Productivity Improvement by Root Cause Analysis in Manufacturing Industry

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Abstract— Now a days PC meter box cover is used in a every house, shops, industries etc. Because of this meter box cover manufacturing industries facing greater competition in the market. PC meter box cover is manufactured by injection moulding process. Various defects found during manufacturing of PC meter box cover. Different defects are silver mark, short, flash, brittleness, voids and discolouration. These defects leads to quality problems. The main objective of this study to find major problems and also find out remedies by which these defects can be reduced.

Key words: PC (Polycarbonate) Meter Box Cover, Cause & Effect Diagram, Pareto Chart, Attribute Defects in Injection Moulding, Root Cause Analysis

I. INTRODUCTION

Now a days injection moulding process is reached at great extent. Many new firms are opened in recent time. Due to this competition level is increased day by day and also the focus is more on the quality area. Injection moulding is a manufacturing process by which the moulded parts can be obtained. In this process hot molten metal is poured into cold cavity of a desired shape under high pressure. Injection moulding process requires the injection moulding machine, raw plastic material and mould to complete the process. Common defects that come from meter box cover part are silver mark, short, flash, brittleness, voids and discolouration. These defects generally come from several sources including different plastic resins, selection of moulding machine & the setting of different process parameters. A study is carried out of two plastic products manufacturing company. These companies are involved in production of meter box cover over the years. The material used to produce the meter box cover in Ist industry is reprocess material of polycarbonate and on the other hand in IInd industry 75% is reprocess material and 25% is virgin material of polycarbonate. The dryer is used before the moulding for 2 to 3 hours. MAGNA MIG275 injection moulding was used for the manufacture of PC meter box cover. The data was collected from both the industries for period of two months from actual production line and by this different type of defects are found during the manufacturing of meter box cover and remedies were suggested.

II. LITERATURE REVIEW

Wilson et al. (1993) have defined the root cause analysis as an analytic tool that can be used to perform a comprehensive, system-based review of critical incidents. It includes the identification of the root and contributory factors, determination of risk reduction strategies, and development of action plans along with measurement strategies to evaluate the effectiveness of the plans.

Dew and Sproull state that identifying and eliminating root causes of any problem is of utmost importance. Root cause analysis is the process of identifying causal factors using a structured approach with techniques designed to provide a focus for identifying and resolving problems. Tools that assist groups and individuals in identifying the root causes of problems will continue to exist.

According to Duggett several root cause analysis tools have emerged from the literature as generic standards for identifying root causes. Some of them are the why why analysis, multi vari analysis. Cause-and-effect diagram (CED), the interrelationship diagram (ID), and the current reality tree (CRT). He has added that why why analysis is the most simplistic root cause analysis tool where as current reality tree is used for possible failures of a system and it is commonly used in the design stages of a project and works well to identify causal relationship. There is no shortage of information available about these tools.

Geno has presented some insight into the comparison of common root cause analysis tools and methods. He indicates that there are some comparative differences between tools and method of RCA. He has added that tools are included along with methods because tools are often touted and used as a full-blown root cause analysis.

Kiran M has identify the major breakdowns causing the production loss to the company. Root cause analysis was conducted for the improvement in the production. Root causes of breakdowns were identified using cause and effect diagram. Counter measures and parallel improvement opportunities for major breakdowns causing production stoppage was also suggested.

Vikas Tayal made an attempt to apply DMAIC approach in the plastic shop. On injection moulding process the DMAIC approach is successfully implemented. DMAIC has been considered as a revolutionary approach to product and process quality improvement, improved overall management performance and also inherent discipline with in the DMAIC approach provides structure and a visible road map for work force to systematically create new knowledge.

Krunali R. Charpe suggested that the temperatures and pressure parameters of an injection moulding machine plays a vital role in product configuration. In this way we can say that problems caused by these parameters has an effect on the life of rotating screw for injection moulding machine and the problem occurred in the rotating screw of machine which is wearing of threads due to effect of temperature of mold materials and using 30% glass filled materials. Directly affects the quality of the components manufactured by injection moulding machine.

Brown has used the root cause technique to analyze the assembly of commercial aircraft. He has concluded that it is the most effective tool to eliminate the causes in most vital assemblies like aircraft, where utmost safety and reliability is needed.

Arcaro has presented various tools for identifying root causes. He describes that RCA techniques are constrained within domain and give a detailed tutorial by supporting theoretical knowledge with practical experiences. He states that all RCA techniques may not be applicable for all processes.

Cox and Spencer have advocated that RCA tools effectively give solution to handle constraints and arrive at an appropriate decision. Like Cox and Spencer, Dettmer has also used root cause analysis on management of constraints. He presents one of the earliest studies on the debate of applying root cause analysis to processes. A proper management decision is necessary to succeed the RCA tools and methods in a particular environment.

Lepore and Cohen move ahead that when change is needed, then think root cause analyzing, identifying and eliminating. The foundations of their studies are pioneering one as they question an accepted practice for root cause analysis and the result of the example studies are encouraging. However, the studies are far from being practical one as they include too many parameters and assumptions.

Vikash Dwivedi focuses on the quality improvement of one of the major defect in plastic injection moulding of components. One of the main defect which is the causes of rejection is "Black specks"(small dark particles on the surface of the opaque parts), on the appearance of the product. The objective of this study is to identify the problem of black specks, which reduces quality, due to defects in manufactured parts, and to suggest measures for the improvement in the injection moulding operation using six-sigma DMAIC methodology.

D. Mathivanan suggested a simple and efficient way to study the influence of injection moulding variables on sink marks using Taguchi approach. Application of Taguchi approach also helps in arriving at optical parameter settings. The sink depth through the validation trials based on the optical parameters and the predicted sink depth using Taguchi's approach for the same settings are found to be in good agreement. The result shows the ability of this approach to predict sink depth for various combination of processing variables with in the design space.

S.R. Vijayakumar suggested that, it is essential for a company to improve the production rate and quality of the products. In order to achieve this, the overall effectiveness was improved with low machine breakdown, less idling and minor stop time, less quality defects, reduced accidents in plants, increased the productivity rate, optimised process parameters, worker involvement, improved profits through cost saving method, increased customer satisfaction and increasing sales.

Mr. Itthiwat Rattanabunditsakun after understanding the manufacturing process, process mapping and current situation of the company, it is found out that the major problem in the process are defect that appeared on the moulded parts. All in all, the objective of this research is to reduce the moulded defect parts from the black dot type in plastic injection moulding process, and use selected injection moulding machines as a pilot. To achieve this objective, an effective cross-functional project team is then formed to support and brainstorm to identify the potential cause of the black dot issue.

III. METHODOLOGY

The manufacturing industries have gone through significant changes in the last decade. New firms in markets have increased competition dramatically. Most of them focus on product quality, production time and cost of product. Because of these, a company should introduce a quality system to improve and increase both quality and productivity continuously. Root cause analysis (RCA) is method of problem solving that tries the root cause of faults or problems that cause operating events. RCA practice tries to solve problems by attempting to identify and correct the root cause of events, as opposed to simply addressing their symptoms. By focusing correction on root causes, problem recurrence can be prevented. Root cause analysis for reducing the breakdowns in the company's manufacturing unit is conducted. The objective of study is to find out the major breakdowns in the company which ccauses a production loss and to suggest counter measures to minimize the effect. Even after producing 24 x 7, the company is not able meet its demand in the market. So firm has to reduce the unwanted stoppages of production so as to maintain the steady production level and to meet the demands in the market. Production may be stopped due to many reasons like breakdown of machine, maintenance work, labour issue, insufficient material supply, problems in the method of production etc... Excluding all other factors like material, method, man, etc... It is necessary to reduce the breakdown of machine or equipment's in the company for the efficient nonstop production to meet the demands. Breakdowns are the most common cause of efficiency loss in manufacturing. Eliminating unplanned down time is critical to improving overall equipment efficiency. It is not only important to know how much down time your process is experiencing but also to be able to attribute the lost time to the specific source or reason for the loss.

The root cause analysis is a four step process involving the following:

1) Data collection
2) Cause charting
3) Root cause identification
4) Recommendation

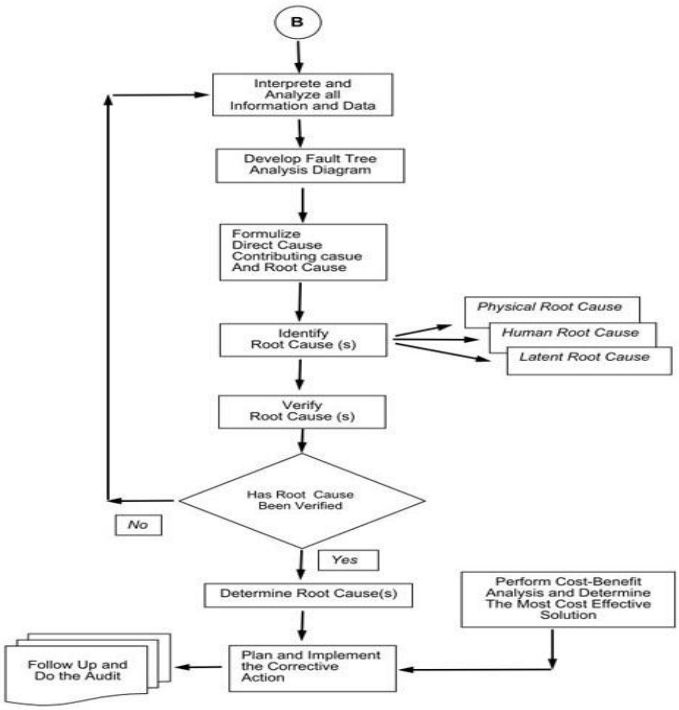

Fig. 1:

IV. DATA COLLECTION AND ANALYSIS

A. Data Collection

Defects data collected consist of mainly defects that occur in a manufacturing of PC meter box cover . But our area of interest is the defects causing production loss. The defects causing stoppages of production process were identified from the data.

Defects data collected are:

1) Silver mark
2) Short
3) Flash
4) Brittleness
5) Voids
6) Discoloured

1) Data Collection of Industry A

S no.	DEFECTS	(Out of 500 pics.) First Month FREQUENCY	(Out of 600 pics.) Second Month FREQUENCY
	Silver mark	32	45
	Short	28	38
	Flash	15	27
	Brittleness	13	22
	Voids	6	14
	Discolouration	3	7

Table 1: Data Collection of Industry A

2) Data Collection of Industry B

S no.	DEFECTS	(Out of 1800 pics.) First Month FREQUENCY	(Out of 2200 pics.) Second Month FREQUENCY
1.	Silver mark	65	91
2.	Short	52	77
3.	Flash	31	51
4.	Brittleness	18	35
5.	Voids	12	19
6.	Discolouration	8	14

Table 2: Data Collection of Industry b

a) Data of Industry A

	First Month	Second Month
Total Production	15000	18000
Total no. of defective parts	2910	4590
Percentage of Defective Parts (%)	19	25

Table 3: Production Data of PC Meter Box Cover of Two Months

S no.	Defects	First Month	%	Second Month	%
1.	Silver mark	960	33	1350	29
2.	Short	840	29	1140	25
3.	Flash	450	16	810	18
4.	Brittleness	390	13	660	14
5.	Voids	180	6	420	9
6.	Discolouration	90	3	210	5

Table 4: Type of Defects Identified In PC Meter Box Cover During the Two Months

b) Data of Industry B

	First Month	Second Month
Total Production	54000	66000
Total no. of defective parts	5580	8610
Percentage of Defective Parts (%)	10	13

Table 5: Production Data of PC Meter Box Cover of Two Months

S no.	Defects	First Month	%	Second Month	%
1.	Silver mark	1950	35	2730	31
2.	Short	1560	28	2310	27

3.	Flash	930	17	1530	18
4.	Brittleness	540	10	1050	12
5.	Voids	360	6	570	7
6.	Discolouration	240	4	420	5

Table 6: Type of Defects Identified In PC Meter Box Cover During the Two Months

B. Data analysis

Pareto chart was plotted based on the above data. Both pareto charts A and B industry reveals that silver mark and short were the major defects. It is found that these defects were mainly responsible for the rejection and hence study was focused on these defects. Pareto chart, where individual values are represented in descending order by bars, and the cumulative total is represented by the line. The left vertical axis is the frequency of occurrence, and right vertical axis is the cumulative percentage of the total number of occurrences. The purpose of the Pareto chart is to highlight the most important among a (typically large) set of factors.

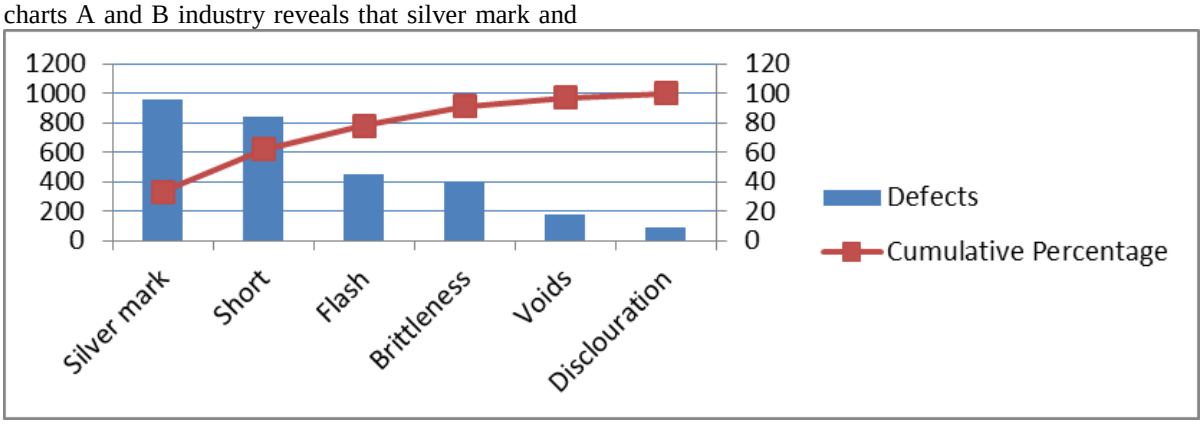

Fig. 1: Cumulative rejection percentage based on the type of defect of industry A during First month

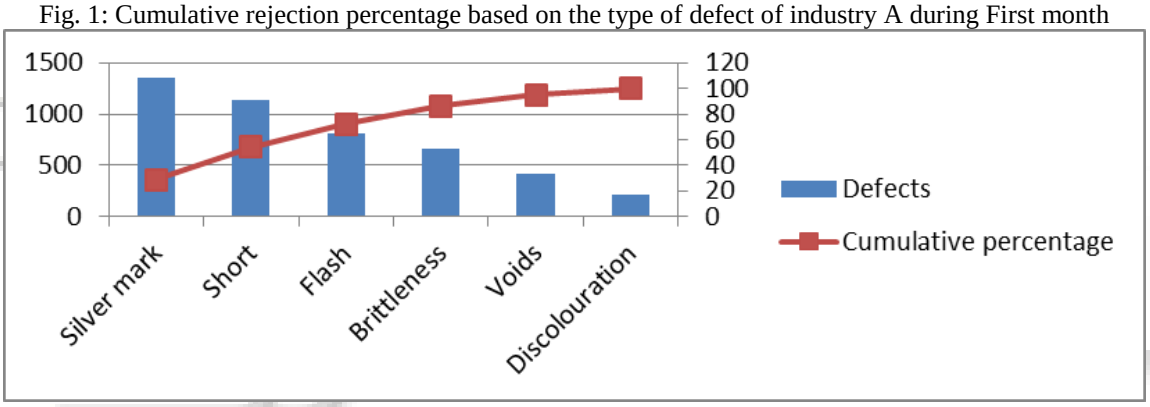

Fig. 2: Cumulative rejection percentage based on the type of defect of industry A during Second month

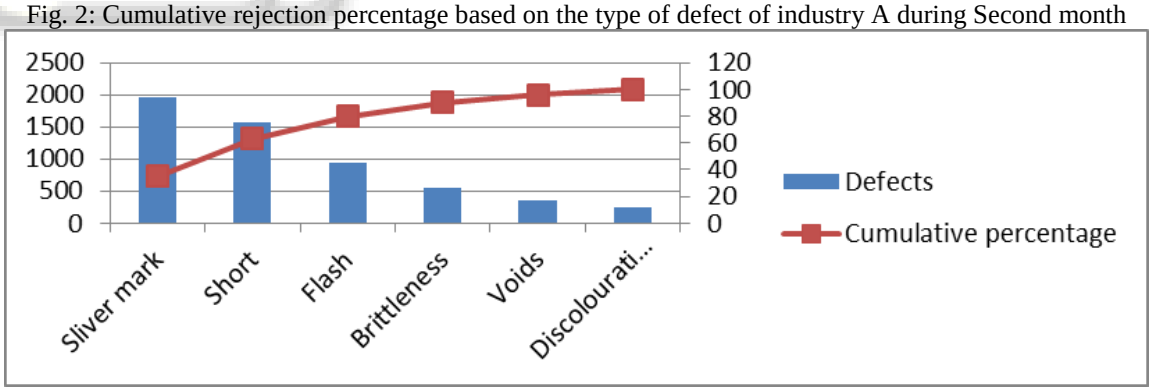

Fig. 3: Cumulative rejection percentage based on the type of defect of industry B during First month

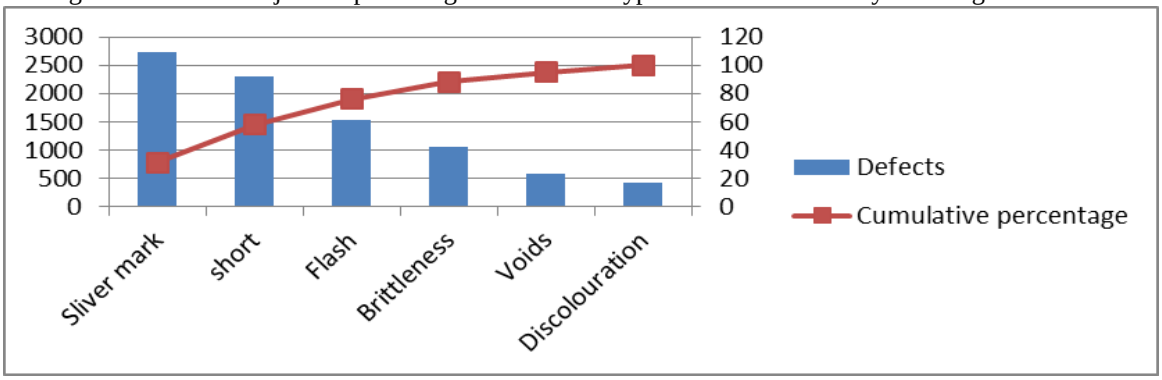

Fig. 4: Cumulative rejection percentage based on the type of defect of industry B during Second month

C. Identifying Causes of Defects

1) Root Cause Identification of Silver Mark

Silver mark are a phenomenon in which shining line shaped patterns appear on the surface of the molded product. These can be considered external appearance quality defects in exterior parts of consumer electrical products, automobiles, motorcycles, etc. The cause of silver streaks is the air or gases contained in the molding material appearing on the surface of the molded production.

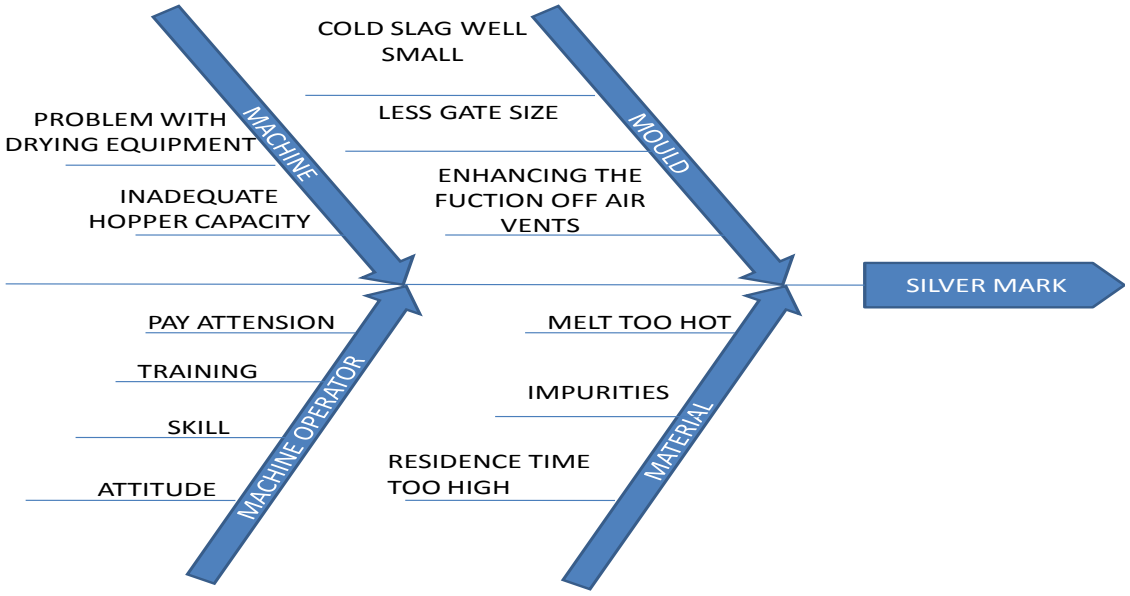

Fig. 5:

2) Root Cause Identification of Short

Machines are one of the factors that can contribute a lot to short shot moulding defect. Improper parameter setting like low injection pressure, low injection velocity and shot size are some of the major machine parameters which will result in short shot and was identified as the root cause . Aging machines and improper maintenance also can lead to defects. Experience of operator, condition of the mould tool, quality of material, contamination with foreign particles, presence of moisture, insufficient pre heating etc. may also causes defects.

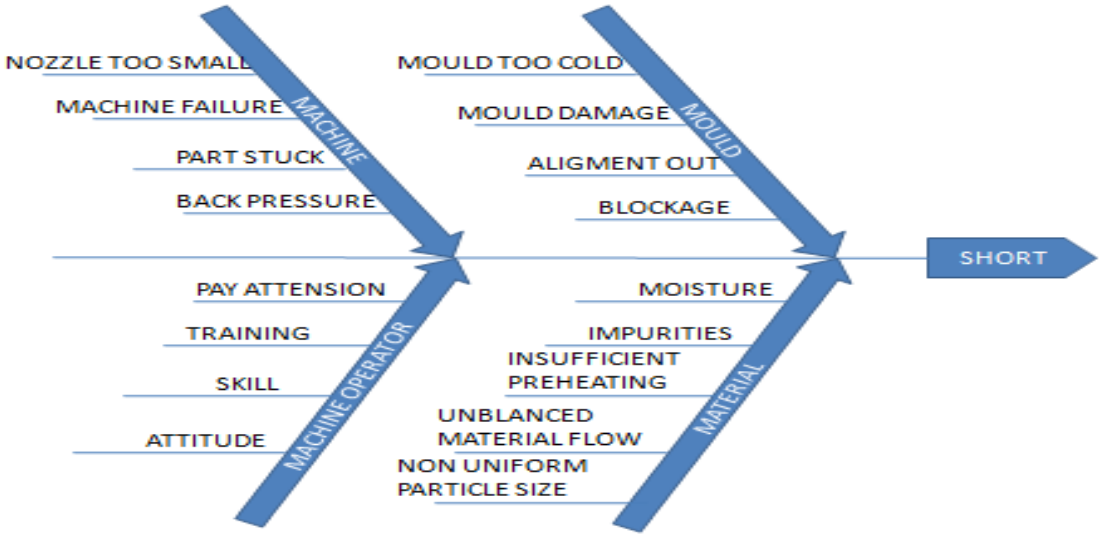

Fig. 6: Calculation

D. For Industry A

1) Given

In first month production of meter box cover pieces per day = 500

For one month = 500*30

= 15000 pieces per month

Ferquency of following defects in Ist month per 500 pieces is found by observations:

For 15000 pieces , the frequency of following defects will be in Ist month :

1) Silver mark = 32*30
   = 960 defects per month
   = 960/15000 x 100
   = 6.4% defects from first month production
2) Short = 28*30
   = 840 defects per month
   = 840/15000 x 100
   = 5.6% from first month production

3) Flash = 15*30
= 450 defects per month
= 450/15000 x 100
= 3% from first month production
4) Brittleness = 13*30
= 390 defects per month
= 390/15000 x 100
= 2.6% from first month production
5) Voids = 6*30
= 180 defects per month
= 180/15000 x 100
= 1.2% from first month production
6) Discolouration = 3*30
= 90 defects per month
= 90/15000 x 100
= 0.6% from first month production

Total no. of defects in Ist month=960+840+450+390+180+90 = 2910
Percentage of overall defective pieces in Ist month =
Total no. of defective pieces / total production * 100
= 2910 / 15000 * 100
= 19.4%
Percentage of individual defects = Total no. of individual defects / total no. of defects * 100

1) Silver mark = 960 / 2910 *100
= 33%
2) Short = 840 / 2910 * 100
= 29%
3) Flash = 450 / 2910 * 100
= 15%
4) Brittleness = 390 / 2910 *100
= 13%
5) Voids = 180 / 2910 *100
= 6%
6) Discolouration = 90 / 2910 *100
= 3%

In second month production of meter box cover pieces per day = 600
For second month = 600*30
= 18000 pieces per month
Ferquency of following defects in IInd month per 600 pieces is found by observations:
For 18000 pieces , the frequency of following defects will be in IIst month :

1) Silver mark = 45*30
= 1350 defects per month
= 1350/18000 x 100
= 7.5% from second month production
2) Short = 38*30
= 1140 defects per month
= 1140/18000 x 100
= 6.3% from second month production
3) Flash = 27*30
= 810 defects per month
= 810/18000 x 100
= 4.5% from second month production
4) Brittleness = 22*30
= 660 defects per month
= 660/18000 x 100
= 3.6% from second month production
5) Voids = 14*30
= 420 defects per month
= 420/18000 x 100
= 2.33% from second month production
6) Discolouration = 7*30
= 210 defects per month
= 210/18000 x 100
= 1.17% from second month production

Total no. of defects in IIst month = 1350+1140+810+660+420+210 = 4590
Percentage of overall defective pieces in IIst month =
Total no. of defective pieces / total production * 100
= 4590 / 18000 * 100
= 25.5%
Percentage of individual defects =Total no. of individual defects / total no. of defects * 100

1) Silver mark = 1350 / 4590 *100= 29%
2) Short = 1140 / 4590 *100 = 25%
3) Flash = 810 / 4590 *100 = 18%
4) Brittleness = 660 / 4590 *100= 14%
5) Voids = 420 / 4590 *100 = 9%
6) Discolouration = 210 / 4590 *100 = 5%

a) Therefore
Average percentage defects of Ist and IInd month =
= (Ist month + IInd month) / 2
= (19.4 + 25.5) / 2
= 22.45%

2) For Industry B
same as industry A

a) Therefore
Average percentage defects of Ist and IInd month =
= (Ist month + IInd month) / 2
= (10.33 + 13.06) / 2
= 11.70%

V. RESULT AND DISSCUSION

The main motto of this study is to identify major defects causing the production loss to the company. The various defects found out in PC meter box cover were shorts, flash, silver mark, brittleness,voids and discolouration. By appying the RCA approach on PC meter box cover the followi ngresult were obtained:

The rejection due to silver mark and short moulding are 6.4% and 5.6% from Ist month production of industry A and 7.5% and 6.3% from IInd month production of industry A. By applying the RCA approach, precentage of defects were reduced. The rejection due to silver mark and short moulding are 3.6% and 5.6% from Ist month production of industry B and 4.1% and 3.5% from IInd month production of industry B and also the average percentage defects of total production from Ist and IInd month of industry A is 22.45% and on the other hand by applying RCA approach the average percentage defects of total production from Ist and IInd month of industry B is reduces upto 11.70%.

The methods by which silver mark and short moulding can be reduced are:

A. Silver Mark

- Apply back pressure to genrate a kneading effect by which the silver mark deffect reduces.
- Slow down the injection speed.
- Change the gate location and thus reduces the silver mark deffect.

B. Short Moulding

- Increase the injection speed by which the material entering into the mold cavity increases which minimize the short moulding deffect.
- Increases the shot size becauses the less shot size may result in short moulding.
- Increases the material temperature becauses if the temperature is too low, there might be chances of plastic granules stuck at the nozzle and make hindrance to the flow of molten plastic resin.

VI. MAINTENANCE

The periodic maintenance should be performed by skilled worker. The procedure is as followed. This is generally carried out in every 10,00,000 cycles.

- Vents should be checked for depth, land and width.
- All plates are removed and their faces cleaned.
- All moving parts must be proper lubricated.
- Corrosion and vent burns must be checked.
- Any excessive wear must be repair or replaced.
- Alignment of parts are properly checked.
- Leaks and flow capacity tested properly.

VII. CONCLUSION

From the result of the application of RCA approach in injection moulding thus reduces the production loss to the company. Root cause of defects were identified using cause and effect diagram. Counter measures and parallel improvement opportunities for major defects causing production stoppage was also suggested.

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