ANALYSIS OF QUALITY IMPROVEMENT USING STATISTICAL PRPOCESS CONTROL TOOLS TO REDUCE THE DEFECT LEVEL OF GREY FABRIC PRODUCT (A CASE STUDY AT PT SARI WARNA ASLI II BOYOLALI)

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ABSTRACT

This study aims to find out the implementation of quality control of products at PT Sari WarnaAsli II Boyolali by using statistical methods, to identify the type of dominant product defects and to identify the factors that resulted in product defect including Light Filling Bar, Miss Pick, and Filling Bar. The method of collecting data are interview, observation, and literature review. Analysis of quality control is done by using Statistical Process Control tools such as check sheet, histogram, c chart, pareto chart, and fishbone chart. Check sheet and histogram are used to present data become easier to be understood for further analysis. C chart analysis result indicate that there are 27 days in March 2016 in which the data is out of control limits, it means that quality control in the company needs further improvement. According to pareto analysis, the dominant of defects are Light Filling Bar (45,3%), Miss Pick (28,8%), and Filling Bar (25,9%). From fishbone chart, it can be known that the main causes that trigger the defects are derived from method factor, personnel (man) factor, and machine factor. The company could take preventive and corrective measures to reduce the defect level and improve quality among others, by enhancing supervision, improving work assessment, and regenerating machines.

Keywords: Quality Control, Statistical Methods, Statistical Process Control

INTRODUCTION

Business in Indonesia is growing more rapidly in a row with the government priority that focused in building the stronger nation economic foundation. The agreement of Asean Economic Community (AEC) in the end of 2015, among the states member of *Association of South East Asia Nations* (ASEAN), bringits own influences for business people in Indonesia. In a similar industry competition, no exception for textile industry, they will be encouraged to improve their competitiveness. A company can implement competitive strategy by giving special attention to the product quality so it can outperform the competitors' products.

According to Assauri (2008: 291), quality is defined as the factors contained in a goods/result that led to the goods/result in accordance with the purpose for what the goods/result was intended or required.Attention to quality generates positive impact to business performance through both the impact on production costs and earnings (Heizer *et al*, 2012: 300). Impact on production costs going through the process of production that comply with the standards that have been determined to be free of the defect level. Its because of the defect product will increase the production costs such as raw material costs, direct labor costs and factory overhead costs. While the impact of the increase in revenue through an enhancement in high quality product sales with the competitive price. Paying attention to the quality of products, the company will obtain the optimal profit and be able to meet consumer demand of quality products with competitive prices.

PT Sari WarnaAsli II that specialize in producing yarn and semi-finished fabric (grey fabric) has implemented a quality control system in producing textile products for export scale. According to the level of the defects, the grey fabric products produced are classified into grade A, B, and C where grade A and B are considered to meetthe company export products standard. Therefore, PT Sari WarnaAsli II Boyolali has set 0% for the grade C production target with the tolerance 3% of grade C products. Even though quality control had been implemented, there were still grey fabric products deemed included in grade C in the percentage of more than 3% because of the high defect level. So, the quality improvement is needed to reduce the defect level of grey fabric product.

Measuring the extent of defect to products that can be received by a company to determine the limits of tolerance of the resulting product defects can use quality control methods using statistical tools. According to Montgomery (2009), Statistical Process Control (SPC) is a methode of quality control which uses statistical methode applied to monitor and control a process. Monitoring and controlling the process ensures that it operates at its full potential. At its full potential, the

process can make as much conforming product as possible with a minimum (if not an elimination) of waste (rework or scrap).It is important to identify the cause of the defects product and find out remedial solutions by using statistical tools so that the percentage of product defects can be kept to a minimum.

LITERATURE REVIEW

Production, Based on Sinulingga (2009: 6), production is the activity of overall process and operation concerning the manufacture of either physical tangible product or intangible service.According to International Conference on Production Research (1983), the activity in the manufacturing are interconnected which include design, material selection, planning, manufacturing, quality assurance, and management and marketing of products (Sinulingga, 2009: 7).

Quality, Crosby defined quality as "conformance to requirements" (Suarez, 1992: 4). He also stated that "Quality must be defined in measurable and clearly stated terms to help the organization take action based on tangible targets, rather than on bunch, experience, or opinions". Based on Goetsch and Davis (2010) quoted by Knowles (2011: 10)"Quality is a dynamic state associated with products, services, people, processes, and environtments that meets or exceeds expectations and helps produce superior value".

Quality Improvement, Montgomery (2009: 7) stated that "Quality Improvement is the reduction of variability in processes and products". The more variability in process performance, the higher waste generated, included wasted of money, time, and effort concerned with the repairs. In other words, quality improvement is the reduction of waste (Montgomery, 2009: 7).

Quality Control, "Quality control is the use of techniques and activities to achieve, sustain, and improve the quality of a product or service" (Besterfield, 1998:2).

Statistical Quality Control, the first to apply the newly discovered statistical methods to the problem of quality control was Walter A. Shewhart (Kumalaningrum *et al*, 2011: 46). Statistical Quality Control (SQC) is a branch of quality control which is the collection, analysis, and interpretation of data for use in quality control activities (Besterfield, 1998: 3). Statistical quality control is conducted using statistical tools contained in Statistical Process Control (SPC). Montgomery (2009: 180), "Statistical process control (SPC) is a powerful collection of problem-solving tools useful in achieving process stability and improving capability through the reduction of variability."

With reference to Benton (1991) and Talbot (2003), there are many advantages of using SPC in quality

control improvement that "could be categorized into the following categories (Awaj *et al*, 2013):

1. Maintain a desired degree of conformance to design,
2. Increase product quality,
3. Eliminate any unnecessary quality checks,
4. Reduce the percentage of defective parts purchased from vendors,
5. Reduce returns from customers,
6. Reduce scrap and rework rates,
7. Provide evidence of quality,
8. Enable trends to be spotted, and
9. Ability to reduce costs and lead times".

RESEARCH METHODS

In this study using two kinds of research variables, i.e. quality control and quality measurement using attribute that used to determine the level of nonconformities that occurs to the products produced by the company.

The sampling in this study using a quota sampling technique. Quota sampling is a sampling technique in which samples will be selected intentionally to a specified number.The sample used in this study is the number of defect point of dominant defect type of grey fabric product in Weaving I Department PT Sari WarnaAsli II Boyolali period March 2016, considering that the total production as well as the number of defect point in March were the highest of the first four months in 2016, in which the total production is 3.346.842 yards and the number of dominant type defect point is 1.135.308 points.

Data used in this study are primary data obtained from PT Sari WarnaAsli II Boyolali. Data obtained in the form of quantitative data and qualitative data. Quantitative data is in the form of numerical data namely data on the number of production and product defect. Qualitative data is in the form of written information, that is information about the type of defects, the cause of the defects, the chart of production process and raw materials used.

Sources of the overall data obtained from PT Sari WarnaAsli II Boyolali. Quantitative data obtained from the document / records in the Weaving I Department of PT Sari WarnaAsli I Boyolali. While the qualitative data obtained from interviews with department managers of Weaving I Department and direct observation in the company.

Data collection method used in this research are through interview, direct observation, and literature review.

In order to handle the quality control problems, it is used statistical tools contained in Statistical Quality Control (SQC) and Statistical Process Control (SPC). The steps should be taken among others:

a. Collecting data using a check sheet.
b. Constructing histogram.
c. Testing the data adequacy.
d. Constructing the control chart C (C-Chart).

e. Determining the improvement priorities (using Pareto Chart).
f. Identifying the dominant causes of product defects (using Fishbone Chart).
g. Creating the recommendation of quality improvement.

FINDING AND DISCUSSION

Quality control activities conducted by Weaving I Department include three stages, among others:

a. Control of Raw Materials/Production Materials
   The number and the type of yarns obtained from the spinning department and supplier are checked whether appropriate to the requirements ordered or not. Then through ultraviolet checking, the yarn with the different type and diameter will be separated.
b. Control of Running Production Processes
   Start from Warping process, Winding process, Sizing process, Reaching Process, Tying Process, and Weaving Process,
c. Control of Finished Products Before Packing by Inspecting process, is an inspection activity and repair the fabric resulting from the weaving process. In the process, the operator cuts the yarn that not neat, repairs the damaged yarns, and cleans the fabrics.

From an interview with the Section Head of PPC / Inspecting,there are three dominant types of fabric defects among others:

a. Filling Bar
   The condition of the webbing of fabric is tight. In the machine, the fabric looks different colors (darker). The distance between weft yarns is not fixed. The number of weft strand in certain range increases.
b. Light Filling Bar
   The condition of the webbing of fabric is rare. In the machine, the fabric looks different colors (brighter). The distance between weft yarns is not fixed. The number of weft strand in certain range decreases.
c. Miss Pick
   The condition of broken off weft, and itoccasionally bound back.

The first step in statistical quality control is collecting data using checksheet. Create Table 1 (check sheet) of the number of production and the product defects is useful to simplify the process of data collection and analysis.

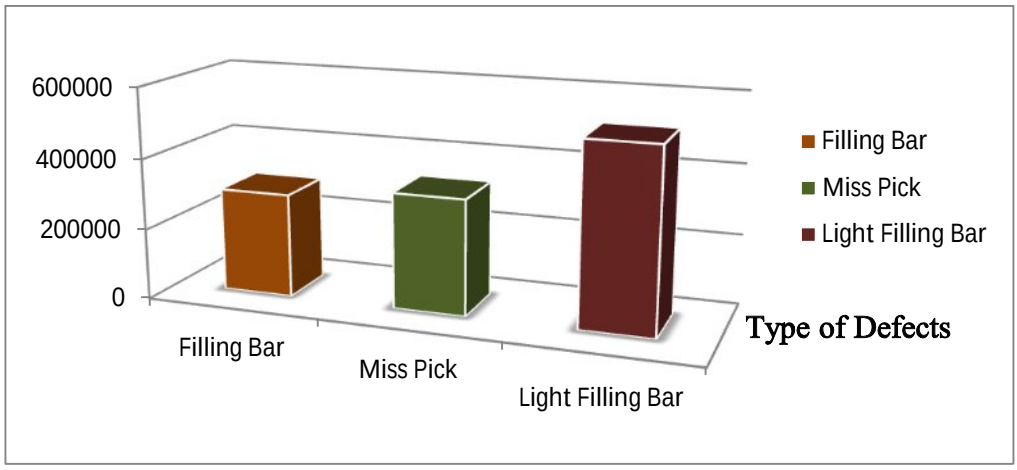
Table 1
Defect Point of Grey Fabric Product
Weaving I Department PT Sari Warna Asli II Boyolali
March 2016

Date	Total Production (Yard)	The Number of Defect Point	Type of Defect		
			Filling Bar (Point)	Light Filling Bar (Point)	Miss Pick (Point)
1	108.528	36.432	10.084	17.219	9.129
2	105.993	35.847	9.686	17.570	8.591
3	103.903	37.293	8.735	16.662	11.896
4	112.165	39.733	11.166	17.157	11.410
5	107.757	40.394	11.887	19.318	9.189
6	102.165	35.312	7.784	14.693	12.835
7	111.448	42.892	9.752	18.980	14.160
8	106.358	38.055	10.711	16.432	10.912
9	111.385	38.827	9.664	17.962	11.201
10	104.144	40.134	9.399	17.753	12.982
11	107.077	38.083	11.510	14.429	12.144
12	107.795	36.910	11.420	18.338	7.152
13	107.217	38.162	9.123	16.469	12.570
14	108.869	31.987	8.579	13.876	9.532
15	104.576	32.977	7.541	14.804	10.632
16	105.053	40.040	9.922	17.774	12.344
17	105.026	33.840	9.019	15.219	9.602
18	106.553	32.616	8.060	15.316	9.240
19	111.342	35.520	8.325	16.276	10.919
20	113.070	39.974	11.005	17.626	11.343
21	104.457	31.690	8.126	14.758	8.806
22	109.623	34.285	10.559	13.473	10.253
23	109.042	34.309	8.119	16.396	9.794
24	108.700	36.737	9.623	16.514	10.600
25	107.619	36.228	8.354	15.478	12.396
26	108.733	35.144	7.717	16.072	11.355
27	111.108	35.401	8.712	17.574	9.115
28	108.383	38.492	10.591	20.248	7.653
29	108.816	35.377	8.743	16.378	10.256
30	111.556	38.721	11.641	16.589	10.491
31	108.381	33.896	8.208	16.998	8.690
TOTAL	3.346.842	1.135.308	293.765	514.351	327.192

Source: PT Sari Warna Asli II Boyolali, 2016.

After the check sheet is made, the next step is to create a histogram. Histogram is a graphical display of the collected data, where each displayed bars indicate the proportion of frequencies in each category by side. From histogram in the Figure 1, it can be seen that from three types of defects, the majority of defects are caused by Light Filling Bar with the number of defect about 514.351 defect points. Then, followed by Miss Pick that causes 327.192 defect points and Filling Bar that causes 293.765 defect points.

Figure 1
Histogram of Product Defects
Period March 2016



Source: PT Sari Warna Asli II Boyolali, 2016.

For further analysis, it can be used the track record of dominant product defects in 4 last months. Table 2 shows the data of dominant product defects during January – April 2016.

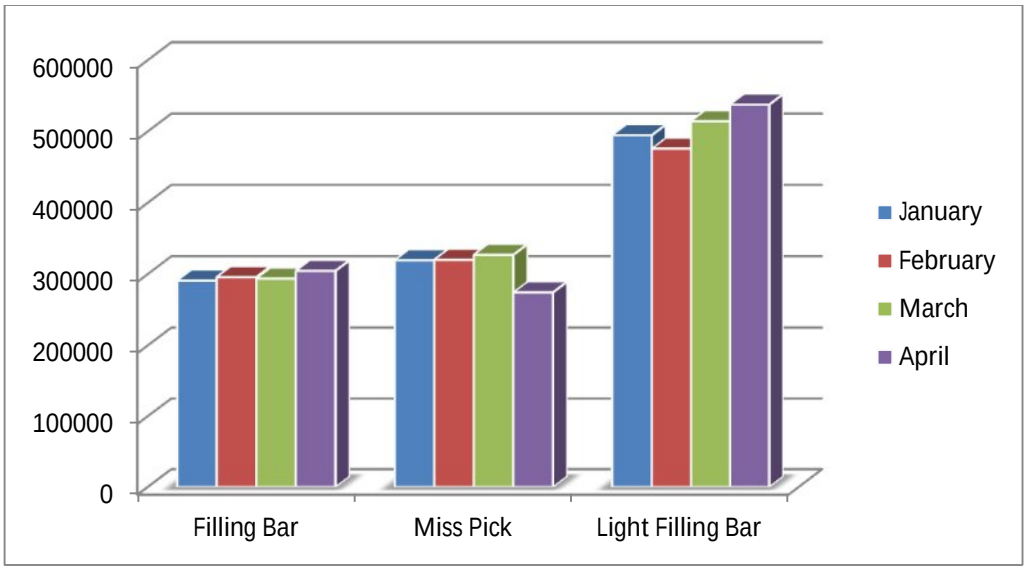
Table 2
The Number of Defect Point in Each Type
Period January – April 2016

Month	Type of Defects			Total Defects
	Filling Bar (Points)	Miss Pick (Points)	Light Filling Bar (Points)	
January	291.003	319.527	494.843	1.105.373
February	295.967	320.212	475.991	1.092.170
March	293.765	327.192	514.351	1.135.308
April	304.638	274.486	537.697	1.116.821

Source: PT Sari Warna Asli II Boyolali, 2016.

From the Table 2, it can be constructed a histogram to illustrate the data more easily. As seen on histogram in Figure 2 that from January 2016 till April 2016, Filling Bar defect was tend to be constant. While, Miss Pick defect increased in the first three month from 319.527 to 327.192, then fall down to 274.486 in April. Light Filling Bar defect was likely to increse even though it dropped in February. So, the quality improvement can be carried out by focusing on Light Filling Bar first.

Figure 2
Histogram of Product Defects
Period January – April 2016



Source: PT Sari Warna Asli II Boyolali, 2016.

Once the data is acquired it is necessary to know whether the data taken are sufficient or not. To calculate whether the obtained data is sufficient or not, it can be used a formula to test the adequacy of the data as follows (Faizuddin, 2015):

$$N' = \frac{(Z)^2 x(\bar{p}) x(1-\bar{p})}{(\alpha)^2}$$

Where:

N' : The number of samples required

Z : Z value at a certain confidence level
Confidence level 90%, Z= 1,65
Confidence level 95%, Z= 2
Confidence level 99%, Z= 3

P : Average nonconformities.

α : Eror level 10% = 0.1
Eror level 5% = 0.05
Eror level 1% = 0.01

The confidence level (Z) which is assumed at 99 % and the level of eror at 1%. Based on existing data, the calculation is:

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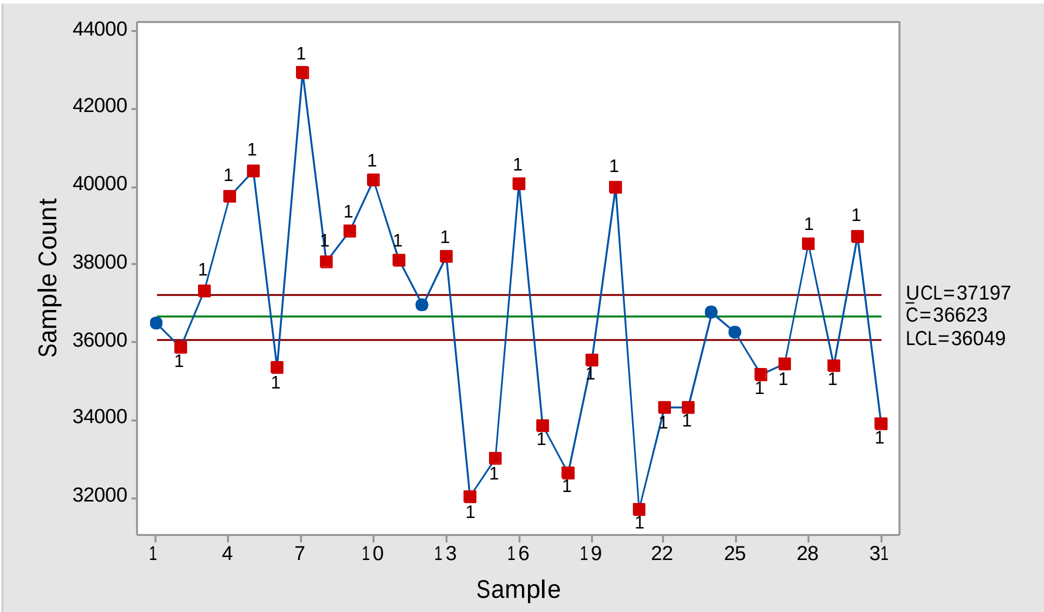
The criteria used is when the sample is taken (N) is greater than or equal to the number of samples required (N'), then the data or sample used are sufficient. However, if the number of samples that have been used (N) is less than or equal to the number of samples required (N'), then the samples or data that have been taken are not sufficient, so need more sampling.Based on these calculations, it was found that the value of N' (Z=3, α=0,01) is equal to 20.168. So the value of N is larger than the value of N' i.e.1.135.308> 20.168, it means that the data or samples collected are sufficient.

Figure 3
C-Chart of Grey Fabric Products Defect Point



Source: PT Sari WarnaAsli II Boyolali, 2016.

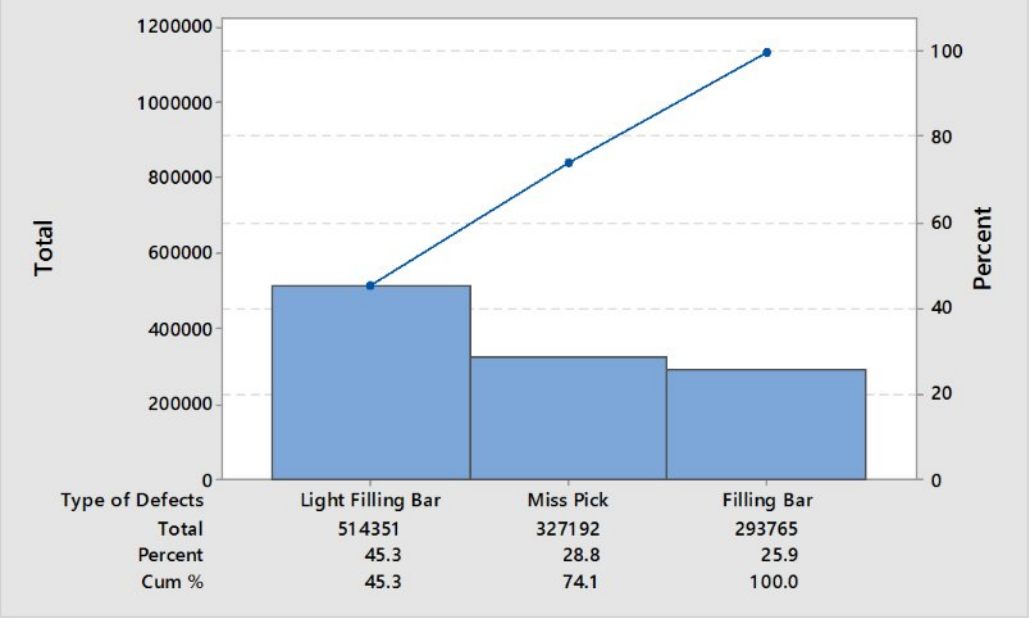
The next step is construct Control Chart C (C-Chart) in order to facilitate the viewing of data that out of control using Minitab 17. The analysis of a control chart C (C-chart), shows that there are still many data that are out of control limits and there are many extreme spread of the data i.e. 87% of the product defect data in March 2016. On the date of 2, 6, 14, 15, 17, 18, 19, 21, 22, 23, 26, 27, 29, and 31, the number of defect level passes through the lower control limit. It means that the defect level is good enough because in production, the lower the defect level, the better the production result. Meanwhile, there are also many data passes through the upper control limit (42% of product defect data) i.e. 13 days in March 2016. Therefore, it can be said that the quality control in Weaving I Department PT Sari Warna

Asli II Boyolali requires further improvement.

Then, construct Pareto Chart. Pareto chart function is to identify or select a major problem from the biggest to the smallest for the quality improvement.This chart shows the most dominant type of product defects in production during March 2016. After knowing the number of defect point in each type then it is sorted by the number of product defect, from the largest to smallest and made the cumulative percentage. The cumulative percentage is useful to state how many differences in the frequency of occurrence among several dominant problems, using Minitab 17.

Based on Pareto Chart below, it can be known that the largest type of defects are caused by Light Filling Bar i.e. 45,3%, then Miss Pick is 28,8%, and Filling Bar is 25,9%. So, the quality improvement can be carried out by focusing on Light Filling Bar first. It is because the Light Filling Bar type has the largest percentage i.e. 45,3%.

Figure 4
Pareto Chart of Product Defects

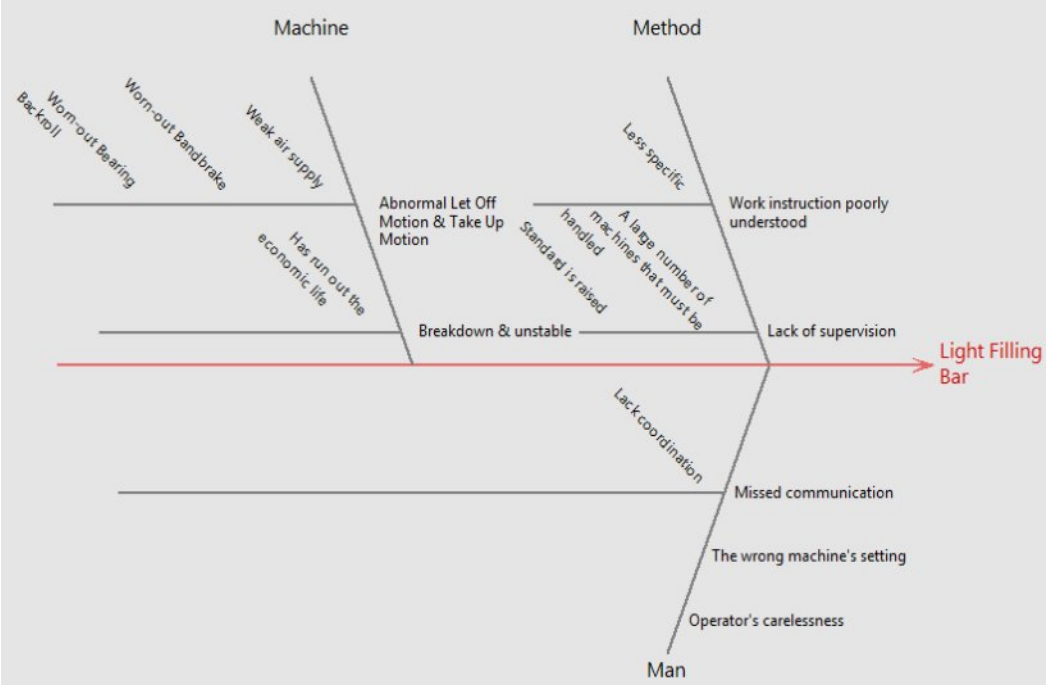


Source: Weaving I Department of PT Sari Warna Asli II Boyolali, 2016.

After knowing the dominant types of product defects, PT Sari WarnaAsli II Boyolali needs to take corrective measures to prevent similar defect or to reduce the number of dominant defects. The most important thing to do and explored is finding the causes of the product defects. As a tool to facilitate in finding the causes of the defects, it can be used the Cause and Effect

Diagram or Fishbone Chart.By using Fishbone Chart, it can be known the causes of each defect type. Figure 5 below is the use of Fishbone Chart for Light Filling Bar:

Fishbone Chart of Light Filling Bar



Source: Result of Observation and Interview, 2016.

CONCLUSION AND RECOMMENDATION

Conclusion

Based on research that has been done in PT Sari Warna Asli II Boyolali, result and discussions indicated that research objectives has been achieved. So it can be drawn some conclusions below:

a. Quality control activities conducted by Weaving I Department include three stages among others, control of raw materials / production materials by ultraviolet checking, control of running production processes from warping process till weaving process, control of finished products before packing by inspecting. By using Control Chart C (C-Chart) in quality control activity, it can be known that many product quality are out of control limits. As seen on C-Chart, there are many data passes through the upper control limit (42%) on the date of 3, 4, 5, 7, 8, 9, 10, 11, 13, 16, 20, 28, and 30. This condition indicate that the processes are uncontrollably and there are still deviations, it means that quality control in Weaving I Department PT Sari Warna Asli II

Boyolali requires further improvement.

b. According to production data obtained from Weaving I Department PT Sari Warna Asli II Boyolali, it can be known that the number of grey fabric production in March 2016 is about 3.346.842 yards with the number of defect is about 1.135.308 points. Based on Histogram and Pareto Chart, the dominant defects consist of Light Filling Bar 514.351 points (45,3%), Miss Pick 327.192 points (28,8%), and Filing Bar 293.765 points (25,9%.).
c. From the analysis using Fishbone Chart, it can be seen the causative factors are material factor, method factor, personnel (man) factor, machine factor, and environtment factor. There are three dominant factors that trigger product defects i.e. method factor, personnel factor, and machine factor.

Recommendation

Weaving I Department of PT Sari Warna Asli II Boyolali needs to intensify the use of Statistical Process Control tools to identify what type of defects, how many point each defect, and what factors that trigger the defects. Thus, the company could carry out the preventive and corrective measures as soon as possible to reduce the defect level.

According to the analysis using Statistical Process Control tools that has been done (Pareto Chart and Histogram), the company could prioritize the quality improvement to suppress the number of product defects by focusing on the most dominant defect i.e. Light Filling Bar, which caused by method factor, personnel (man) factor, and machine factor. Because Light Filing Bar has the biggest percentage viz., 45,3%, then Miss Pick about 28,8%, and Filling Bar about 25,9%. Moreover, the Light Filling Bar is likely to increase than the others during January – April 2016.

Generally, the main causes that trigger product defects are method factor, personnel (man) factor, and machine factor as well. In accordance with observation that has been carried out, in which the defects of grey fabric product were occured during production process, using machine that run by operator with certain method. Therefore, recommendation actions to overcome the product defects that caused by those factors, could be done in following ways:

a. Method Factor

1) Provide the more specific instruction not only verbally during the meeting but also in written instruction, so result of meeting can be used by operator as an additional guidance.
2) Always do a routine evaluation to determine the number of machines that will be handled by each operator, considering not only the

labour cost that increase but also in terms of production quality, production quantity, condition of the machine, and from the ability of the operator itself.

3) Improve supervision on sizing process and operator must pay more attention to factors that affect the SPU standard.

b. Personnel (Man) Factor

1) Enhance supervision so that operators could be more conscientious and the performance could be increased.
2) Conduct rechecking by the supervisor.
3) Briefing could be held regularly every beginning and end of the work.
4) Improve surveillance and give warning and sanction to workers that make mistakes.
5) Conduct training for worker routinely.
6) Make the new work assessment system to motivate worker.

c. Machine Factor

1) Hold machine maintenance routinely and periodically.
2) Required enough stock for the easy worn-out spare parts. So, spare parts that worn-out and can not be repaired are able to immediately replaced.
3) Replace the machine that has run out its economic life (machine regeneration).
4) Recheck the setting of machine before and after work routinely.
5) The worker should be able to better maintain the cleanliness of the machine and each of its parts.

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