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Quality Control Analysis of Belt Conveyor with Statistical Process Control Approach: A Case Study in Fabrication Manufacturing Industry

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ABSTRACT

In the field of construction includes construction of steel, installation of heavy components and construction (buildings, roads, or bridges). The current job activity is construction and conveyor belts manufacturing. If a product needs to satisfy the customer, the product should be made with a stable process where the process should be able to operate with small variances around the target value that will characterize product quality. Based on these issues, the purpose of the study is to achieve higher product quality, maintain stable quality, and make better specifications by reducing the defective products. Data measurement results are within control limits, from 15 components found only 3 that are far the from data spec means all data are out of control and this because of the high data variances. An improvement proposal to overcome defects in belt conveyor products such as direct training and coaching to every operator, in the determination of allowance should be adjusted to field measurements and perform predetermined measurements and use safety tools such as ear plug, so all operators are comfortable and concentrated in working and lighting inside the room.

Key Words: *Process Capability, Process Capability index, Fabrication, Quality, Statistical Process Control.*

1. INTRODUCTION

The current project activity is the construction and conveyor belt manufacturing, basically good service quality brings customer satisfaction and loyalty and guidance for high spirits to make recommendations, reduce complaints and improve customer level of customer retention [1]. Service quality is referred to as a strategic one and the main axis in competition. Due to all the reasons mentioned above, it is important to check and improve the quality of their services. Service companies must find the needs and expectations of their customers by looking at the size of their customers' trust and satisfaction over a period of time, and doing their best to further improve its professional services. If companies offer, retain, and increase customer satisfaction and trust, they will be equally profitable [2].

Based on the characteristics that cause the reject on the conveyor belt is measurement of components that are not in accordance with the specification, Connection on the ring component is not neat, the surface parts of the uneven side of the component, and the surface of the component is not smooth. The statistical process control (SPC) is used to control the production process continuously and identify the damage that occurs when the production process takes place. SPC is also used to collect and analyze data on sample inspection results in product quality monitoring activities. The monitoring and production process uses Statistical Process Control (SPC) to provide better information and control. Therefore, data processing with SPC requires follow-up process control to avoid further production defects. The purpose of Statistical Process Control (SPC) is to achieve higher product quality, maintain uniform quality, and make better specifications by reducing damaged products. The goal to be achieved in this study is to analyze the conveyor belt conveyor process within the control boundaries. After analysis, determine the capability of the conveyor belt conveyor process. Then design improvements to reduce defects in belt conveyor products.

2. LITERATURE REVIEW

2.1 Statistical Process Control (SPC)

Quality control is not just a checking activity or determining whether the product is good (acceptable) or ugly (reject) [5]. Statistical quality control is the method used companies collect and analyze data on variations which occurred during production to determine if necessary adjustment. All processes have variety variation form. Variations in the process can also exist due to a common cause or a special cause. Variation due to built-in error in system design causing many differences to exist. This process is called a general cause change, variation because the causes are usually absent process but caused by workers or extraordinary condition or event called special reason variation [6]. Statistical Process Control (SPC) is one of the tools used to solve this problem. This tool is used to achieve stability and improve capability by minimizing variability. The purpose of Statistical Process Control (SPC) is to achieve higher product quality and minimize production costs by reducing the damaged product produced. Quality is an important criterion used by users in deciding to purchase products [7]. Statistical process control (SPC) is a collection of great tools that aid in visualization, tracking, and identification of variation variations that can be set in one process that create products, services, or information. Tool has developed as a Statistical Process Control in Proteomics (SProCoP) applies the SPC aspects (eg, control charts and Pareto analysis) to Skyline proteomic software.

2.2 Function of Control Charts

The main purpose of the use of control charts is to monitor and improve process performance over time and to learn various and resources. There are several functions from the control chart[10], which are: (i) provides statistical facilities for tracking and monitoring variation of the process from time to time, (ii) provides tools for continuous process control, (iii) and then distinguishes specifically from the usual causes of variation to be a guide to local action or management, (iv) helps to improve the process of doing it consistently and can be predicted to achieve higher quality, lower cost, and higher effective capacity, (v) it works as a general language to discuss the process performance.

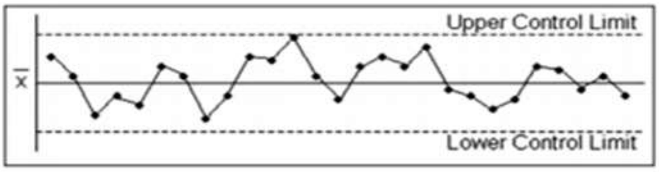

Figure2.1: Sample Process Monitoring Is Under-control

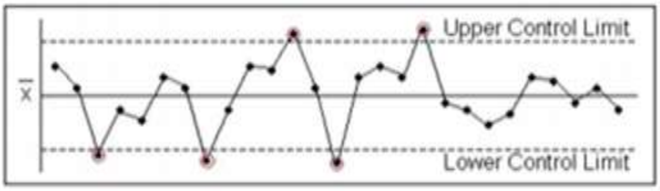

Figure2.2: Sample Process Monitoring Is Out of Control

2.3 Type of Control Charts

The main purpose of the use of control charts is to monitor and improve process performance over time and to learn various and resources. There are several functions from the control chart[10], which are : (i) provides statistical facilities for tracking and monitoring variation of the process from time to time, (ii) provides tools for continuous process control, (iii) and then distinguishes specifically from the usual causes of variation to be a guide to local action or management, (iv) helps to improve the process of doing it consistently and can be predicted to achieve higher quality, lower cost, and higher effective capacity, (v) it works as a general language to discuss the process performance.

The control chart is most effective when used for repetition an important process for the organization and for data available. There are two categories control chart: variable control chart and attribute control chart. This is used when the measurement is quantitative (for example, height, weight, or thickness). There are two types of control variables, which are as follows: X bar-R chart and X bar-S chart. X-bar and the distance chart are part of the control chart category; the function is to set a control charts for data changes (data which is quantitative and sustainable in the measurement, such as dimensions or time measurable). The X-bar graphically monitors the location of the process from time to time, based on an average of a series of observations, called subgroups. Range chart monitors variations between observations in subgroups over time, X-bar and various the graphs is used when the measurements are grouped (subgroup) between two and ten observations. X-bars and R graphs consist of two graphs, both of which are the same horizontal axis showing the sample number.

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2.4 TQM

TQM is a customer-focused management philosophy that focuses on sustainable process improvement and organizational management by means of design procedures, statistical control, human resource management strategies and policy use. In addition, TQM has primarily transformed and reproduced working procedures and reflected on the management of many companies in the 1990s; However, it also creates new and important challenges for every organization. Although TQM was originally launched into the manufacturing industry, its use has also continued to expand into the service industry. Accreditation with internationally recognized quality recognized specifications, such as American Six Sigma and European ISO 9000, have is a basic demand for doing business with several companies [13]. After reviewing the literature on TQM intensively, we have selected the following seven TQM dimensions according to its importance in the service industry: customer focus, highest management commitment, quality information system, continuous improvement, use of ICT, knowledge partnership, and service culture [14].

2.5 Relationship between soft-hard TQM

There are some results have not been determined, by overall, some aspects of soft and hard quality management are possible; The component of soft quality management can indirectly and directly influence on performance, while the hard aspects may be directly related to performance. Therefore, harsh quality management can act as an intermediate variable between performance and gentle quality management [15]. Examined the relationship between soft and hard elements of TQM in 40 Malaysian manufacturing certified ISO 9000 [16].

3. RESEARCH METHOD

The topic research methodology used statistical process control (SPC). Literature review has been carried out to examine the definitions and theories of Statistical Process Control. Also perform a field observation by observing the Company with the purpose of knowing the production process. Then the issues is formulated to be finalized following a structured's research objectives based on what has been formulated from the problems and determine the limitations made in this research. The collected data are characteristic of the belt conveyor quality, the belt conveyor quality feature data and the characteristics of the defect. Data processing is done by statistical process control using map variable X-Bar, R and map Attribute C then performed with Capacity Process Analysis. The SPC is calculated using the Belt 15 and 5 component data with 30 sample. After knowing the results of the minitab seen at the beginning of the first range whether within the control limit or not if it not then do the uncontrolled data disposal after the range in the control limit and then rearrange the X-Bar. The next data is within the control limit. Beside that, also calculate the map C. Calculate the process capability index seen from CP and CpK values. Analyses the obtained previous data then process using X-Bar and R control charts, after obtain the analysed data then conclusions and recommendations for improvement from the research will follow.

4. RESULT

4.1 Data collection

Based on the quality standard of belt conveyor in the company, below is the specification data for characteristic of Belt Conveyor quality.

Table4.1. Specification characteristics of belt conveyor quality

No.	Characteristics	Standard (Measure)		
		LSL	U SL	Target
1	Width Belt Cover	91.38	91.42	91.4
2	Upper Ring Width	3.98	4.02	4
3	Ring Ring Width	3.98	4.02	4
4	Right Handle Right	22.98	23.02	23
5	Right Handle Width	4.98	5.02	5

Table4.1. Specification characteristics of belt conveyor quality (continue)

No.	Characteristics	Standard (Measure)		
		LSL	U SL	Target
6	Left Handle Length	22.98	23.02	23
7	Left Handle Width	4.98	5.02	5
8	Right Door Belt Cover Right	46.78	46.82	46.8

9	Belt Door Belt Cover Right	44.98	45.02	45
10	Left Belt Door Left Length	46.78	46.82	46.8
11	Left Belt Door Left Width	44.98	45.02	45
12	Right Belt Cover Right Hole	34.98	35.02	35
13	Right Belt Cover Right Hole	34.98	35.02	35
14	Long Belt Cover Left Left	34.98	35.02	35
15	Left Belt Cover Left Width	34.98	35.02	35

Belt quality features are divided into 15 components : (1) width belt cover, (2) upper ring width, (3) ring ring width, (4) right handle right, (5) right handle width, (6) left handle length, (7) left handle width, (8) right door belt cover right, (9) belt door belt cover right, (10) left belt door left length, (11) left belt door left width, (12) right belt cover right hole, (13) right belt cover right hole, (14) long belt cover left left, (15) left belt cover left width. There are components of them features broad belt protection components. Based on the characteristics of belt, defect meant are measurements of components that do not match with the specification, such as connection on the ring component is untidy, the component parts surface are uneven or not smooth.

4.2 Data processing

Once the data collection completed, it continue with data processing using Statistical Process Control. First method is using X-Bar and R variable map on the belt cover component to measure the product width. The following table is the width measurement result on belt cover:

Table4.2. Measurement data of belt cover with width characteristic

Sample	X1	X2	X3	X4	X5	X-BAR	R
1	91.5	91.4	91.2	91.5	91.5	91.42	0.3
2	91.2	91.2	91.4	91.3	91.4	91.3	0.2
3	91.7	91.6	91.7	91.5	91.5	91.6	0.2
4	91.6	91.5	91.4	91.6	91.6	91.54	0.2
5	91.3	91.4	91.3	91.4	91.5	91.38	0.2
:	:	:	:	:	:	:	:
30	91.3	91.3	91.5	91.4	91.5	91.4	0.2
Average						91.451	0.213

N = 30 n = 5

A_2 = 0.577 D_3 = 0

D_4 = 2.114

$\bar{X} = \frac{91.5+91.4+91.2+91.5+91.5}{5} = 91.42$

$\bar{\bar{X}} = \frac{91.42+91.3+91.6+\cdots+91.4}{30} = 91.451$

R = 91.5 – 91.2 = 0.3

$\bar{R} = \frac{0.3+0.2+0.2+\cdots+0.2}{30} = 0.213$

$UCL\bar{X}$ $= \bar{\bar{X}} + A_2.\bar{R}$
= 91.451+ (0.577) 0.213
= 91.574

UCL_R $=D_4 \times \bar{R}$
= 2.114 x 0.213
= 0.451

$LCL\bar{X}$ $= \bar{\bar{X}} – A_2.\bar{R}$
= 91.451- (0.577) 0.213
= 91.328

UCL_R $=D_3 \times \bar{R}$
= 0 x 0.213
= 0

Here are the results of X-Bar and R control map processing takenfrom minitab software:

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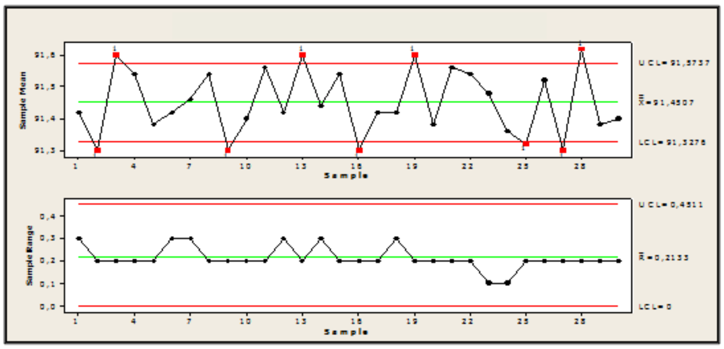

Figure4.1: X-Bar Map and Feature Feature Frame R Length

Here is a session for the processing of X-Bar and R map above:

Test Results for R Chart of C1; ...; C5

```
TEST 1. One point more than 3,00 standard deviations from center line.
Test Failed at points:  5

* WARNING * If graph is updated with new data, the results above may no
          * longer be correct.
```

Test Results for Xbar Chart of C1; ...; C5

```
TEST 1. One point more than 3,00 standard deviations from center line.
Test Failed at points:  2; 3; 9; 13; 16; 19; 25; 27; 28

* WARNING * If graph is updated with new data, the results above may no
          * longer be correct.
```

Figure4.2: Minitab Results Of Belt Cover With Width Characteristic

The X-Bar and R map data processing result shown in Figure4.1 and Figure4.2 no revision are required since the data is in good controlled. Next step is to look into the Xbar map. A revision has made for data 2. 3. 9. 13. 16. 19. 25. 27 and 28. Those out of control data are deleted and revised. The root cause of out of the control value occurs due to the operators careless during cutting process and operating the machine in the production floor. Beside that the machine condition (old mc) also contribute to the cutting result, uneven on its surface. Below is a new X-Bar and R processing data result after the revision:

Table4.3. New data of belt cover component with width characteristics

Sample	X1	X2	X3	X4	X5	XBAR	R	UCL	LCL	X-BarBar	UCL-R	LCL-R	R-Bar
1	91,5	91,4	91,2	91,5	91,5	91,42	0,3	91,583	91,330	91,456	0,463	0	0,219
2	91,6	91,5	91,4	91,6	91,6	91,54	0,2	91,583	91,330	91,456	0,463	0	0,219
3	91,3	91,4	91,3	91,4	91,5	91,38	0,2	91,583	91,330	91,456	0,463	0	0,219
4	91,5	91,6	91,3	91,3	91,4	91,42	0,3	91,583	91,330	91,456	0,463	0	0,219
5	91,5	91,5	91,6	91,4	91,3	91,46	0,3	91,583	91,330	91,456	0,463	0	0,219
:	:	:	:	:	:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:	:	:	:	:	:
21	91,3	91,3	91,5	91,4	91,5	91,4	0,2	91,583	91,330	91,456	0,463	0	0,219
		Average				91,456	0,219						

N = 21   n = 5

A_2 = 0.557 D_3 = 0

D_4 = 2.114

$$\bar{X} = \frac{91.5+91.4+91.2+91.5+91.5}{5} = 91.42$$

$$\bar{\bar{X}} = \frac{91.42+91.54+91.38+91.42+\cdots+91.4}{21} = 91.456$$

R= 91.5 – 91.2 = 0.3

$$\bar{R} = \frac{0.3+0.2+0.2+0.3+\ldots+0.2}{21} = 0.219$$

UCL$\bar{X}$ $= \bar{\bar{X}} + A_2.\bar{R}$
= 91.456+ (0.577) 0.219
= 91.583

UCL_R $= D_4 \times \bar{R}$
= 2.114 x 0.219
= 0.463

$LCL\bar{X}$	$= \bar{\bar{X}} - A_2.\bar{R}$	UCL_R	$= D_3 \times \bar{R}$
	= 91.456- (0.577) 0.219		= 0 x 0.219
	= 91.330		= 0

The following graph is X-Bar processing data of the Belt Cover Characteristics after revised, shown all are within specification:

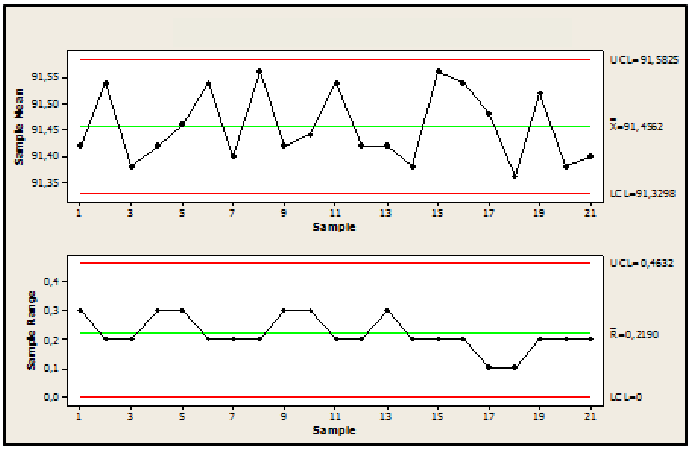

Figure4.3: X-bar and Charts R Component Belt Cover Revision Characteristics Width

After revision completed by removing those out of control value, by referring to Figure.3 that only X-bar and R data are within the control limit.

4.3 Capability process analysis (CPA)

Process capability analysis is the process capability calculation to meet specifications or to measure the performance of a data process. Where data estimates can be shown average values and how they are distributed and whether or not the data is within the required limit of specifications. through the analysis of this process analysis. There of the 15 components only 12 components can be passed to the CPA calculation because the third component is a component of the left hand operator of long features. component side cover side of the feature width and component parts belt cover hole leaving the data sample width characteristics obtained from all controls. CPA Belt Component Width Features, the following graph is Minitab software resultst to determine the process capabilities of the Belt Protection component in its wide range of features.

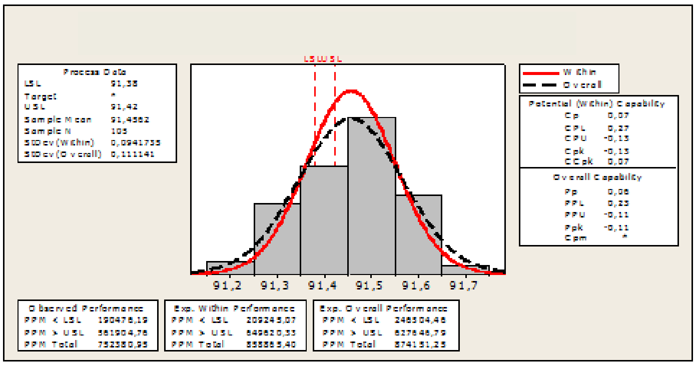

Figure4.4: CPA Belt Component for Width Features

Figure 6 showed the process does not appears in the middle of graph since the Cpk value smaller than Cp. Process capabilities on the belt protection component are also not suitable since the Cpk value lesser than 1 (-0.12), its means the process has producing a poor product and Cp value also less than 1.33 (0.07) which means having a low process capability. The calculation as below:

Example Computation:

d_2	= 2.326	T	= 91.4	$\bar{\bar{x}}$	= 91.456
USL	= 91.42	LSL	= 91.38	$\bar{R}$	= 0.219
N	= 5				

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$$\sigma = \frac{\overline{R}}{d_2} \qquad Cp = \frac{USL - LSL}{6\sigma}$$

$$\sigma = \frac{0,219}{2.326} = 0,094 \qquad Cp = \frac{91,42 - 91,38}{6 \times 0,094} = 0,070$$

$$CPU = \frac{USL - \overline{\overline{X}}}{3\sigma} \qquad CPL = \frac{\overline{\overline{X}} - LSL}{3\sigma}$$

$$CPU = \frac{91,42 - 91,456}{3 \times 0,094} = -0,127 \qquad CPL = \frac{91,456 - 91,38}{3 \times 0,094} = 0,27$$

Cpk = minimum {CPU.CPL}
= min {-0.127 ; 0.27}
= -0.127

Once Cp and Cpk calculation completed then continue with the % of rework and reject calculation

$$\%rework = 1 - P(Z < \frac{USL - \overline{X}}{\sigma})$$

$$= 1 - P(Z < \frac{91,38 - 91,46}{0,094}) = 1 - P(Z < -0,384) = 65\%$$

$$\%reject = P(Z < \frac{LSL - \overline{X}}{\sigma})$$

$$= P(Z < \frac{91,42 - 91,46}{0,094}) = P(Z < -0,385) = 21\%$$

% Total defect = % rework + % reject
= 65% + 21%
= 86%

Shown the rework (%) achieved 65% (exceed the specification limit), another rework process is required. In reject (%) achieved 21% means there is a high rejection product.

4.4 Diagram pareto

The Pareto is a diagram use to identify, organize and work by eliminating the non conformity product permanently. Below is a table of product defects occurrs at company.

Table4.4. Number of defective product types

No	Non Prime Type	Defect	Persentase
1	Components that do not comply with specifications	30	34.48%
2	Connection to ring component untidy	20	22.98%
3	Surface parts of parts are not balanced components	22	25.28%
4	The component surface is not smooth	15	17.24%
	Total	87	100.00%

the data in table 5 needs to be sorted out based on number of defects. from largest to smallest and make the cumulative percentage. The cumulative percentage is useful to define the difference of occurance frequency among some of the dominant issues.

Table4.5. Number and persentage of defect

No	Non Prime Type	Defect	Persentase	Persentase cumulative
1	Components that do not comply with specifications	30	34.5%	34.5%
2	untidy connection of the component	22	25.3%	59.8%
3	Surface parts of parts are not balanced components	20	23%	82.8%
4	The component surface is not smooth	15	17.2%	100.00%
Total		87	100.00%	

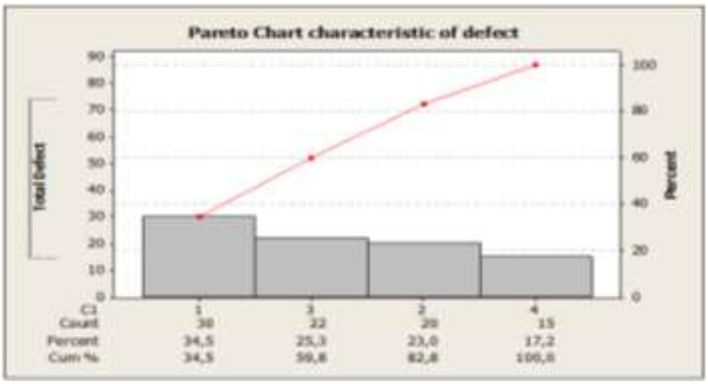

Figure4.5: Pareto Diagram Characteristic of Belt Conveyor

Figure 7 the improvements will only focusing on the top 3 major defect which are: (1) components that do not comply with specifications, (2) untidy connection of the component, and (3) curface parts of parts are not balanced components. These 3 types of defects has contribute a 82.8% of total defect occurrs at the belt conveyor product.

4.5 Cause and effects chart (fishbone chart)

The fishbone chart shows the relationship between the problems encountered with possible causes and the factors that affecting them. The factors that affect and cause damage to the product in general can be classified as follows: 1. The Influence of component measurement charts that do not conform to specifications. There is the complete cause and effect chart for damaged features due to component measurements does not follow with the belt carrier specification :

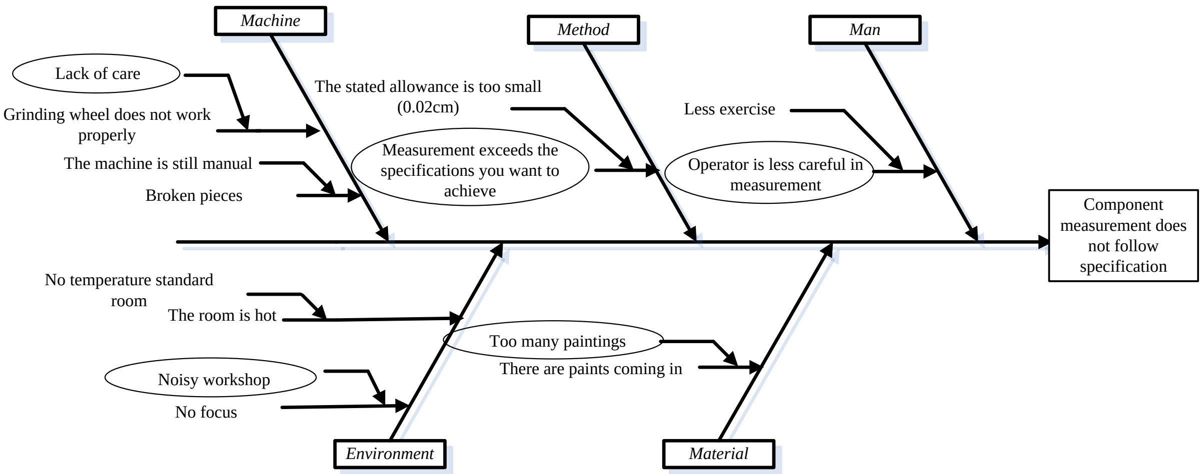

Figure4.6: Cause & Effect Chart for Component Measurements not follow Specifications

Figure.8 showed a fishbone chart the function is to determine the cause of the defect for component out of specification, which is the cause of the highest characteristic. In this cause and effect diagram shows some factors that are studied such as human factors, method, machine, material and environment. Further analysis result as below: (1) human factors for this issues is that due to lack of intensive training, operator less knowledge on how to measure the part, (2) for the method factors is the measurement exceeds the specifications since the stated tolerance is only 0.02cm, (3) the machine factor is due to machine condition that still running

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manual will affect to unneat cutting result, (4) the material factors are found on the paint condition, its too much painting, (5) there are 2 Environmental factors affecting the above issuedue to noisy workshop and also the room temperature is too hot. 2. Cause and effect chart for untidy connection of the component. Here is the cause and effect chart for untidy connection of the componentin belt conveyor products:

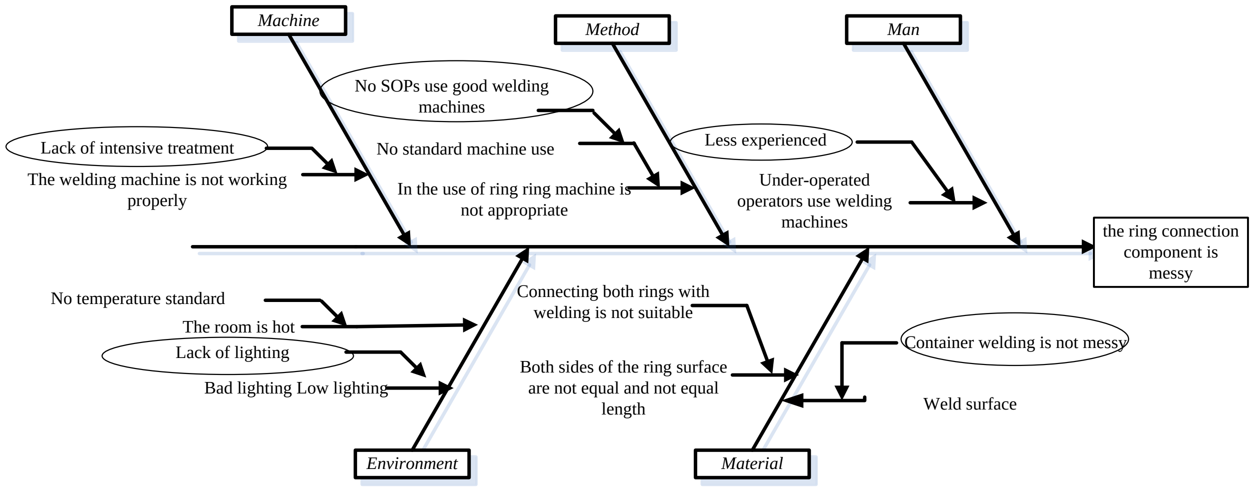

Figure4.7: Cause & Effect Chart for Untidy Connection of the Component

Above chart is a cause and effect chart analysis result for the second case that is untidy connection of the component, same as before this diagram also shows us 5 factors for analysis, they are human factors, method factor, machine factor, material factor and environment factor : (1) from human factors that affect the issue is due to operators who are less skills while using welding machines. This is due to running by unexperienced operators, (2) method factors that influence this issue is the use of ring is inappropriate. this because no standard machine is used. And the root cause was narrowed down to no SOP usedat welding machine, (3) machine, the engine is not functioning properly and due to lack of intensive care, (4) the material factors that affect both sides of the ring surface are uneven length. this affected by the second ring connector which is different and then the last factors that affecting the curved surface is caused by cutting waste, (5) environmental factors that affect this issue there are bad lighting due to less lighting facilities,ledat the rooms are too hot and the room is not standard. 3. Cause and effect chart on the last issue surface parts of parts are not balanced components , the cause and effect chart showed as below:

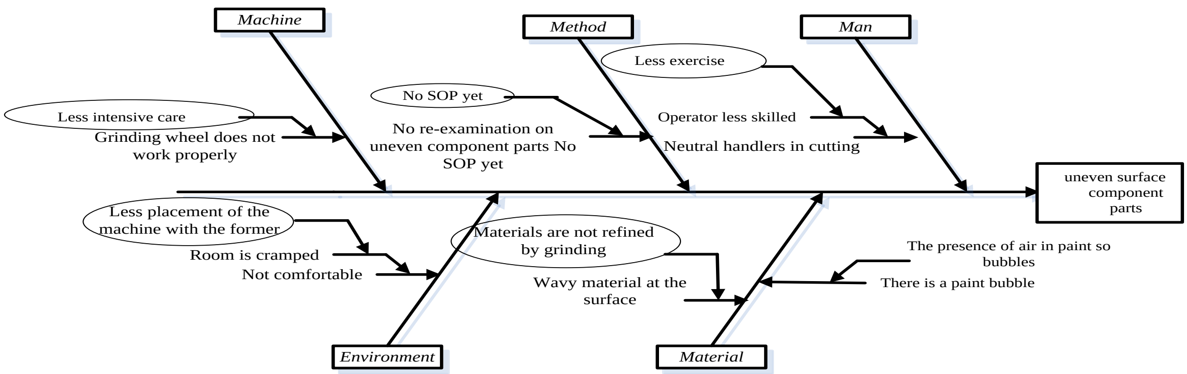

Figure4.8: Cause & Effect Chart for Surface Parts of Parts are Not Balanced Components

Figure 10 diagram has determined the cause of the last issue surface parts of parts are not balanced components . Same as before in the cause and effect chart shows some factors they are human factors, method, machine, material and environment. The description as below: (1) from the human factor that affected is the cutting operator do an unproper cut and this is because less skill operators due to lack of training, (2) for method factor there are no re-examination/checking was done on the uneven component due to no SOP in placed, (3) as for machine factors affecting the issue is due to grinding knife is not function properly and this is due to lack of intensive care, (4) as for material factors due to recieved a wavy material on the surface from supplier and then there is a wave of paint caused by the presence of air bubble in the paint until it is lathered, (5) environmental factors affected by less comfortable environmental because of the narrow space. Influenced by poor room arrangement.

5. CONCLUSION

There found some of measurements are out of control limits from each of component. By the total 15 components, there are detect 3 out of 15 that the data is far from the spec or beyond the control limits this is due to high data variability. The proposed improvements have defined to eliminate the product defects in belt conveyor products, which are conducting training and direct guidance on each operator. in determining the tolerance following the measurement tool/surface and follow the measurements standard that have been set and use security tools such as ear protection so all operators are comfortable and focus on work and lighting especially during high processes.

REFERENCES

[1] Sangeetha, J., & Mahalingam, S. (2011). Service quality models in banking: a review. *International Journal of Islamic and Middle Eastern Finance and Management*, *4*(1), 83-103.

[2] Teimouri, M., Yaghoubi, N. M., & Kazemi, M. (2012). The Effect of Electronic Service Quality on Customers Behavioral Intentions. *International Journal of Marketing Studies*, *4*(2), 179.

[3] Purba, H. H. & Aisyah, S. (2017). *Quality Improvement and Lean Six Sigma*. 1st ed. Expert. Yogyakarta.

[4] Bouslah, B., Gharbi, A., & Pellerin, R. (2018). Joint production, quality and maintenance control of a two-machine line subject to operation-dependent and quality-dependent failures. *International Journal of Production Economics*, *195*, 210-226.

[5] Syafwiratama, O., Hamsal, M., & Purba, H. (2017). Reducing the nonconforming products by using the Six Sigma method: A case study of a polyes-ter short cut fiber manufacturing in Indonesia. *Management Science Letters*, *7*(3), 153-162.

[6] Shah, S., Shridhar, P., & Gohil, D. (2014). Control chart: A statistical process control tool in pharmacy. *Asian Journal of Pharmaceutics (AJP): Free full text articles from Asian J Pharm*, *4*(3).

[7] Purba, H. H., & Prasetyo, R. D. (2018). Quality Control by Methodscontrol X and R in Value Insulation Products TV Model 21ES251E2in Electronic Fabrication Company in Indonesia. *International Journal of Recent Engineering Science*.*5*(2).11-15.

[8] Bereman, M. S., Johnson, R., Bollinger, J., Boss, Y., Shulman, N., MacLean, B., ... & MacCoss, M. J. (2014). Implementation of statistical process control for proteomic experiments via LC MS/MS. *Journal of the American Society for Mass Spectrometry*, *25*(4), 581-587.

[9] MacLean, B., Tomazela, D. M., Shulman, N., Chambers, M., Finney, G. L., Frewen, B., ... & MacCoss, M. J. (2010). Skyline: an open source document editor for creating and analyzing targeted proteomics experiments. *Bioinformatics*, *26*(7), 966-968.

[10] Swarbrick, J. (2013). *Encyclopedia of pharmaceutical technology*. CRC Press.

[11] Montgomery, D. C. (2007). *Introduction to statistical quality control*. John Wiley & Sons.

[12] Gaspersz, V. (2007). *Lean Six Sigma*. Gramedia Pustaka Utama.

[13] Au, G., & Choi, I. (1999). Facilitating implementation of total quality management through information technology. *Information & management*, *36*(6), 287-299.

[14] Arshad, A. M., & Su, Q. (2015). Role Of Total Quality Management In Service Innovations: An Empirical Study Of Pakistan's Financial Services Firms. *Journal of Applied Business Research*, *31*(3), 891.

[15] Abdullah, M. M. B., & Tari, J. J. (2012). The influence of soft and hard quality management practices on performance. *Asia Pacific Management Review*, *17*(2), 177-193.

[16] Al-Khalili, A., & Subari, K. (2013). Understanding the linkage between soft and hard total quality management: evidence from Malaysian manufacturing industries. *JJMIE*, *7*(1), 223.

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