover (Rh) casting with zero level of rejection. In a trial run of 200 units, there was a saving of Rs 19,525 on each casting.

Index Terms— Quality Circles, Housing Accessory, Zero defect.

I. INTRODUCTION

Quality Circle is a small group of people in the same work area who meet voluntarily on a regular basis to identify, analyze, discuss and solve various types of problems in that area, leading to improvement in their performance and enrichment of their work life. Members of a particular Quality Circle should be from the same work area so that problems selected will be familiar to all members. The ideal size of a circle is between 5 and 8 and the size should be such that the circle is effective and should offer enough time to every member to participate and contribute at each meeting. The membership is strictly voluntary. Members are neither compelled to join nor kept out. A Quality Circle process is made up of interrelated parts: the members, the facilitators, the coordinators and the steering committee. The Quality Circle is the basic force in solving work related problems. Some of the Quality Circle's main objectives include ensuring harmony, effective teamwork, job satisfaction, quality improvement, better communication, productivity and team building. The key factors for the success of any Quality Circle is its structure of the functional rapport between its different elements.

II. LITERATURE REVIEW

Total quality management is an important and prominent approach to management.[1]The approach and analysis of the problems by means of the quality circle have led to an optimization of the human and financial effort involved.[2][3][4] However, there is still a need for continuous improvement even among organisations recognized for their TQM achievements.[5] Companies perceive benefit from quality Circles in three areas: improvement of work performance, company competitiveness and profitability, and employee outcomes.[6][7][8] The relationship between TQM practice and organisational performance is significant in a cross-sectional point of view.[9][10] Employee performance and innovation performance partially mediate the relationship between TQM practices and firm performance.[11] However, these links are complex.[12][13][14][15] While features such as quality training, process improvement, and benchmarking do not generally produce any advantages, certain tacit, behavioural, imperfectly imitable features such as open culture, employee empowerment, and executive commitment can be significantly advantageous.[16] Studies have shown that total quality management is positively related to manufacturing performance.[17] Quality Improvement Methods with Quality Circles have shown the most significant long-term benefits in terms of increase in sales.[18] The implementation of TQM practices in R&D divisions and in knowledge management has made significant contribution to R&D performance of companies[19] as well as their knowledge management.[20]

III. PILOT STUDY

3.1 Identification & selection of Problems

In the pilot study conducted a total of 80 problems were identified & were categorized into three groups

Group A: Problems requiring minimal involvement of other departments.

Group B: Problems requiring involvement of other departments.

Group C: Problems requiring management sanction for implementation.

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Gopi S, Associate Professor(email: gopi.s@cmrit.ac.in)
Asher John Sathya, Scholar(email: asjo15me@cmrit.ac.in)
Abhinav Suresh, Scholar(email: absu15me@cmrit.ac.in)

Number of problems under Group A, B and C were 46, 23 & 11 respectively. Selection of problem was done based on the ratings provided by quality circle members to the questionnaire. 'High rejection of housing accessory cover castings' was rated as the most critical problem as per the responses received.

3.1.1 Problem Statement

Housing accessory cover (Rh) Casting is used in a critical helicopter component. This is a magnesium alloy formed by thin walled casting. It needs special attention and careful control of all parameters casting has several contours with very close dimensional tolerance. Supply of housing Accessory Cover (Rh) casting for a critical helicopter component project was delayed beyond the committed date due to high rejection at floor inspection and radiography. The existing rejection rate at the time of conducting the study was 56%.

3.2 Data Analysis of problem

Brain storming sessions among various quality circles identified the reasons for rejections, which caused the supply of housing accessory cover casting of the project beyond the committed dates were;

a) Shrinkage: Change in volume of metal as it changes from liquid to solid phase.

b) Micro Shrinkage: Very finely divided porosity resulting from interdendritic shrinkage.

c) Inclusion: Particles of impurities, usually Oxides, Sulphides and Silicates.

d) Non-Formation: Non-fusion of two metal streams in the casting.

Table 1: Rejection Data Analysis.

Sl.no.	Melt No.	Place of Rejection	Reason for Rejection
1	MG 02 AP 06	Floor, Radiography Inspection	Shrinkage, Non – Formation
2	M5 02 AP 15	Radiography Inspection	Micro Shrinkage, Shrinkage
3	MG 02 AP 17	Radiography Inspection	Micro Shrinkage, Shrinkage, Inclusion
4	MG 02 JU 08	Radiography Inspection	Micro Shrinkage, Shrinkage, Inclusion
5	MG 02 NR 40	Floor, Radiography Inspection	Non – Formation, Shrinkage
6	MG 02 DR 05	Radiography Inspection	Micro Shrinkage, Shrinkage
7	MG 02 JU 18	Floor, Radiography Inspection	Non – Formation
8	MG 02 JU 24	Radiography Inspection	Micro Shrinkage, Inclusion
9	MG 02 JU 33	Radiography Inspection	Micro Shrinkage, Shrinkage
10	MG 02 JU 40	Radiography Inspection	Shrinkage

Observation: 10 batches of housing accessory cover (Rh) were rejected during floor inspection & Radiography due to defects.

3.2.1 Casting Specifications

Table 2: Casting specifications

Project	Critical helicopter component
Part number	1201p 636h 211 702
Part Name	Housing accessory cover
Material	Rz5 (Mg alloy)
Unit Weight	10Kg
Casting type	Sand casting
Value per casting	Rs 19,525
Gating Ratio	2.8:3.6:1
Pouring Temperature	750° C

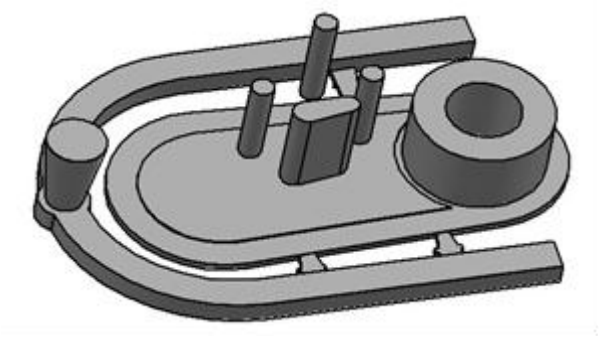

Fig-1: Housing accessory cover

3.2.2 Identification of Root Causes

During Brainstorming session, the members followed a systematic approach to identify and analyse the causes for rejections in Housing Accessory Cover (Rh) Casting.

3.2.2.1 Shrinkage and Micro-Shrinkage

1. Insufficient risers
2. High pouring temperatures
3. Absence of chills
4. Fine sand for facing
5. Improper calibration of Pyrometer
6. Absence of heat insulating sleeves
7. Absence of blind risers
8. Lack of concentration
9. Lack of skill
10. Overheating of Mould & Cores
11. Improper mixing of molten metal

3.2.2.2 Non – Formation

1. Inaccurate Pyrometer
2. Inappropriate gating ratio
3. Change of location of Ingates
4. Poor surface finish of pattern
5. Improper skimming of molten metal
6. Non-uniform preheating of Molds & Cores
7. Improper calibration of Pyrometer
8. Low pouring temperature
9. Lack of concentration
10. Lack of skill

3.2.2.3 Inclusion

1. Inappropriate mixing of sand and binder
2. Inappropriate AFS sand size used
3. Improper filtering system
4. Problem with mould coat
5. Faulty skimmer & cleaner
6. Absence of Flow Offs
7. High pouring temperature
8. Poor quality binder
9. Improper Sulphur spray
10. Inadequate skimming of liquid metal

3.2.3 Root Cause Analysis

3.2.3.1 Identification by Validation

Table- 3. Defect: Shrinkage and Micro Shrinkage

Sl.no.	Cause	Observation	Verification	Conclusion
1	Insufficient Risers	Absence of Riser	Riser introduced in Trial-1 Melt no. MG04JU18 avoids shrinkage	Cause
2	Absence of Heat Insulating Sleeves	No need of sleeves	As per Hps 625.2	Not a cause
3	Overheating of Molds & Cores	Preheating Temperature =110^{0}C	Contact Tip Pyrometer	Not a cause
4	Absence of Blind Risers	No need of Blind Risers	As per Hps 612.3	Not a cause
5	Improper mixing of Molten Metal	Standard Practice	As per Hps 612.3	Not a cause
6	High pouring temperature	Pouring Temperature = 750^{0}C	Trial-1&2 Melt no. MG04JU18 & MG04JU24 Pouring Temperature = 730^{0}c	Cause
7	Absence of Chills	No Chills used for mould preparation	Chills used in Trial-1&2 Melt no. MG04JU18 & MG04JU24 avoids micro shrinkage	Cause
8	Improper calibration of Pyrometer	Pyrometer calibrated	Calibrate as per Fdy – 2340	Not a cause
9	Lack of skill	Skilled moulders	Certification of Skills	Not a cause
10	Lack of concentration	Dedicated moulders	Certification of Dedication	Not a cause
11	Fine sand for Facing	Silica Sand AFS 60 used	Zircon AFC 80 used in Trial-2 Melt no. MG04JU24 avoids micro shrinkage	Cause

Table-4. Defect: Non - Formation.

Sl.no.	Cause	Observation	Verification	Conclusion
1	Inaccurate Pyrometer	Usage of calibrated Pyrometer	Calibrated as per Fdy-5667	Not a cause
2	Inappropriate Gating Ratio	Gating ratio 3.7: 4.7: 1	As per Trial-3 Melt no. MG04JU33 with modified gating ratio 2.8: 3.6: 1	Cause
3	Change the location of Ingates	Position of ingates as per method sketch	As per Trial-3 Melt no. MG04JU33 with Ingates Non-Formation was avoided	Cause
4	Poor surface finish of Pattern	Mould surface found satisfactory	Mould surface finish as per Fdy-T-2040	Not a cause
5	Improper skimming of Molten metal	Mould surface found satisfactory	As per Hps 612.3	Not a cause
6	Non-uniform Mould & Core preheating temperature	Range of 80^{0}Cto 100^{0}C	Monitoring of temperature by Pyrometer to required temperature	Not a cause
7	Low pouring temperature	Pouring temperature = 750^{0}C	Trial-3 Melt no. MG04JU33 pouring temperature 730^{0}C not effected to Non-Formation	Not a cause
8	Improper mould & core assembly	As per standard practice	As per Hps 615.2	Not a cause
9	Lack of Skill	Skilled moulders	Certification of Skills	Not a cause
10	Lack of concentration	Dedicated Moulders	Certification of dedication	Not a cause
11	Improper calibration of Pyrometer	Skilled calibration personnel	Certification of Skills	Not a cause

Table -5. Defect: Inclusions.

Sl.no.	Cause	Observation	Verification	Conclusion
1	Inappropriate mixing of Sand & Binder	Standard practice	Conforms to Hps 613.1	Not a cause
2	Improper filtering system	Mesh 16x22 was used	Usage of 3x2x9 multilayered mesh Trail-4 M04JU40 avoids inclusion	Not a cause
3	Problem with mould coat	Proprietary product	Conforms to HPS 610.3	Not a cause
4	Inappropriate AFC size used	AFC 30 – 35	As per Hps 611.2	Not a cause
5	Faulty Skimmer & Cleaner	Standard tools	As per Fdy-1345	Not a cause
6	Obscene of Flow Offs	No Blow offs at the Runner bar as per methods	Introduction of Flow Offs avoids inclusions	Not a cause
7	High pouring temperature	Pouring temperature = 730^0C	Trial-4 Melt no. MG04JU40 pouring temperature = 730^0C	Not a cause
8	Poor quality Binder	Proprietary product	Conforms to Hps 613.1	Not a cause
9	Improper Sulphur spray	Standard practice	As per Hps 612.3	Not a cause
10	Inadequate skimming of molten metal	Standard practice	As per Hps 614.2	Not a cause

3.2.4 Root Causes

3.2.4.1 Root Causes of Defect: Shrinkage & Micro - Shrinkage

1. Insufficient risers
2. High pouring temperature
3. Improper directional solidification

3.2.4.2 Root Causes of Defect: Non - Formation

1. Inappropriate Gating Ratio
2. Wrong position of ingates

3.2.4.3 Root Causes of Defect: Inclusion

1. Absence of filters of required specification in the required location
2. Absence of flow offs of required specification in the required location

Table-6. Defect check sheet (Batch Quantity: 2 Nos).

Defect	Shrinkage	Micro Shrinkage	Non-formation	Inclusion
Occurrences of defects %	8	6	3	3
Occurrences of defects %	40	30	15	15
Cumulative Occurrences of defects	**40**	**70**	**85**	**100**

Based on data analysis, shrinkage had occurred eight times, micro shrinkage had occurred six times, inclusion & non-formation had occurred three times in the batch tested. Since casting acceptance is based on elimination of all these defects, all of them are considered vital and the sequence of defect elimination was on the basis of number of occurrences of the defect (Shrinkage, Micro Shrinkage, Inclusion and Non-Formation).

IV. RESULT ANALYSIS

Table-7. Defect check sheet (Batch Quantity: 2 Nos)

Sl.no.	Melt No.	Stage of Rejection	Reason for Rejection			
			S	MS	I	N-F
1	MG02 AP 06	Floor, Radiography Inspection	Y	-	-	Y
2	M5 02 AP 15	Radiography Inspection	Y	Y	-	-
3	MG02 AP 17	Radiography Inspection	Y	Y	Y	-
4	MG 02 JU 08	Radiography Inspection	Y	Y	Y	-
5	MG 02 NR 40	Floor, Radiography Inspection	Y	-	-	Y
6	MG 02 DR 05	Radiography Inspection	Y	Y	-	-
7	MG 02 JU 18	Floor, Radiography Inspection	-	-	-	Y
8	MG 02 JU 24	Radiography Inspection	-	Y	Y	-
9	MG 02 JU 33	Radiography Inspection	Y	Y	-	-
10	MG 02 JU 40	Radiography Inspection	Y	-	-	-

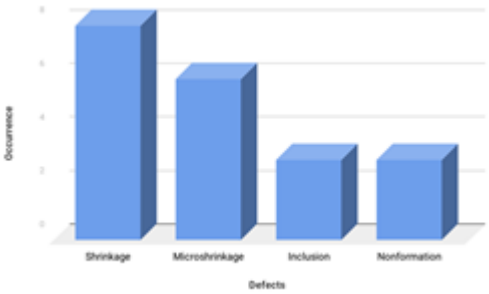

Fig.2. Graph for No. of Occurrences vs Defect.

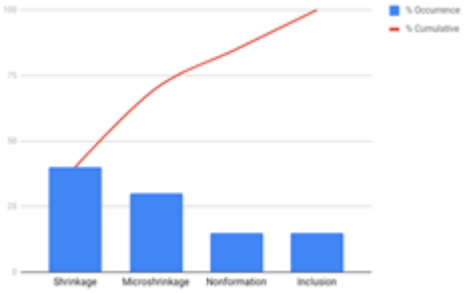

Fig. 3. Cumulative occurrence of defects

4.1 Foreseeing probable resistance

Deming wheel tool used to identify the solution and selection of feasible solution.

4.1.1 Reasons for resistance

1. Cavities for multi layered mesh & reservoir needs to be hand cut
2. Difficulty in locating the shaped ingates during mould preparation
3. Difficulty in locating reservoir during mould making

4.1.2 Overcome by

1. Using thermocol to provide cavities for multi layered mesh & reservoir
2. Locations where shaped ingates & reservoirs where required were provided with pins.

V. TRIAL IMPLEMENTATION

While implementing the proposed modifications step by step, the following results were recorded from the trials:

5.1 Trial - 1

1. Introduction of riser
2. Reduction of pouring temperature from 750C to 740C
3. Introduction of chills at the thick portion

5.1.1 Trial – 1 Result

1. Shrinkage and Micro Shrinkage persisted. Hence the casting was rejected

5.2 Trial – 2

1. Pouring temperature was further reduced from 740C to 730C
2. Introduction of Zircon Sand for Facing during mould making.

5.2.1 Trial - 2 Result

1. Shrinkage and Micro Shrinkage were completely avoided. However, Inclusion and Non - Formation was noticed and hence the casting was rejected

5.3 Trial – 3

1. Changing of Gating Ratio from 2.8:3.6:1 to 3.7:4.7:1
2. Changing the location of Ingate

5.3.1 Trial – 3 Result

1. Non-Formation was avoided but inclusions were noticed. Hence the casting was rejected

5.4 Trial – 4

1. Multi-layer mesh (3x2x9) were introduced.
2. Flow offs were introduced at Runner bar end.

5.4.1 Trial – 4 Result

1. All defects encountered were successfully eliminated and 100% Radiographic Quality Castings were produced.

VI. REGULAR IMPLEMENTATION

Table 8. Data on regular implementation.

Sl. no.	Melt No.	Shrinkage	Micro Shrinkage	Non-Formation	Inclusion	Remarks
1	MG 04 JU 46	NIL	NIL	NIL	NIL	ACCEPTED
2	MG 04 JU 53	NIL	NIL	NIL	NIL	ACCEPTED
3	MG 04 JU 64	NIL	NIL	NIL	NIL	ACCEPTED
4	MG 04 JU 72	NIL	NIL	NIL	NIL	ACCEPTED
5	MG 04 JY 04	NIL	NIL	NIL	NIL	ACCEPTED
6	MG 04 JY 18	NIL	NIL	NIL	NIL	ACCEPTED
7	MG 04 JY 26	NIL	NIL	NIL	NIL	ACCEPTED
8	MG 04 JY 37	NIL	NIL	NIL	NIL	ACCEPTED
9	MG 04 JY 48	NIL	NIL	NIL	NIL	ACCEPTED
10	MG 04 JY 60	NIL	NIL	NIL	NIL	ACCEPTED
11	MG 04 JY 68	NIL	NIL	NIL	NIL	ACCEPTED
12	MG 04 AU 20	NIL	NIL	NIL	NIL	ACCEPTED
13	MG 04 JY 51	NIL	NIL	NIL	NIL	ACCEPTED
14	MG 04 AU 60	NIL	NIL	NIL	NIL	ACCEPTED
15	MG 04 SR 14	NIL	NIL	NIL	NIL	ACCEPTED
16	MG 04 SR 26	NIL	NIL	NIL	NIL	ACCEPTED
17	MG 04 NR 10	NIL	NIL	NIL	NIL	ACCEPTED
18	MG 04 NR 28	NIL	NIL	NIL	NIL	ACCEPTED

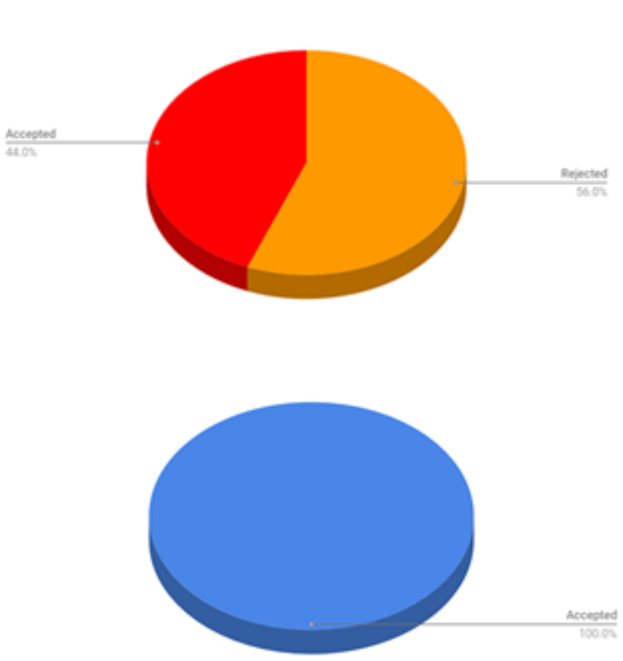

Fig. 4. (a) Old method; (b)New method

Table 9. Comparison of Old and New methods on regular implementation.

Method / Details	Old Method	New Method
No. of Castings poured	36	36
No. of Castings accepted	16	36
No. of Castings rejected	20	0
% of Rejection	56	Nil

VII. CONCLUSION

On regular implementation of the new method, Rs. 19,525/- was saved per casting, which produced a total tangible benefit of Rs. 39,05,000/- for a batch of 200 castings. Additionally, there was increased work satisfaction on achievement, increased self-reliance in using complicated technologies and improved morale among employees.

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