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A STUDY ON QUALITY CONTROL TECHNIQUES IN PLASTIC INJECTION MOULDING AT PUNE

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ABSTRACT

Quality control in the production department is a serious concern in this competitive world of business which if left unchecked could lead to product wastes, low productivity and poor quality products. To protect these unwanted effects from happening, statistical process control, a statistical tool is to be used to control the quality of the products. This study was conducted at Pune in a plastic injection moulding company which was facing a problem of more number of defects in the daily production which is increasing day by day. Firstly the basic research was conducted on the monthly production data of May and June 2017 and analysis was done by using tabular frequency distribution of different defects. Pareto charts and Fishbone diagrams were drawn for different defects like Short Mould, Black dirty spots, Flow marks etc. After implementing the action plan, the average number of defects was reduced from 9.72% to 8.75%.

Key words: Plastic injection moulding, Statistical process control, Pareto Chart, Fishbone diagram, Quality control, Short moulds, Black dirty spots, Flow marks.

Introduction:

Injection molding (British: moulding) is a manufacturing technique for making parts from both thermoplastic and thermosetting plastic materials in production. Molten plastic is injected at high pressure into a mould, which is the inverse of the product's shape. After a product is designed, usually by an industrial designer or an engineer, moulds are made by a mould maker (or toolmaker) from metal, usually either steel or aluminum, and precision machine to form the features of the desired part. Injection moulding is widely used for manufacturing a variety of parts, from the smallest component to entire body panels of cars. Injection moulding is the most common method of production, with some commonly made items including bottle caps and outdoor furniture.

Review of literature:

Rohani and Teng concluded that simple techniques like the "seven basic quality control (QC) tools" are very valuable and cost effective to find the defects and improve the quality. This paper presents a case study in which a local plastic injection moulding company employs part of the "seven basic quality control (QC) tools" to significantly improve the process yield quality. However to make them successful as cost effective and problem solving tools, strong commitment from top management is desired.

Bharti et. al (2011) concluded that Injection moulding has been a challenging process for many manufacturers and researchers to produce products meeting requirements at the lowest cost. Its complexity and the enormous amount of process parameter manipulation during real time production create a very intense effort to maintain the process under control. Complexity and parameter manipulation may cause serious quality problems and high manufacturing costs. Determining optimal process parameter settings critically influences productivity, quality and cost of production in the plastic injection moulding (PIM) industry. Six Sigma is the most fervent managerial methodology not only in manufacturing area but also in the services industry. Many investigations have indicated that Six Sigma can increase organization's competitive capability and enhance the quality of products or services by conducting the projects.

M. Joseph Gordon (2010) stated that Total quality process control (TQPC) for injection moulding is the process for the repeatable manufacture of a product that consistently meets the customer's requirements. Quality begins with senior management implementing a policy for excellence and an attitude which is achievable. The employees of "COMPANY" are

dedicated to the delivery of quality product and technical services contributing to the success of their customers throughout the world. They believe high ethical standards are essential for the achievement of our individual and organizational goals. The company can achieve this by using proven quality management operations and methods like ISO 9001:2008, Total Quality Management, Six Sigma and other proven quality methods. Process control with statistical process control (SPC), is just one section of this national standard that requires the company to develop quality methodology to ensure a quality operation to provide continuous quality products and services to its customers in a repeatable process.

Statement of the Problem:

As plastic moulding industry has to face many problems each and every day about the Raw Materials, Machines, Operations etc. Many of them are repetitive so we need to prioritize them and accordingly sort out them or minimize them. Here in this small scale plastic industry the researcher sorted some basic problems regarding quality. Following are the problems, on which the researcher has to work on,

1. The number of defects found is more in the daily production.
2. Less knowledge of quality to workers in the organization.

Objectives of the project:

The objectives of this study are as follows.

- To study quality control tools used in plastic injection moulding.
- To identify the root causes of the Problems occurring during the injection process.
- To recommend suitable actions to improve the defects.

Scope of the Study:

Scope of this project is to control the Quality by using Basic and simple techniques. Quality is the only parameter which sticks to the loyalty of customer. It is our duty to maintain, control, Improve the quality of the products. This research will give us some quality control techniques related with plastic injection moulding and their importance in quality improvement.

Methodology:

The methodology of this research can be divided into three parts as follows.

1. In first phase, the researcher studied the company operations to find out the main problems in company. In this phase the researcher collected the data from field observations.
2. In the second phase, the data collected is to be represented and analysed by using some quality control tools.
3. The corrective action plan was suggested by the researcher for the problems found during his research.
4. Comparison of the problems faced before and after implementing the corrective action plan was done for giving the suggestions.
5.

Sources and methods of Data Collection:

Primary data was collected by field observation and having a discussion with some concerned people like operator, supervisor and plant head.

i. **Field Observation:** There are two types of observations online observation and offline observation. Online means observations taken at the time of operations and offline means after and before of operations. In this case the machines, Operators and products are under observation of the researcher. Daily production report was produced to check the performance of the day.

ii. **Discussion with some concerned people:** The researcher had a discussion with operator, supervisor and plant head for getting their opinion about the production report. Final data is recorded accordingly to the defects found.

Data collection:

The data was collected by the production department on daily basis. And observations made during 01/08/2017 to 03/08/2017 are furnished below.

Table 1: Data Collection Sample (Daily)

Problem / Days	Half Shot	Burn Mark	Sink Mark	Flow Mark	Scratches	Black Spot	Colour Variation	Damage	Oil Mark	Dust
01/08/2017	120	132	86	141	21	118	21	26	16	17
02/08/2017	129	115	73	125	29	144	24	34	18	23
03/08/2017	118	127	81	112	35	129	18	28	22	16

The problems found during production were recorded in this format day by day so that we can calculate the total rejection at the end of the month.

From the month wise data the researcher has to prioritize problems on which the researcher has to work on. Month wise data for the months of May and June is presented below.

Table 2: Data Collection Sample (Monthly)

Problems / Months	Half Shot	Burn Mark	Sink Mark	Flow Mark	Scratches	Black Spot	Colour Variation	Damage	Oil Mark	Dust
May 2017	3160	1560	1140	2590	300	3020	120	400	690	520
June 2017	3460	1720	980	2980	380	2860	160	370	950	290

The data of two months May and June is historical data for us. It was useful to prioritize the problems. Accordingly the researcher has to prepare Pareto chart and get solution to those major problems.

Data Presentation:

The data recorded for the month of May is presented here in the following table.

Table 3: Data Regarding No. of Defects in Different Operations in May Month

Problems	Short mould	Burn mark	Sink mark	Black spot	Oil mark	Flow mark	Dust	damage	Colour variation	Scratches
May 2017	4250	1680	1120	2890	870	2140	660	560	300	350

Pareto chart for the month of May: On the basis of the observations given in Table 3, a Pareto chart is prepared as below.

Table 4: Calculation for Pareto chart for the month of May

Type of Defects	**Rejected Quantity**	**Percentage Contribution**	**Cumulative Percentage**
Short Mould	4250	28.68	28.68
Black Spot	2890	19.50	48.18
Flow Mark	2140	14.44	62.62
Burn Mark	1680	11.34	73.95
Sink Mark	1120	7.56	81.51
Oil Mark	870	5.87	87.38
Dust	660	4.45	94.20
Damage	560	3.78	97.98
Scratches	350	2.36	89.74
Colour Variation	300	2.02	100.00
Total Rejection	14520	100.00	

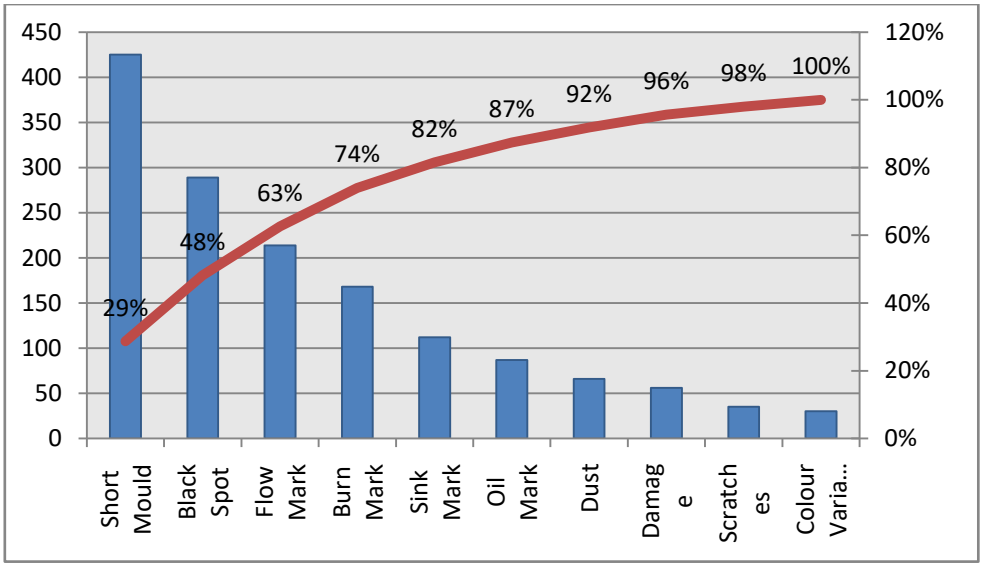

Fig. 1: Pareto Chart for the month of May

The total production for the month of May is 149450. So the percentage of rejection is calculated as below.

Rejection Percentage = (total rejection/Total production)*100

= (14520/149450)*100

= 9.72%

The data recorded for the month of June is presented here in the following table.

Table 5: Data Regarding No. of Defects in Different Operations in the month of June

Problems	Short mould	Burn mark	Sink mark	Black spot	Oil mark	Flow mark	Dust	damage	Colour variation	Scratches
June 2017	3160	1560	1140	3020	690	2590	520	400	120	300

The total production for the month of June is 139280. So the percentage of rejection is calculated as below.

Rejection Percentage = (Total rejection/Total production)*100

= (13500/139280)*100

= 9.69%

Pareto chart for the month of June: On the basis of the observations given in Table 5, a Pareto chart is prepared as below.

Table 6: Calculations for Pareto chart for the month of June

Type of Defects	Rejected quantity	Percentage Contribution	Cumulative Percentage
Short Mould	3160	23.41	23.41
Black Spot	3020	22.37	45.78
Flow Mark	2590	19.19	64.96
Burn Mark	1560	11.56	76.52
Sink Mark	1140	8.44	84.96
Oil Mark	690	5.11	90.07
Dust	520	3.85	96.15
Damage	400	2.96	99.11
Scratches	300	2.22	92.30
Color Variation	120	0.89	100.00
Total Rejection	13500	100.00	

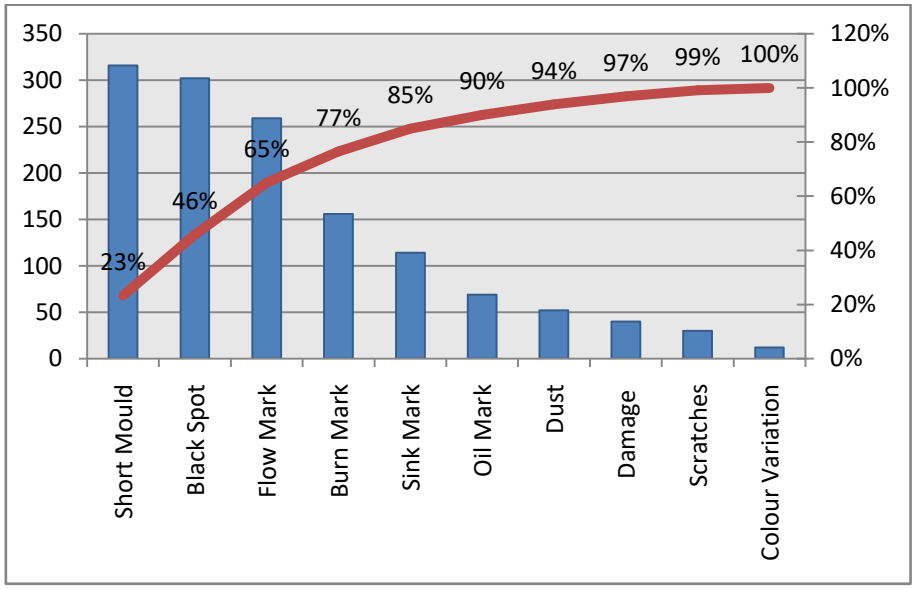

Fig. 2: Pareto Chart for the month of June

Comment on the data of May and June:

The researcher collected historical data of company for the months of May and June for analysis. Data is arranged in such a manner that it will give rejection with the occurred problem with reason. Data presented in Table 1 and Table 2 gives us the frequency of number of problems occurred during the plastic moulding injection. After observing the data the researcher has found out Major problems and Minor problems in the production process. The Major problems found out by the researcher are as follows.

- Short Mould or Half Shot
- Black Spot or Dirty Spot
- Flow Mark

Hence corrective action should be taken to minimize the rejection rate. For this Fishbone diagram was drawn to find the root causes of the problems.

Fishbone Diagram:

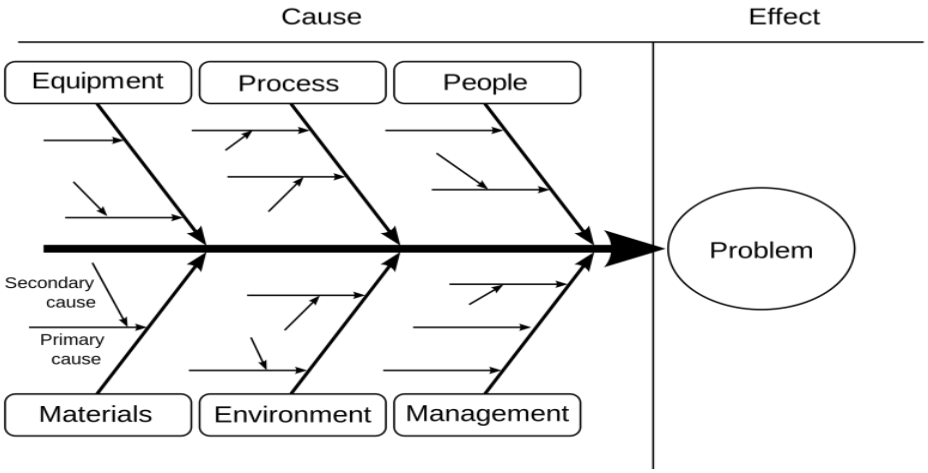

Fig. 3: Structure of Fishbone Diagram

Ishikawa diagrams also called as fishbone diagrams or herringbone diagrams or cause and effect diagrams or Ishikawa are causal diagrams created by Kaoru Ishikawa (1968) that show the causes of a specific event. Common uses of the Ishikawa diagrams are product design and quality defect prevention to identify potential factors causing an overall effect. Each cause or reason for imperfection is a source of variation. Causes are usually grouped into major categories to identify these sources of variation. The categories typically include

- People: Anyone involved with the process.
- Methods: How the process is performed and the specific requirements for doing it, such as policies, procedures, rules, regulations and laws.
- Machines: Any equipment, computers, tools, etc. required to accomplish the job.
- Materials: Raw materials, parts, pens, paper, etc. used to produce the final product.
- Measurements: Data generated from the process that are used to evaluate its quality.
- Environment: The conditions, such as location, time, temperature and culture in which the process operates.

Fishbone Diagram for Short Mould:

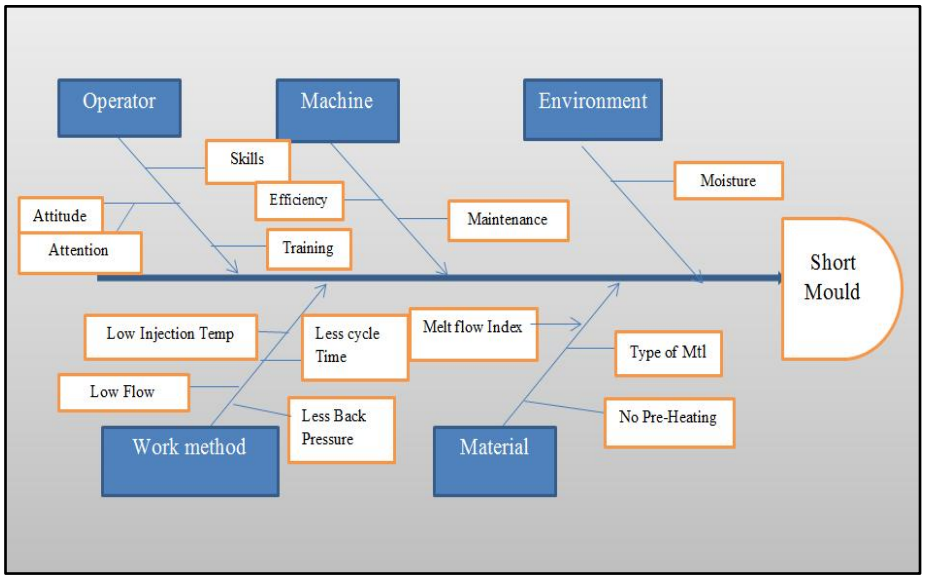

Fig. 4: Fishbone Diagram for Short Mould

It was found in the study that Short Mould is usually caused by injection moulding process parameters such as holding time, injection temperature and flow pressure. If the Injection pressure and temperature is low then material could not flow properly. Fig. 4 shows some possibility that might be the cause of Short mould. Causes of short mould are mainly due to Machine, Mould and Material. The main causes of the short mould regarding with machine includes Insufficient material feed, Very low Barrel temperatures, Faulty check ring, improper gate, Inadequate back pressure, Very low Nozzle temperature, insufficient pressing capacity. The main causes of the short mould regarding with mould includes too low Mould temperature, too small Gates or runners, insufficient venting etc.

Fishbone diagram for Black Dirty Spot:

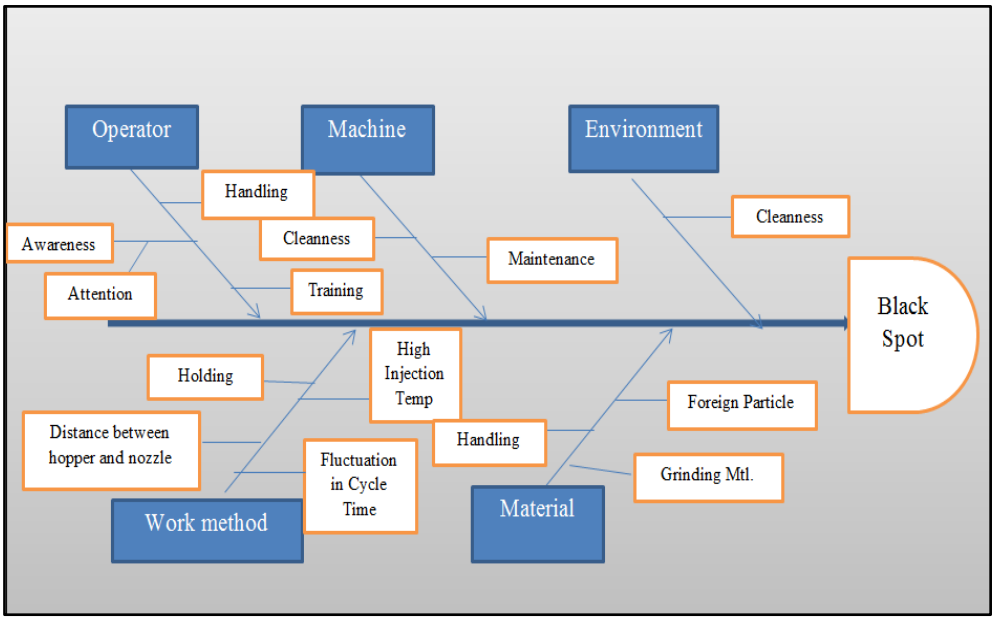

Fig. 5: Fishbone diagram for Black Dirty Spots

The researcher found that Dirty spots are caused by incoming raw material, mould and operator handling, problems with machines etc. The main causes of dirty spots regarding machine are excessive residence time in the barrel, Inefficient Injection conditions, Cracked injection cylinder or pitted screw, Oil leaking into injection unit, Inconsistent process cycle etc. The main causes of black dirty spots regarding with material includes excessive condensation and excessive lubricants on the material, contamination of raw material etc. Some of the causes regarding mould are contamination caused by grease or Lubricants, Burned material caused by improper venting etc.

Fishbone Diagram for Flow Mark:

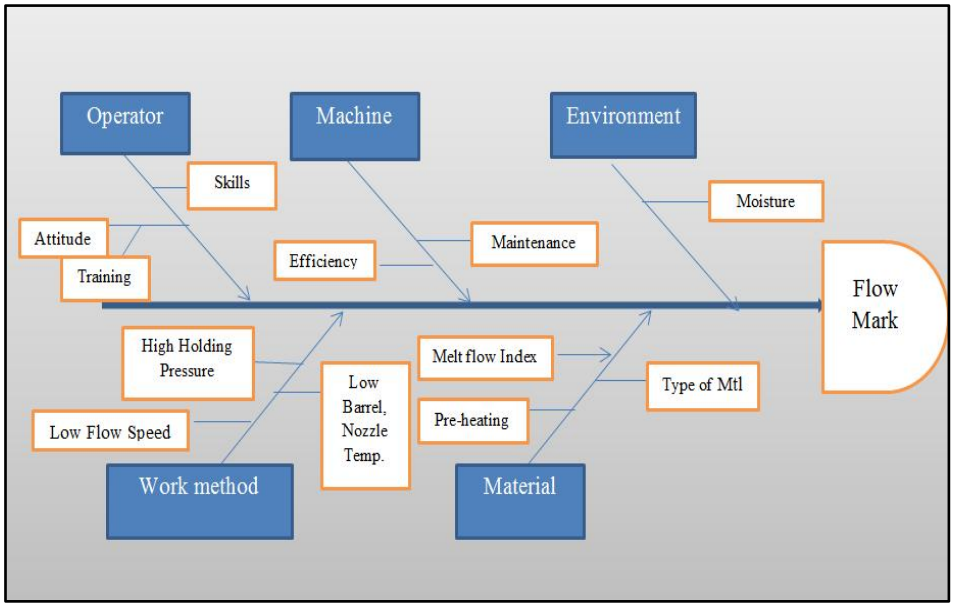

Fig. 6: Fishbone Diagram for Flow Mark

It was found by the researcher that Flow lines or marks are usually caused by injection moulding process parameters Such as holding time, injection temperature and flow pressure. Raw material and tooling design can also be the causes to the problem. Fig. 6 shows some possibility that might cause to the flow lines or marks. The main causes of flow lines or marks regarding with machine includes Inadequate injection pressure, inadequate residence time, Very low Barrel temperature, Very low Nozzle temperature, Inconsistent cycle time. The main causes of flow lines or marks regarding with mould includes improper finishing of mould, use of excessive lubricants. And the main causes of flow lines or marks regarding with Material includes No pre-heating for raw material, Low Flow index of material, Low quality of material used in the process.

Action Plan for these problems:

The related areas for improvement can be classified into operator, material, Machine, work method and environment. Following Tabulated data is Summarize the action plan for respective analysis of the top three defects.

Table 7: Action plan For Short Moulds

Parameters	Action Plan
Operators	• Must pay full attention.
Machines	• The temperature of machines should be high. • The speed of Barrel screw should be high. • Holding time and pressure should be more.
Materials	• Check the material flow index.
Methods	• Take trial of mould and accordingly set process sheet. • Follow process sheet.

Table 8: Action Plan for Dirty Dots

Parameters	Action Plan
Operators	• Material must be handled properly from any dirt. • Must have good attitude.
Machines	• Machine, mould, hopper must confirm clean all the time. • Screw and Barrel must be clean.
Materials	• Check every lot of Raw Material. • Check Quality of grinding (Recycling) Materials. • Use special purpose material for purging.
Methods	• Connector between machine and hopper must confirm clean. • Follow procedure.
Environment	• Work environment must be healthy.

Table 9: Action plan For Flow Marks

Parameters	Action plan
Operators	• Must have desired skills. • Must pay full attention towards work. • Follow work procedure properly.
Machines	• Check the efficiency of machines and take care of its maintenance.
Materials	• Material should be pre-heated and have a proper drying time. • Check Material Flow Index Of Raw Material.
Methods	• Machines must have correct and desired temperature, Flow conditions and Holding pressure.

Results after implementing action plan:

The results received after implementing the corrective action plan are as follows.

Results for the month of August 2017:

After implementing quality control techniques suggested by the researcher, the results found in the month of August are pretty good as compared to the months of May and June. The rejection rate is reduced by 0.97%. The following data shows the recorded data of August month. Interpretation of May, June and August is given in Table 11 Pareto chart of August month is drawn for comparison purpose.

Table 10: Data Regarding No. of Defects in Different Operations in August 2017

Problems	Short mould	Burn mark	Sink mark	Black spot	Oil mark	Flow mark	Dust	damage	Colour variation	Scratches
August 2017	2935	1350	980	2690	583	2030	390	350	150	280

Rejection in the month of August 2017:

The total production of August month is 134200 and the rejected samples are 11738. So the percentage of rejection can be calculated as below.

Rejection Percentage = (Total rejection/Total production)*100

= (11738/134200)*100

= 8.75%

Discussion on Results Arrived:

The researcher prepared Pareto Charts for the data of May and June 2017 and on the basis of those Pareto Charts, the researcher prioritized the problems and set the action plan. The result arrived for the month of August 2017 is shown in the Table 10. From that table the researcher found that the number of defects produced is less as compared to the defects found in the months of May and June 2017. The percentage of rejection also reduced from 9.72% to 8.75%.

Results:

The following table shows comparison between the number of rejections for the months of May, June and August 2017. The percentage of rejection of the month of August 2017 is reduced by 0.97% as compared to May 2017 and it is reduced by 0.94% as compared to June 2017.

Table 11: Comparison of rejection rate of production

	May	June	August
Total production	149450	139280	134200
Rejected Items	14520	13500	11738
Rejection Percentage	9.72	9.69	8.75

Conclusion:

Part of the "Seven QC tools" had been used for quality improvement activities. For example, fish-bone diagram was used to describe an unsatisfactory condition or phenomenon and help to examine why that problem raised by systematically arranging the contributable factors. An improvement action plan was set up, then the data was collected for two months and reexamination of defects was done.

Also the visual management plays an important role in quality. The work instructions prepared for worker will help to understand the problem. Better implementation of visual management helps to the all departments of company and makes continuous flow of work.

The set goals were achieved based on two months collected data that showed the average number of defects had changed to 8.75% from initial 9.72%. It was noted that even a simple QC tool can make significant improvement to the company and visual management also plays a key role in maintaining the quality of production.

Suggestions:

- Company should be more disciplined and all operators must go through some training especially on handling parts to avoid from some defects that caused by handling like finger print, stain mark and scratches. Especially, new operators must know how to handle the parts properly. Work instructions sheet can be used as a guide for proper work.
- Company should also focus on visual management more effectively which helps workers a lot and provide better view for customers.
- Machine must have a daily check sheet and machine operator must check the machine conditions for every shift to confirm the machines are in good condition.
- Every incoming lot material must go through Melt Flow Index checking to confirm the material to avoid from flow line defect.
- For dirty spot make assure that the raw material should not contain any foreign particles. Also the environment of company should also dust free, isolated as much as possible.

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