Productivity Improvement by Quality circle: A Case of Foundry.

Amar Kawale, Safal Shambharkar, Chetan Choudhary.

***Abstract*:-** The paper explores how quality circle can be used in manufacturing industry. Quality circle as a management tool to enhance the effectiveness and productivity of quality department in the manufacturing industry. It argues that the concept encourages employee participation as well as promotes teamwork and motivates people to contribute towards organizational effectiveness through group processes. Paper concludes that if concept is appropriately implemented in the field of manufacturing industry, the output will not only be amazing but it will also help us to work on our lacunae and facilitate designing of a better system.

Keywords: *Quality circle, productivity,*

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Introduction

Concept and Definition of Quality Circle

A Quality Circle (QC) is a small, voluntary group of employees and their supervisor(s), comprising a team of about 8 to 10 members from the same work area or department group ofstaff that meets regularly to solve problems relating to their job scope or workplace. QC works on the basis of a continuous and on-going process in an organization. Normally members of a particular QC come from the same workshop that face and share similar problems in their daily work life. Ideally, the group size should be seven or eight to give enough time to each member to actively participate and contribute in each meeting. The philosophy is that everyone will take more interest and pride in their work if they have a share in the decision-making process or have a say in how their work should be conducted. QC gives employees greater satisfaction and motivation. Quality circles were first developed in the 1960s by a man named Kaoru Ishikawa in Japan. Quality circles are useful because the members of the team are from the same workplace and face similar problems. Quality circles are a management tool that has many benefits for their own work environment. Some examples of those benefits are control and improvement of quality, more effective company communication, using employee problem solving capabilities, and more job involvement.

Data analysis:

Case study of cast iron foundry

Sun Cast Division (Name is changed) is a cast iron foundry in KTC group of industries situated at M.I.D.C., Hingna, Nagpur. In this plant they manufacture cast iron fittings. The plant is having six major departments:

1. Marketing
2. Production Planning and control
3. Production
4. Quality
5. Maintenance
6. Dispatch

Quality Department is one of the crucial area where management cannot compromise with standards. So the management decided to increase the competence of this department and many measures were taken to ensure the highest quality. In quality department, major cause of concern was **rejection.** As per company policy overall rejection should be below 4%. But the present monthly rejection is around 4 to 5 % from last couple of years.

The main causes of rejection of castings are:

1. Inferior sand quality.
2. Improper molding.
3. Core defect.
4. Inferior molten metal quality.
5. Improper pouring.
6. Improper handling of castings.
7. Improper dimensioning of castings.

A panel was initiated to study the above problems and come out with efficient solutions to meet the requirements of the management. Lot of brainstorming was conducted and it was decided to solve these problems by implementing ‘Quality Circle Program’. A group was formed and the problem of **rejection** was selected for observation on preferential basis.

Working model of Quality Circle.

The operation of Quality Circle involves the following sequential steps:

1. **Identification of a problem:** The members of the Circle are supposed to identify the problems that are to be solved.
2. **Selection of the problem:** The members then decide the preferences and select the problem of apex priority.

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3. **Analysis of the problem:** The selected problem is then classified and analyzed by basic problem solving techniques like brain storming and Pareto analysis etc.
4. **Generating alternative solutions:** Identifying various causes helps to generate various alternative solutions.
5. **Select the most appropriate solution:** The most appropriate and suitable solution is selected after considering various solutions related to cost, possibility of implementation etc.
6. **Preparation of action plan:** The members prepare plan of action to the implemented solution like area of implementation, date and time etc.
7. **Approval of the Management:** The chosen solution and the plan of action must be put forward before the management for their approval.
8. **Implementation:** The management evaluates the solution and examines the same before implementation. The management may consider a pilot run also.

Actual working of Quality Circle / Operation in KTC group of industries, Sun Cast Division.

Step 1. Identification of a problem:
Losses due to Rejection:
A. Cost of Production increases:
Currently average cost of production is Rs.39.5/Kg. In this the raw material cost is Rs.24.25 and processing cost (including all other expenses) is Rs.15.25. Pig iron is the basic raw material and it can be used again if the casting get rejected. The rate of the Pig Iron is around Rs.18/Kg. The rejected castings can be used as foundry return and again used as a metallic (raw material). The efficiency of the cupola furnace is 93% i.e. loss in cupola is 7%. So for every 100 kg of metallic raw material we get 93 kg of molten metal.

Table 1: Melting loss of cast iron in cupola furnace.

Loss in cupola	7 %.
Loss in terms of Rs.	Rs.1.26 (Considering current average per kg cost of cast iron Rs.18) (0.07*18)
Loss recover in Rs.	Rs.18 – Rs.1.26 = Rs.16.74

So Rs.16.74 can be recovered by using rejected castings as a foundry return.

Total Loss due to rejection in Rs./Kg. =Rs.39.5 - Rs.16.74
=Rs.22.76

Considering:
1. Average Production per month 75000 to 80000 fittings in nos.
2. The Average Weight of fittings 5.8 Kg.
3. Monthly working days 25.

Table 2: Calculation of average cost of rejection per month

Average rejection from last 2 years is 4.29%.	
Average Production / Month	80000 Nos.
Average % Rejection / Month	4.29.
Rejection in Nos. / Month	3432 Nos.
Rejection in Kg. / Month	19906 Kg.
Cost of rejection per kg	Rs. 22.76
Average cost of rejection / Month	**Rs. 453060**

Table 3: Calculation of saving due to reduction in rejections:

Reduction in rejection (in %)	1
Reduction in rejection (in Nos.)	800
Reduction in rejection (in Kg.)	800 x 5.8 = 4640
Rate/Kg.	22.76
Saving (In Rs)	(4640 x 22.76) = **105606**

From above calculation it is observed that for every 1 % reduction in rejection the total saving is Rs.105606.

B. Cost of Rework increases: Rs.1.5/Kg.

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a. M-Seal expenses.
b. Welding expenses.
c. Grinding Expenses.

C. Delay in dispatch.
D. Increased customer complaints.
E. Loss of customer.
F. Loss of Customer Goodwill

Step 2. Selection of problem:

After identification of the problem as the increased value of rejection against the targeted value, we need to consider the various types of rejection and their intensity of occurrence. To study this rejection data of last 2 years of all types of rejection reasons have been collected.

Table 4: Month wise (last 25 months) actual rejection against the target value.

Month wise actual rejection against the target value.								
Name of process	Mould Making	Mould Making	Core Making	Cupola Melting	Metal Pouring	Knockout & Fettling	Pattern Making	Total
Performance Indicator	Rejection due to inferior sand quality	Rejection due to improper molding	Rejection due to core defect	Rejection due to inferior molten metal quality	Rejection due to improper pouring	Rejection due to improper handling of castings	Rejection due to improper dimensioning	
Target	0.80%	0.80%	0.60%	0.80%	0.80%	0.20%	0.20%	4.00%
Jan-08	0.83%	0.98%	0.80%	0.74%	0.44%	0.18%	0.08%	4.05%
Feb-08	0.88%	0.86%	0.80%	0.74%	0.55%	0.21%	0.11%	4.14%
Mar-08	0.75%	0.76%	0.72%	0.83%	0.62%	0.22%	0.12%	4.02%
Apr-08	0.80%	0.72%	0.77%	0.61%	0.68%	0.31%	0.21%	4.10%
May-08	0.89%	0.81%	0.85%	0.50%	0.61%	0.31%	0.21%	4.18%
Jun-08	0.81%	1.10%	0.92%	0.94%	0.36%	0.11%	0.01%	4.24%
Jul-08	0.99%	0.75%	0.84%	0.52%	0.63%	0.26%	0.16%	4.15%
Aug-08	0.86%	0.98%	0.75%	0.67%	0.78%	0.30%	0.20%	4.54%
Sep-08	0.80%	0.74%	0.77%	0.62%	0.68%	0.33%	0.23%	4.18%
Oct-08	0.77%	0.75%	0.77%	0.81%	0.65%	0.24%	0.14%	4.13%
Nov-08	0.82%	0.63%	0.81%	0.88%	0.65%	0.24%	0.14%	4.17%
Dec-08	0.81%	1.01%	0.79%	0.91%	0.46%	0.16%	0.06%	4.20%
Jan-09	0.83%	0.98%	0.80%	0.74%	0.44%	0.18%	0.08%	4.05%
Feb-09	0.88%	0.86%	0.80%	0.74%	0.56%	0.19%	0.09%	4.11%
Mar-09	0.81%	0.82%	0.63%	0.83%	0.62%	0.22%	0.12%	4.05%
Apr-09	0.80%	0.84%	0.77%	0.61%	0.68%	0.26%	0.16%	4.12%
May-09	0.89%	1.02%	0.83%	0.62%	0.81%	0.18%	0.08%	4.43%
Jun-09	0.81%	1.10%	0.81%	0.94%	0.61%	0.16%	0.06%	4.48%
Jul-09	0.99%	0.75%	0.84%	0.61%	0.63%	0.24%	0.14%	4.20%
Aug-09	0.86%	0.98%	0.75%	0.67%	0.78%	0.15%	0.14%	4.33%
Sep-09	0.68%	0.74%	0.61%	0.65%	0.68%	0.31%	0.21%	3.89%
Oct-09	0.77%	0.81%	0.77%	0.81%	0.65%	0.31%	0.21%	4.33%
Nov-09	0.81%	0.51%	0.88%	0.81%	0.48%	0.18%	0.08%	3.75%
Dec-09	0.83%	0.98%	0.71%	0.93%	0.51%	0.12%	0.09%	4.17%
Jan-10	0.85%	1.03%	0.83%	0.61%	0.51%	0.18%	0.08%	4.09%

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Intensity of occurrence of various types of rejection.

From the above month wise rejection data the intensity of occurrence of various types of rejection is calculated.

Table 5: Intensity of occurrence of various types of rejection.

Types of rejection	Total months	Within limits	Above Limit
1. Inferior sand quality.	25	08	17
2. Improper molding.	25	10	15
3. Core defects.	25	06	19
4. Inferior molten metal quality.	25	03	22
5. Improper pouring.	25	15	10
6. Improper handling of castings.	25	11	14
7. Improper dimensions of castings.	25	21	04

As per the intensity of exceeding targeted rejection. The all seven types of defects are arranged in descending order:

1. Inferior molten metal quality.
2. Core defects.
3. Inferior sand quality.
4. Improper molding.
5. Handling of castings.
6. Improper pouring.
7. Improper dimensioning.

Rejection of casting due to inferior molten metal quality is very much so we consider this problem on first priority.

Step 3: Analysis of the problem:

Thorough analysis was done by the quality circle team on each type of rejection and following main causes were found out.

A. Rejection of castings due to inferior molten metal quality:

1. Inclusions: An inclusion is a metal contamination of dross if solid, or slags, if liquid.

Reason: These usually are metal oxides, nitrides, carbides, calcides, or sulfides, they can come from material that is eroded from furnace or ladle linings, or contaminates from the mold.

2. Misrun: Misrun occurs when the liquid metal does not completely fill the mold cavity, leaving an unfilled portion.

3. Cold Shuts: Cold shuts occur when two fronts of liquid metal do not fuse properly in the mold cavity, leaving a weak spot.

Reason: Both are caused by either a lack of fluidity in the molten metal or cross-Sections that are too narrow.

4. Porosity: It occurs in the casting in the form of pinhole porosity. It creates very small voids throughout the castings.

Reason: Caused by the gases like hydrogen, oxygen and nitrogen absorbed by the molten metal. During solidification gas is released and driving itself out of the metal it creates very small voids through the castings.

4. **Hot spots** are areas on the surface of casting that become very hard because they cooled more quickly than the surrounding material. This type of defect can be avoided by proper cooling practices or by changing the chemical composition of the metal.

B. Rejection of castings due to core defects:

Blow holes and Open blows: These are spherical, flattened or elongated cavities present inside the casting or on the surface. When present inside the casting it is called blow hole while it is termed as open blow if it appears on the surface of the casting.

Reason:

1. Moisture left in the mould and the core. Due to heat of the molten metal the moisture is converted into steam, part of which when entrapped in the casting ends up as blow hole or ends up as open blow when it reaches the surface.

2. Cores not sufficiently baked.

C. Rejection of castings due to inferior sand quality. :

1. Metal Penetration: This defect occurs as rough and uneven external surface on the casting. It takes place when the molten metal enters into the space between the sand grains and holds some of the sand tightly with it even after fettling.

Reason: Use coarse sand.

2. Drop: This defect appears as an irregular deformation of the casting. It occurs on account of a portion of the sand breaking away from the mould and dropping into the molten metal.

Reason: Low green strength in the sand.

3. Fusion: This defect appears as rough glossy surface over the casting. When molten metal comes in contact with the sand and the latter under the action of excessive heat of the metal, melts and gets fused to the casting surface.

Reason: Lack of enough refractoriness in the sand and poor facing sand.

D. Rejection of castings due to improper molding:

1. Mismatch or Shift: Mould Shift: It is a misalignment between two mating surface, leaving a small clearance between them and changing their relative locations.
Reason: Misalignment of mould boxes. Worn out of boxes.
Core Shift: It occurs at the core prints, providing a gap between the core and core seats.
Reason: Due to improper supporting of core. Improper location of cores. Faulty core box design.
2. Run Out: Occurs when molten metal leaks out of the mould during pouring resulting in incomplete casting.
Reason: Defective Mould Boxes. Improper molding.
3. Shrinkage: During solidification of metal there is volumetric shrinkage. This should be adequately
Compensate otherwise voids will be produced in casting.
Reason: This defect occurs on account of inadequate and improper gating, risering and chilling due to which proper solidification does not takes place.
4. Metal Penetration.
5. Drop. 6. Swell..

E. Rejection due to improper handling of castings:

a. Casting gets crack.
b. Damage to the outer surface of the castings.
c. Dirt and other unwanted material stick to castings.

d. Misplacement of castings
e.

F. Rejection of castings due to improper Dimensioning:

a. Wrong internal diameter barrel.
b. Wrong outer diameter barrel.
c. Wrong internal diameter socket.
d. Wrong outer diameter socket.

Step 4: Generating alternative solutions:

A. Rejection of castings due to inferior molten metal quality:

The various alternative solutions to avoid this type of rejection are:
1. In order to reduce oxide formation the metal can be melted with a flux.
2. Other ingredients can be added to the mixture to cause the dross to float to the top where it can be skimmed off before the metal is poured into the mold.
3. The slag should be skimmed from the ladle before pouring.
4. The fluidity can be increased by changing the chemical composition of the metal or by increasing the pouring temperature.
5. After melting the metal tapped in a red hot ladle, check the temperature in the ladle and it should be around 1180 to 1340 deg. C.
6. Molten metal temperature should be checked for metal temperature, chill test / sample to be sends to laboratory for Si % checks before pouring into the moulds. If required silicon powder is to be added in the ladle at the time of tapping of metal from cupola.
7. Poring temperature should be properly maintained.
8. Casting should be made to solidify quickly.
9. Acceptance standards of raw materials.

Table 6: Acceptance standards of raw materials.

Raw material	Constituents	Acceptable Range
1. Pig iron	Carbon	3.6 to 4.2 %
	Silicon	0.50 % min.
	Manganese	0.10 % min.
	Phosphorus	0.35 % max.
	Sulphur	0.1 % max.
2. C.I. Skull	Carbon	3.0 to 4.0 %
	Silicon	0.6 to 1.2 %
	Manganese	0.4 to 0.6 %
	Phosphorus	0.2 % max.

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	Sulphur	0.1 % max.
3. Hard Coke	Total moisture	7.0 % max
	Ash	33 % max.
	Moisture	1.5 % max.
	Volatile matter	3.2 % max.
	Fixed carbon	62 % min.
	Coke size	4” min.
4. Ferro silicon:	Silicon	70 % min.
5. Ferro manganese:	Manganese	70 % min.
6. Ferro molybdenum:	Molybdenum	60 % min.
7. Graphite:	Ash	26 % max
	Moisture	1 % max.
	Volatile matter	6 % max.
	Fixed carbon	70 % min.

B. Rejection of castings due to core defects:
1. Proper Core Baking should be done.
2. Core man should place the cores at a distance apart from each other (i.e. there should be gap in between cores for free flow of heat) for uniform heating.
3. Quantity of coal and locations of coal should be decided as per the following requirements:
   a. Amount of heating required to cores.
   b. Depend upon their size.
   c. Placement of cores on the stands.
   d. Weather conditions.
   e. Coal size and quality.
4. Cores should be uniformly baked.
5. After putting the cores on stands the coal should be fired and the hot room door should be closed.
6. Cores should be heated for about 10 – 12 hours.
7. Hot room temperature should be maintained such that the cores get skin dried and the core can be handled manually.
8. Under baked cores should not be given for production before proper baking.
9. Proper sand preparation for Core making:
10. Core sand and molding sand should be properly screened (with 3 mm screen), so that it is free from metallic and non-metallic inclusions.
11. Acceptance standards of materials.

Table 7: Acceptance standards of raw materials.

Raw material	**Constituents**	**Acceptable Range**
1. Sand	Reclaimed sand	90 %
	Fresh sand	10 %
	Bentonite	1 – 2 %
	Coal dust	2 – 2.5 %
	Moisture	4 – 5 %
2. Coal dust	Ash	22 % max
	Moisture	12 % max.
	Volatile matter	32 % max.
	Fixed carbon	41 % min.
3. Steam coal	Ash	25 % max
	Moisture	05 % max.
	Volatile matter	35 % max.
	Fixed carbon	45 % min.

12. Sand sample should be send to laboratory for analysis of moisture contents.
13. Daily record of the sand properties observed and changes if made should be maintained in sand analysis register.

C. Rejection of castings due to inferior sand quality:
The various alternative solutions to avoid this type of rejection are:

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1. Increase in green strength of the sand by suitable modification in its composition to avoid metal penetration and drop.
2. Use of sand of high refractoriness to avoid fusion.
3. Use of proper facing sand.
4. Use of fine sand to avoid metal penetration.
5. Sand should be uniformly mixed with its ingredients with the help of shovel.
6. Sand sample should be send to laboratory for analysis of moisture contents.
7. Daily record of the sand properties observed and changes if made should be maintained in sand analysis register.
8. Any change in sand composition (if required properties are not obtained, as per analysis of the samples received from Q.A.) should be made in consultation with the concern section supervisor of molding and core making.
9. Sand composition should be maintained as per the given chart.

Table 8: Sand composition ingredients.

Ingredients	**Molding Sand Contents**
Reclaimed sand	90 %
Fresh sand	10 %
Bentonite	3 – 4 %
Coal dust	2 – 3 %
Moisture	4 – 5 %

D. Rejection of castings due to improper molding:

The various alternative solutions to avoid this type of rejection are:

1. Proper clamping of boxes during pouring and placement of sufficient weight.
2. Provide adequate support to core.
3. Proper location of core.
4. Replacement or repair of defective mold box.
5. Use of proper design of mold box to run out.
6. Proper ramming should be done. Not so hard and not so soft. To avoid metal penetration, drop and swell.
7. Provide adequate support to mold.
8. Proper gating and rising should be providing on the mold.
9. Proper venting should be provided on the top box.
10. Both the mould cavities should be repaired for any loose sand followed by dusting the mould cavity with soap stone powder.

E. Rejection of castings due to improper handling of castings:

F. Rejection of castings due to improper pouring:

G. Rejection of castings due to improper dimensioning of castings:

To Solve all this problems On Job Training is given to worker on the proper handling and storage of castings, pouring and dimensioning.

Step 5: Select the most appropriate solution:

The most appropriate and suitable solution is selected after considering various solutions related to cost, possibility of implementation etc. After a long brain storming amongst the quality circle member it has been decided that a check list is to be prepared including all alternative solutions. In this checklist respective persons have to give his remarks as per his on field observation.

Checklist format for mold making:

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Daily Check List

Name of Process: Mold Making

Performance Indicator: Rejection of castings due to inferior sand quality

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Name Of Member :
Date:

S.No.	Points to be Check	Time			Remark
1	Increase in green strength of the sand by suitable modification in its composition to avoid metal penetration and drop.				
2	Use of sand of high refractoriness to avoid fusion.				
3	Use of proper facing sand.				
4	Use of fine sand to avoid metal penetration.				
5	Sand should be uniformly mixed with its ingredients with the help of shovel.				
6	Sand sample should be send to laboratory for analysis of moisture contents.				
7	Any change in sand composition (if required properties are not obtained , as per analysis of the samples received from Q.A.) should be made in consultation with the concern section supervisor of molding and core making.				
8	Daily record of the sand properties observed and changes if made should be maintained in sand analysis register.				
9	Sand composition should be maintained as per the given chart. Ingredients — Molding Sand Contents Reclaimed Sand — 90 % Fresh Sand — 10 % Bentonite — 3 – 4 % Coal Dust — 2 – 3 % Moisture — 4 – 5 %				

Like wise checklist format for all process is prepared with the all-alternative solutions.

Step 6. Preparation of action plan: The members prepare plan of action to the implemented solution like area of implementation, date and time etc.

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Quality Circle: Group Member

S.No.	Name of the Process (Area)	Name of the Member
1	Core Making	Member 1 Member 2
2	Melting	Member 3 Member 4
3	Molding	Member 5
4	Pouring	Member 6
5	Sand Making	Member 7
6	Handling	Member 8
7	Quality	Member 9
8	PPC	Member 10
9	Production	Member 11

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Quality Circle : Meeting Plan	
Total Member	11
Reporting Person	Manager (Quality Department)
Frequency of Meeting	Daily
Time	9.30 To 10.00 am.
Points of discussion	Causes of rejection and possible remedies

All the members of respective process are assigned a respective format and do the necessary work. It is decided that all members must meet every day at morning 09.00, with all their observation.

Step 7. Approval of the Management: The chosen solution and the plan of action put forward before the management for their approval. Since KTC Management itself interested in the implementation of the "Quality Circle" they give their approval for this implementation after seeing all the implementation details.

Conclusion:
Following table shows month wise actual rejection against the target value after implementation of "Quality Circle" techniques.

Table 9: Month wise actual rejection against the target value after implementation of "Quality Circle".

Month wise actual rejection against the target value.								
Name of process	Mould Making	Mould Making	Core Making	Cupola Melting	Metal Pouring	Knockout & Fettling	Pattern Making	
Performance Indicator	Inferior sand quality	Improper molding	Core defect	Inferior molten metal quality	Improper pouring	Improper handling of castings	Improper dimensioning	Total
Target Value	0.80%	0.80%	0.60%	0.80%	0.80%	0.20%	0.20%	4.00%
Mar-10	0.83%	0.81%	0.76%	0.71%	0.78%	0.16%	0.11%	4.16%
Apr-10	0.76%	0.79%	0.68%	0.61%	0.56%	0.24%	0.14%	3.78%
May-10	0.76%	0.78%	0.58%	0.56%	0.66%	0.18%	0.17%	3.69%
Jun-10	0.73%	0.71%	0.58%	0.55%	0.58%	0.19%	0.18%	3.52%
Jul-10	0.83%	0.81%	0.68%	0.56%	0.53%	0.18%	0.22%	3.81%
Aug-10	0.81%	0.75%	0.63%	0.60%	0.58%	0.16%	0.15%	3.68%
Sep-10	0.88%	0.74%	0.61%	0.56%	0.51%	0.22%	0.11%	3.63%
Oct-10	0.68%	0.78%	0.58%	0.55%	0.56%	0.20%	0.16%	3.51%
Nov-10	0.79%	0.81%	0.59%	0.65%	0.51%	0.24%	0.14%	3.73%
Dec-10	0.71%	0.76%	0.58%	0.58%	0.53%	0.18%	0.16%	3.50%
Jan-11	0.76%	0.76%	0.55%	0.59%	0.55%	0.11%	0.18%	3.50%
Feb-11	0.78%	0.71%	0.58%	0.56%	0.58%	0.18%	0.18%	3.57%
Mar-11	0.73%	0.76%	0.58%	0.58%	0.49%	0.19%	0.11%	3.44%

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Cost Saving:

Table 10: Monthly rejection data before and after implementation of "Quality Circle".

	Before implementation (Jan 08 to Jan 10)	**After implementation (Mar 10 to Mar 11)**
Monthly Rejection	4.29 %	3.65 %

Considering 1. Average Production per months = 80000 Nos.
2. Average wt per kg of fittings = 5.8 Kg.
3. Average cost of rejection per kg = Rs. 22.76

Table 11: Cost saving after implementation of "Quality Circle".

Particulars	**Before implementation (Jan 08 to Jan 10)**	**After implementation (Mar 10 to Mar 11)**
Monthly Rejection	4.29 %	3.65 %
Rejected castings per month in nos.	(4.29 x 80000) = 3432	(3.65 x 80000) = 2920
Rejected castings per month in kg.	3432 x 5.8 = 19906	2920 x 5.8 = 16936
Cost of Rejection per month in Rs.	19906 x 22.76 = 453060	16936 x 22.76 = 385463

Total per month Saving = Rs.453060 - Rs.384563
= Rs.67597

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