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A CASE STUDY TO KNOW THE ACCEPTANCE MEASUREMENT SYSTEM AND PROCESS CAPABILITY USING STATISTICAL PROCESS CONTROL IN MANUFACTURING INDUSTRY

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Abstract:-
Validation new equipment before be used continously in production process is very necessary. With the validation we can know the process capability performance of new machine that already installed. This process align with IATF 16949 clausa 8.1.1 requirement. Bead Grommet machine is one of new machine that has been installed in the truck and bus tire manufacturing company which is need to be validated to know whether machine stable and capable for continous production. Special characteristic for the output bead grommet process that need to be controlled as necessary is the Bead Inner Circumference (BIC). Bead inner circumference of tire is critical to quality when the tire set into the rim. Bead inner circumference out from the standard can generate into death or injured.
Validation for the new Bead Grommet machine to know the Process capability use Statistical Process Control methodology. In term to know the quality measurement before do the Statistical Process Capability study the measurement tools need be assured with calibrated it and already verified with the Measurement System Analysis study. Data collection that be achieved from the study is proceed as the reference for conclusion.
The results of the analysis imply that measurement tool is can be used for captured the product variation that be happened during production process. Based on data which collected and analyze the process with the new machine installed show that capability process machine Bead Grommet capable. This conclusion reflected from Cp and Cpk value.

"**Keywords:-***Statistical Process Control (SPC), Process Capability, Measurement System Analysis*"

1. INTRODUCTION

Tire industry still have an opportunity for growing up, according to TechSci Research report, "Global Tire Market Forecast and Opportunities, 2021'', global tire market is forecast to grow at a CAGR of 8.4% in value terms during 2016-2021 Ken Mathews (2017) (1). Since the company have the market for export especially for USA market it was a good decision for company take opportunity with expansion their production capacity. Installment new equipment in production facility is the critical aspect that need to be considered since the tire is part of safety product that be assembled into vehicle. Regulation for the product in term to protect the customer also give pressure to the tire manufacturer. NHTSA (National Highway Traffic Safety Administration) reported that tire failures trigger more than 8,000 traffic accidents each year resulting in death or serious injuries. Many tire failures directly result from a manufacturing defect or design Find Law (2017) (2). Concern with the tire manufacturing defect that can generate serious injured and death, company must very concern and pay more attention for how to eliminate that risk.

Risk that exist in the tire manufacturer is about fullfilment the product output of bead processing for bead wire inner circle or bead diameter. Diameter of the tire bead is critical to the functioning of the tire bead. It should ensure the coupling between tire and rim and transmit power Cristiano Fragassa et al. (2016) (4). In the tire industry bead inner circle can be categoried as special characteristics, because a bead product characteristics and it manufacturing process parameter can affect safety or compliance with regulations, fit, function, performance, requirements, or subsequent processing of product. IATF 2016 (3). If bead manufactured smaller than the mean critical diameter results in tension and causing failure and if a bead made larger diameter than the critical results in bead kinking while mounted and causing failure. Arun Kumar Doradla (2015) (7). The diameter of the bead on tire to small the tire will difficult during set it onto the rim , and if the diameter of bead inner circle to big then the tire very loos during fitment set it onto the rim. Bead wire on tire should ensure the coupling between tire and rim and transmit power (Palit et al. 2015) (5). The bead wire of functional tire can work at pressures of 30–35 psi (Palit et al. 2015) (5). Bead wires help to transfer the load of vehicle to the tire through the rim. Arun Kumar Doradla (2005) (7) some factors that contribute to bead failure are bead stresses, improper mounting procedure, bead manufacturing, and bead vibration.

Consider with the bead manufacturing failure, it is important thing that manufacturing must keep and ensure their production process continually comply with the process and product requirement which is already designed and determined on it. Aligned with IATF 16949 clausa 8.1.1 requirement, company must be ensured their facility can achieve the conformity both product and process. Assign and validate the process after new machine had been installed is very necessary to give assurance that company can fullfill the requirement and not happened product failures deliver to market .This paper discussing about use a statistical process control for measure the process ability that manufacturing a product meets the specification after the new machine had been installed. It also provide how to asses the measurement system before capability study, with measurement system analysis. Capability indices Cp and Cpk are easily understood and could be straightforwardly applied to the manufacturing industry (Chen et al. 2001, 2002) (6).

2. Literature Review

2.1 Quality of measurement

It is necessary that before we decide which measurement device will be used for measure a product characteristics, we should asses it to make sure that the measurement device proper and suitable for capture the variation. With measurement system analysis we can see Daimler Chrysler Corporation (2002). (8) accurately determine how much of the total observed variability is due to the gauge; Daimler Chrysler Corporation (2002). (8) accurately isolate the sources of variability in the system; and Kooshan Farhad (2012) (9) assess whether the device for measure is capable, so the result of measurement system analysis (MSA) must be accurate as well.

2.1.1. Linearity.

The change in bias over the normal operating range. Georgia A. Louka, George J. Besseris (2010) (10) or linearity is necessary to be validated before the measurement device to be defined. In this study the measurement device must well accurate perform for measure bead diameter in the operating range rim tire diameter of Truck and Bus Radial tire with bead size diameter 15 inch until 24 inch. AIAG measurement System Analysis reference manual describe the linerarity as below ilustration:

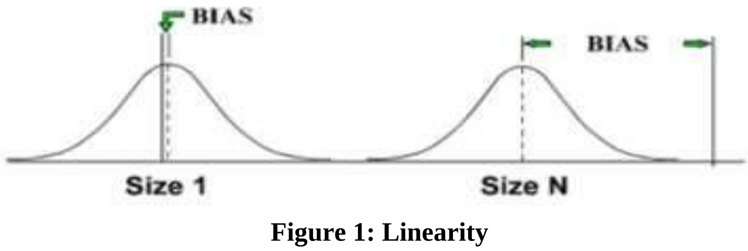


Figure 1: Linearity

2.1.2. Stability.

The change of bias measurement to the reference value over time called as stability. Minitab 16. (11) . For this study since there are available master value of true rims bead diameter then it can be used for reference value. This master provide by the supplier of measurement device. The stability as be ilustrated in AIAG measurement System Analysis reference manual as follow:

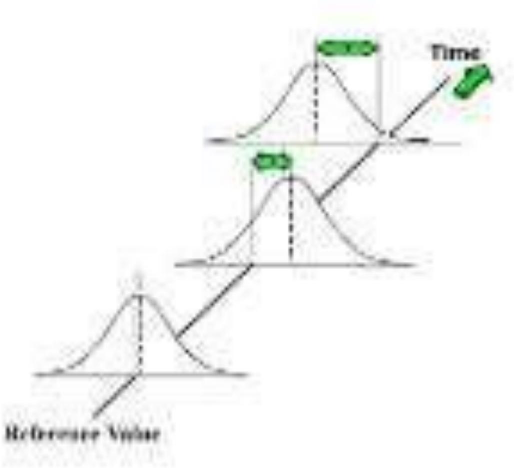


Figure 2: Stability

2.1.3. Gage repeatability & reproducibility (GR&R)

A GR&R study is a method of determining the suitability of a gauge system for measuring a particular process. Abolfazl Kazemi et al. (2010) (12) this method very useful to verify is there exist part variation, appraisal variation. Total GR&R is the estimation of the combined estimated variation from repeatability and reproducibility A. Al-Refaie, N. Bata, (2010) (13). Ilustration for the GR&R as below ilustration:

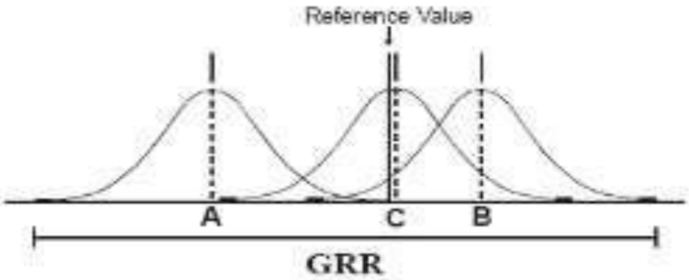


Figure 3: Gage R&R

The acceptability measurement system with the analyze the % GRR as below Tabel:

Tabel 1: Accepatance of the % GRR Criteria

% GRR	Decision
<%10	Acceptable measurement system
%10 to %30	May be acceptable for some applications and This needs to be agreed with the customer
>%30	Considerred to be unacceptable measurement system

2.2 SPC (Statistical Process Control) with Xbar – Range Chart.

Statistical process control can be used for analyze if the process in control or not. According to minitab if during sampling process the subgroup less than 8, Xbar – Range Chart should be used to draw the control chart. The formula for analyze is as below:

2.2.1 Xbar chart

UCL = Upper Control limit = Xbar-bar + A2R ....(1)
CL = Center Limit = Xbar – bar …………………...(2)
LCL = Lower Control Limit = Xbar-bar - A2R…..(3)

For the value of A2 following the constanta refers to the size sample in subgroup data that be taken.

2.2.2 Range (R) Chart

UCL = Upper Control limit = D4.R ....(4)
CL = Center Limit = R ....(5)
LCL = Lower Control Limit = D3.R...(6)

Table for the reference use from SPC manual AIAG shown as below:

Table 2: Constants and formulas for control charts :

	$\overline{X}$ and R Charts				$\overline{X}$ and s Charts			
	Chart for Averages	Chart for Ranges (R)			Chart for Averages	Chart for Ranges (R)		
	Control Limits Factor	Divisors to Estimate σ_X	Factors for Control Limits		Control Limits Factor	Divisors to Estimate σ_X	Factors for Control Limits	
Subgroup Size	A_2	d_2	D_3	D_4	A_3	c_4	B_3	B_4
2	1.880	1.128	—	3.267	2.659	0.7979	—	3.267
3	1.023	1.693	—	2.574	1.954	0.8862	—	2.568
4	0.729	2.059	—	2.282	1.628	0.9213	—	2.266
5	0.577	2.326	—	2.114	1.427	0.9400	—	2.089
6	0.483	2.534	—	2.004	1.287	0.9515	0.030	1.970
7	0.419	2.704	0.076	1.924	1.182	0.9594	0.118	1.882
8	0.373	2.847	0.136	1.864	1.099	0.9650	0.185	1.815
9	0.337	2.970	0.184	1.816	1.032	0.9693	0.239	1.761
10	0.308	3.078	0.223	1.777	0.975	0.9727	0.284	1.716
11	0.285	3.173	0.256	1.744	0.927	0.9754	0.321	1.679
12	0.266	3.258	0.283	1.717	0.886	0.9776	0.354	1.646
13	0.249	3.336	0.307	1.693	0.850	0.9794	0.382	1.618
14	0.235	3.407	0.328	1.672	0.817	0.9810	0.406	1.594
15	0.223	3.472	0.347	1.653	0.789	0.9823	0.428	1.572
16	0.212	3.532	0.363	1.637	0.763	0.9835	0.448	1.552
17	0.203	3.588	0.378	1.622	0.739	0.9845	0.466	1.534
18	0.194	3.640	0.391	1.608	0.718	0.9854	0.482	1.518
19	0.187	3.689	0.403	1.597	0.698	0.9862	0.497	1.503
20	0.180	3.735	0.415	1.585	0.680	0.9869	0.510	1.490
21	0.173	3.778	0.425	1.575	0.663	0.9876	0.523	1.477
22	0.167	3.819	0.434	1.566	0.647	0.9882	0.534	1.466
23	0.162	3.858	0.443	1.557	0.633	0.9887	0.545	1.455
24	0.157	3.895	0.451	1.548	0.619	0.9892	0.555	1.445
25	0.153	3.931	0.459	1.541	0.606	0.9896	0.565	1.435

2.3 Normality test

Normality test be used to know wheter tha data that already gather in normal distribution or no. If the data in normal distribution then parametric statistic can be used. The normality is affected by instrument and data that be collected. Arifianto et al. (2009) (14). If the p-value less than 0.05 then can be resumed that data already collected have no different with the virtual normal . If the p-value more than 0.05 then can be resumed that the data have significant different with normal virtual. This sample size can be used to determine if the data had been collected from the normal population or not. Filino. (2011) (15). Test the normality can be used with the methoda Kolmogorov Smirnov. This testing is examine the different both data that to be tested against the normal standard. If the result less than 0.05 it means that there is no significant different and opposite with this if the testing result p value more than 0.05 there is exist the differences. Filino. (2011) (15).

2.4 Cp and Cpk.

Process capability is the capability of process that can produce the product fullfill the specification. If the process as good process, most of the output product in statistically with control chart in the specification limit. If the production process output the data have tendency in statistically out of the specifictaion limit than we can resume that the process is bad. The capability for production is low Vincent Gaspersz . (1998) (16).

The index capability for process that indicate the acceptance criteria Vincent Gaspersz .(2001) (17):

1. If Cp > 1,33 capability process is good.
2. If 1.00≤ Cp ≤ 1,33 the process is good and need control with the Cp value 1.
3. If Cp < 1.00 the process is low capability then need for process improve.

Index of process capability (Cpk) indicate the capability process to produce product fullfill the specification limit , where during calculation process considering the spread of data and centering of data of the process in the bell shape. When the process meet the target Cpk=Cp. Cpk will satisfy if the shift of the bell shape of distribution data not far from the target and the standard deviation or variation that occured in small value Vincent Gaspersz.(2001) (17).

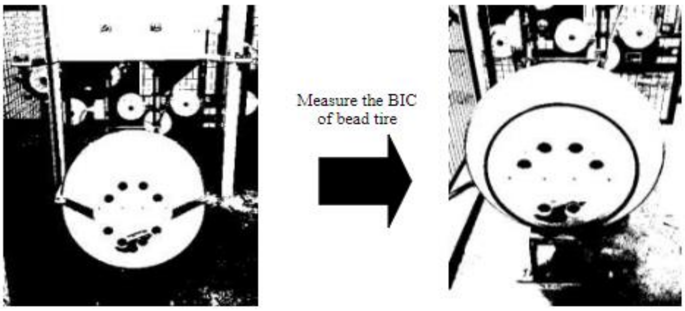
3. Case study

3.1 Explanation of bead product and Device Measurement

The study to be done in tire manufacturing which produced TBR tire. Product Characteristics that be measured was bead as part of work in process tire processing. The ilustration of the product as shown as below picture:

Picture 4: Product output for bead processing

The measurement device that be used to measure the product characteristics as below :



Picture 5: Bead inner circle measurement device

3.2 Flow process methodology.

Flow of study process during study be done as below figure:

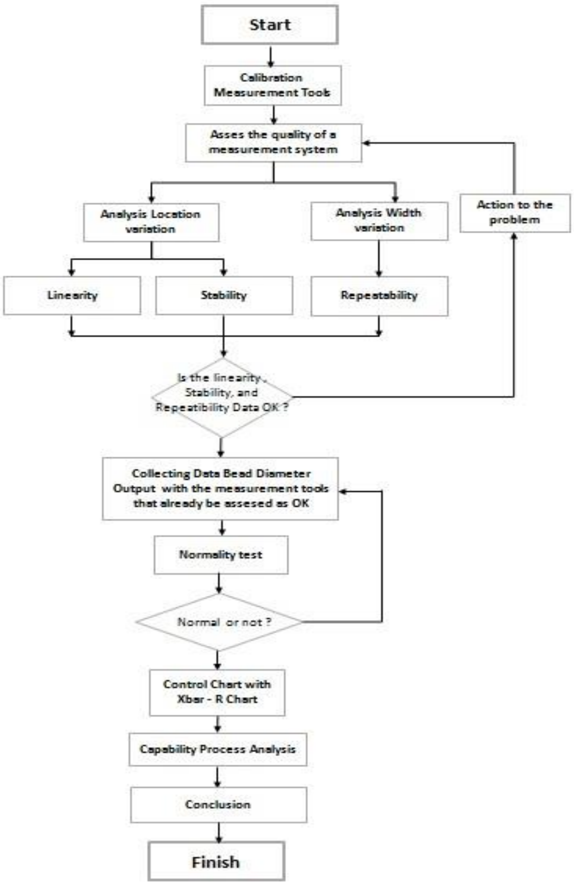
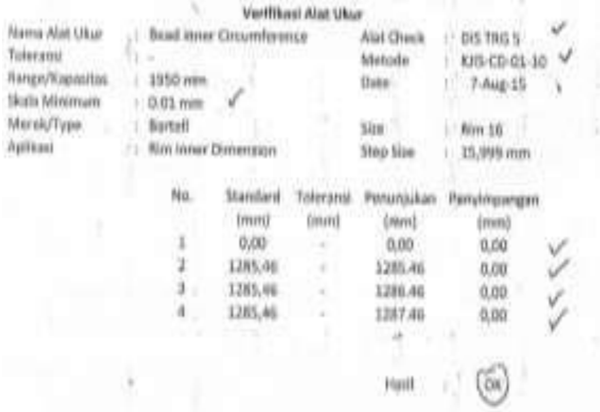


Figure 6: Flow Process Methodology

4. Data analysis and Discussion

4.1. Assesing the quality of measurement system.

4.1.1 Calibration as prerequesite.
From the calibration as the prerequesite, the result of calibration process for the measurement data that calibration result is OK.



Verifikasi Alat Ukur

Nama Alat Ukur	: Bead inner Circumference	Alat Check	: DIS TRG 5
Toleransi	: -	Metode	: KJIS-CD-01-10
Range/Kapasitas	: 1950 mm	Date	: 7-Aug-15
Skala Minimum	: 0.01 mm		
Merek/Type	: Bartell	Size	: Rim 16
Aplikasi	: Rim Inner Dimension	Step Size	: 15,999 mm

No.	Standard (mm)	Toleransi (mm)	Penunjukan (mm)	Penyimpangan (mm)
1	0,00	-	0,00	0,00
2	1285,46	-	1285.46	0,00
3	1285,46	-	1286.46	0,00
4	1285,46	-	1287.46	0,00

Hasil : OK

Verifikasi Alat Ukur

Nama Alat Ukur	: Bead Inner Circumference	Alat Check	: DIS TRG 20
Toleransi	: -	Metode	: KJIS-CD-01-10
Range/Kapasitas	: 1950 mm	Date	: 7-Aug-15
Skala Minimum	: 0.01 mm		
Merek/Type	: Bartell	Size	: Rim 20
Aplikasi	: Rim Inner Dimension	Step Size	: 19,981 mm

No.	Standard (mm)	Toleransi (mm)	Penunjukan (mm)	Penyimpangan (mm)
1	0,00	-	0,00	0,00
2	1617,92	-	1617,97	0,05
3	1617,92	-	1617,95	0,03
4	1617,92	-	1617,97	0,05

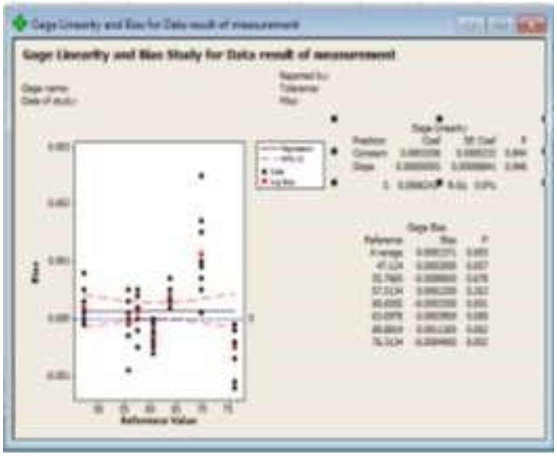
Hasil : OK

Figure 7: Internal Laboratorium report for the verification result

4.1.2 Linearity for the measurement system
The data result of measurement to the reference value as below:

Characteristic : Bead Inner Circle for Master reference

Part	1	2	3	4	5	6	7
Reference Value	47.1240	55.7665	57.5134	60.6055	63.6976	69.8819	76.3134
1	47.1243	55.7662	57.5136	60.6051	63.6979	69.8824	76.3123
2	47.1248	55.7664	57.5134	60.6055	63.6981	69.8834	76.3122
3	47.1243	55.7665	57.5134	60.6049	63.6980	69.8826	76.3132
4	47.1245	55.7666	57.5138	60.6050	63.6980	69.8844	76.3130
5	47.1240	55.7665	57.5138	60.6054	63.6983	69.8826	76.3127
6	47.1240	55.7656	57.5138	60.6052	63.6981	69.8836	76.3130
7	47.1239	55.7664	57.5132	60.6049	63.6978	69.8820	76.3130
8	47.1239	55.7670	57.5134	60.6053	63.6978	69.8829	76.3133
9	47.1242	55.7668	57.5139	60.6054	63.6979	69.8836	76.3132
10	47.1241	55.7664	57.5129	60.6050	63.6980	69.8828	76.3132
Average	47.12	55.77	57.51	60.61	63.70	69.88	76.3129



(a) **(b)**

Figure 8: (a) Measurement result for master bead inner circle (b) MINITAB Gage Linearity

Acceptance for the linearity for the measurement refers to MSA, Fourth Edition AIAG as follow :
For Slope the Hypothesis

$$H_0 : a = 0 \quad slope = 0$$

$$t\,slope = \frac{|a|}{\frac{s}{\sqrt{\sum(xi - xbar)^2}}} \leq t_{gm-2,\,1-(\alpha/2)} \qquad \text{.....................(7)}$$

For the Bias (Intercept) the hypothesis:

$$H_0 : b = 0 \quad intercept\ (bias) = 0$$

$$t\,intersep = \frac{|b|}{\left[\sqrt{\frac{1}{gm} + \frac{xbar^2}{\sum(xi - xbar)^2}}\right] s} \leq t_{gm-2,\,1-(\alpha/2)} \qquad \text{.....................(8)}$$

From data processing the linearity with the α = 0.05

|ta| =	t_{slope}	=	0.32469
|tb| =	$t_{intercept}$	=	0.00562
$t_{gm-2,\,1-(\alpha/2)}$ =	$t_{68,0.975}$	=	1.9955

Since t- slope and t- intercept less than t- value ($t_{68,\,0.975}$) then the linearity measurement system is acceptable.(11)

4.1.3 Gage R & R for the mesaurement system

Measurement device be studied for Gage R & R with 3 operators that will in continously do for inspection process the product. Product that for sampling process for measurement system analysis be taken from production output. Each product be tested by 3 operators. Each product be measured 3 times by each operator who measure it.

Measurement result from the study be shown in tabel 3.

Tabel 3: Gage R & R Data Collecting Sheet

Gage Repeatability and Reproducibility Data Collection Sheet													
Appraiser / Trial		Part										AVERAGE	
		1	2	3	4	5	6	7	8	9	10		
A	1	55.7676	55.7666	55.7668	55.7678	55.7662	55.7560	55.7524	55.7528	55.7505	55.7528		55.75995
	2	55.7678	55.7666	55.7670	55.7680	55.7662	55.7563	55.7524	55.7526	55.7510	55.7523		55.76002
	3	55.7678	55.7670	55.7670	55.7678	55.7670	55.7565	55.7520	55.7528	55.7508	55.7522		55.76009
	Average	55.768	55.767	55.767	55.768	55.766	55.756	55.752	55.753	55.751	55.752	Xa(bar) =	55.7600
	Range	0.0002	0.0004	0.0002	0.0002	0.0008	0.0005	0.0004	0.0002	0.0005	0.0006	Ra(bar) =	0.0004
Appraiser / Trial		Part										AVERAGE	
		1	2	3	4	5	6	7	8	9	10		
B	1	55.7674	55.7668	55.7668	55.7680	55.7664	55.7563	55.7520	55.7524	55.7516	55.7528		55.76005
	2	55.7676	55.7666	55.7670	55.7678	55.7664	55.7565	55.7526	55.7528	55.7515	55.7524		55.76012
	3	55.7670	55.7670	55.7668	55.7680	55.7668	55.7563	55.7522	55.7528	55.7514	55.7524		55.76007
	Average	55.767	55.767	55.767	55.768	55.767	55.756	55.752	55.753	55.752	55.753	Xb(bar) =	55.7601
	Range	0.0006	0.0004	0.0002	0.0002	0.0004	0.0002	0.0006	0.0004	0.0002	0.0004	Rb(bar) =	0.00036
Appraiser / Trial		Part										AVERAGE	
		1	2	3	4	5	6	7	8	9	10		
C	1	55.7668	55.7662	55.7668	55.7678	55.7662	55.7566	55.7524	55.7528	55.7510	55.7528		55.75994
	2	55.7668	55.7662	55.7668	55.7676	55.7666	55.7563	55.7524	55.7522	55.7512	55.7526		55.75987
	3	55.7668	55.7668	55.7670	55.7678	55.7666	55.7565	55.7526	55.7526	55.7510	55.7526		55.76003
	Average	55.767	55.766	55.767	55.768	55.766	55.756	55.752	55.753	55.751	55.753	Xc(bar) =	55.7599
	Range	0	0.0006	0.0002	0.0002	0.0004	0.0003	0.0002	0.0006	0.0002	0.0002	Rc(bar) =	0.00029
Part Average		55.767	55.767	55.767	55.768	55.766	55.756	55.752	55.753	55.751	55.753	X(barbar) =	55.7600
												Rp =	0.017

Tabel 4: Gage R & R Report

Gage Repeatability and Reproducibility Report			
Measurement unit Analysis			% Total Variation (TV)
Repeatability-Equpment Variation (EV)			
EV = R(barbar) X K_1	Trial	K_1	% EV = 100 [EV/TV]
= 0.00021	2	0.8862	= 3.92%
	3	0.5908	
Reproducibility-Appraiser Variation (AV)			
AV = $\sqrt{[Xdiff(bar)\ x\ K_2]^2 - \left[\frac{EV^2}{nr}\right]}$	Appraisers	K_2	% AV = 100 [AV/TV]
	2	0.7071	= 1.11%
= 0.00006	3	0.5231	
	n = parts		
	r = trials		
Repeatability & Reproducibility (GRR)			
GRR = $\sqrt{EV^2 + AV^2}$	parts	K_3	% GRR = 100 [GRR/TV]
= 0.00021	2	0.7071	= 4.08%
	3	0.5231	
Part Variation (PV)	4	0.4467	
PV = Rp x K_3	5	0.403	% PV = 100 [PV/TV]
= 0.00526	6	0.3742	= 99.92%
	7	0.3534	
Total Variation (TV)	8	0.3375	
TV = $\sqrt{GRR^2 + PV^2}$	9	0.3249	ndc = 1.41 (PV / GRR)
= 0.00527	10	0.3146	= 34.534

Draw and proceed result with the Minitab

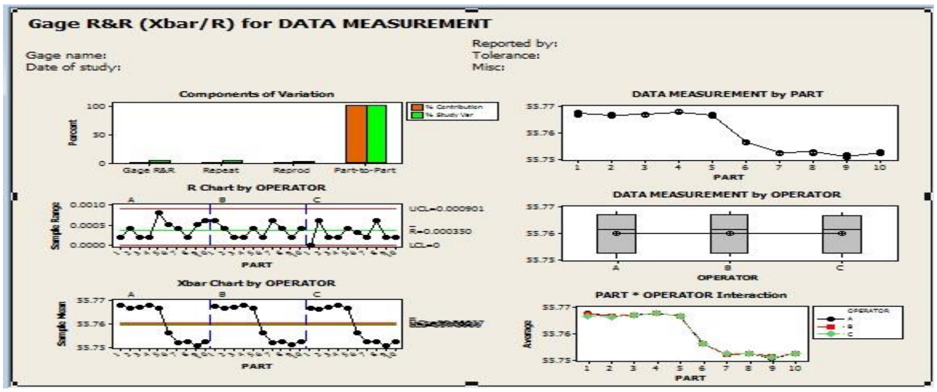


Figure 9: Gage R and R from MINITAB

Gage R & R result the measurement system was acceptable because the % GRR below than 10 % and the NDC value 34. Since the % Gage R& R less than 10 % it can be accepted. Daimler Chrysler Corporation (2002) (8)

4.2 Statistical Process Control Analysis

When the measurement system already done and the result can be accepted, continous with take sampling data for statistical process control. The process study addressing to the product bead tire with the size 16 inch, it study be set up consider with production schedule. Data for the study result that already collected and proceed into the control chart as below with total subgroup 60 and sample size for each subgroup is 3 datas sampling:

Tabel 5: Collecting data result for the bead inner circle study

Date of Production	NO	BIC (mm)	BIC (mm)	BIC (mm)	Average
	1	1310.220	1310.390	1310.280	1310.297
	2	1310.350	1310.350	1310.260	1310.320
	3	1310.290	1310.250	1310.220	1310.253
	4	1310.330	1310.330	1310.240	1310.300
	5	1310.330	1310.330	1310.260	1310.307
	6	1310.290	1310.290	1310.230	1310.270
	7	1310.270	1310.270	1310.250	1310.263
19/02/2016	8	1310.290	1310.310	1310.230	1310.277
	9	1310.330	1310.310	1310.280	1310.307
	10	1310.270	1310.310	1310.260	1310.280
	11	1310.290	1310.210	1310.270	1310.257
	12	1310.290	1310.310	1310.230	1310.277
	13	1310.270	1310.270	1310.260	1310.267
	14	1310.310	1310.270	1310.300	1310.293
	15	1310.310	1310.290	1310.260	1310.287
	16	1310.330	1310.310	1310.240	1310.293
	17	1310.350	1310.310	1310.280	1310.313
	18	1310.310	1310.290	1310.220	1310.273
	19	1310.270	1310.350	1310.260	1310.293
	20	1310.330	1310.370	1310.280	1310.327
	21	1310.350	1310.410	1310.240	1310.333
	22	1310.290	1310.210	1310.280	1310.260
19/02/2016	23	1310.310	1310.200	1310.230	1310.247
	24	1310.310	1310.390	1310.240	1310.313
	25	1310.330	1310.350	1310.260	1310.313
	26	1310.350	1310.350	1310.260	1310.320
	27	1310.330	1310.390	1310.240	1310.320
	28	1310.370	1310.390	1310.270	1310.343
	29	1310.310	1310.190	1310.240	1310.247
	30	1310.330	1310.370	1310.230	1310.310
	31	1310.410	1310.210	1310.300	1310.307
	32	1310.270	1310.220	1310.310	1310.267
	33	1310.230	1310.230	1310.290	1310.250
	34	1310.250	1310.370	1310.150	1310.257
	35	1310.170	1310.210	1310.320	1310.233
	36	1310.230	1310.370	1310.280	1310.293
	37	1310.210	1310.250	1310.300	1310.253
16/03/2016	38	1310.190	1310.270	1310.260	1310.240
	39	1310.170	1310.250	1310.280	1310.233
	40	1310.190	1310.210	1310.160	1310.187
	41	1310.230	1310.270	1310.300	1310.267
	42	1310.210	1310.220	1310.260	1310.230
	43	1310.290	1310.350	1310.270	1310.303
	44	1310.170	1310.310	1310.250	1310.243
	45	1310.210	1310.270	1310.290	1310.257
	46	1310.250	1310.270	1310.260	1310.260
	47	1310.230	1310.310	1310.250	1310.263
	48	1310.230	1310.330	1310.290	1310.283
	49	1310.190	1310.310	1310.290	1310.263
	50	1310.170	1310.250	1310.280	1310.233
	51	1310.250	1310.330	1310.300	1310.293
	52	1310.190	1310.250	1310.280	1310.240
16/03/2016	53	1310.150	1310.250	1310.300	1310.233
	54	1310.190	1310.270	1310.290	1310.250
	55	1310.230	1310.290	1310.260	1310.260
	56	1310.210	1310.310	1310.240	1310.253
	57	1310.270	1310.310	1310.300	1310.293
	58	1310.270	1310.260	1310.330	1310.287
	59	1310.250	1310.210	1310.240	1310.233
	60	1310.250	1310.200	1310.280	1310.243

With the MINITAB software the data be proceed and the result shown by figure 9:

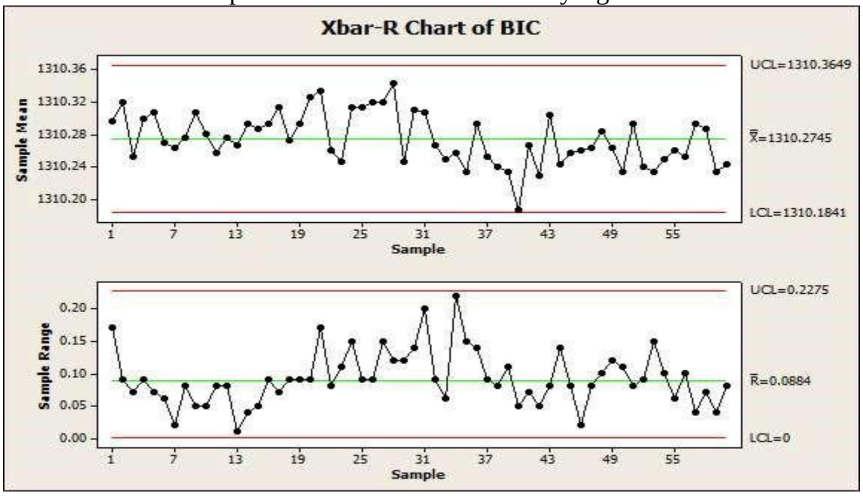


Figure 10: Control chart X bar – R chart for the bead inner circle

From the control chart all data sampling are in control limit it means that the data sampling bead in control.

4.3 Normality Test Result

Test normality data with use kolmogorov – smirnov in MINITAB the figure shown as figure 10:

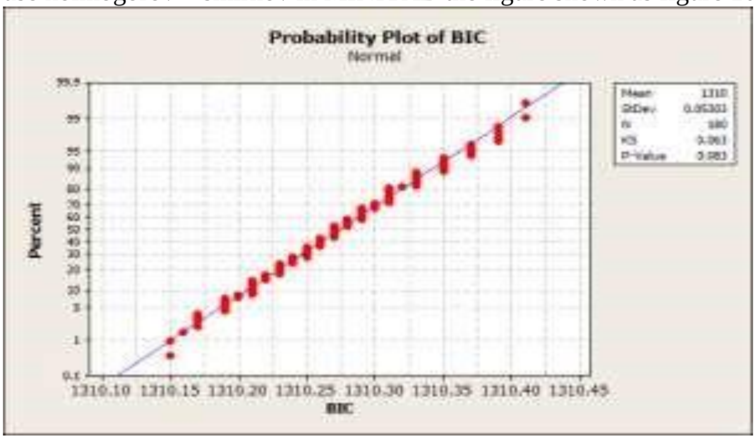


Figure 11: Normality test result

The p-Value=0.083 and the p – Value is greater than 0.05, the each point follow the straight line and each point close to straight line, it indicate the data is normal Chandana (2017)(18), then can be used for continue to analyze the process capability with normal data.

4.4. Capability Process Study

Plooting data to MINITAB the capability of process for making bead tire shown as figure 11

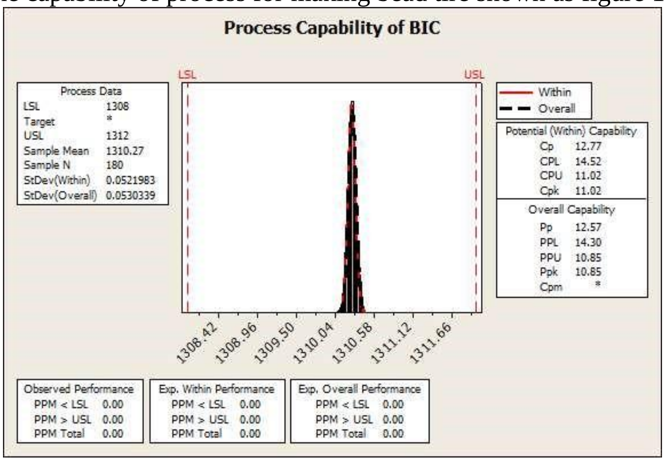


Figure 12: Process Capability Study for Bead Inner Circle

Cp value get from the MINITAB is 12.77 and the Cpk Value is 11.02 it have means that the process is in control and very capable to produce the bead inner circle spec 1308 mm until 1312 mm.

5. Conclusion

From the study it known that a. measurement device that be used for measure the product characteristics, bead inner circle, was accepted for measurement system in bead processing.
b. Study capability process during producing bead size 16 inch have Cp value 12.77 and Cpk value 11.02 it indicate that the process was very capable to fullfill the specification. Company have confidence that their process is capable to fullfill the safety requirement, further discussion is about control for the measurement system and process capability with concern to avoid the risk and prevention with failure mode effect analysis (FMEA) methodology. Since there are exist for 4 M factors, Machine, Man, Methode and Material in their process.

References

[1].Ken Mathews, "Global Tire Market to Grow at CAGR 8.4% till 2021" www.techsciresearch.com/news/1451-global-tire-market-to-grow-at-cagr-8-4-till2021.html be accesed on 09 December 2017.

[2].FindLaw, a Thomson Reuters business, "Tire Defects - An Overview", 2017. www.sandersparks.com/Tire-Defects_PC/Overview-Tire-Defects_PC.shtml , be accesed on 09 December 2017.

[3].IATF 16949.2016. "Quality Management System Requirements for Automotive Production and relevan service part organizations. AIAG,ANFIA, FIEV, SMMT, VDA

[4].Cristiano Fragassa, Martin Ippoliti, "TECHNOLOGY ASSESSMENT OF TIRE MOULD CLEANING SYSTEMS AND QUALITY FINISHING, 2016, International Journal for Quality Research 10(3) 523–546.

[5].Palit P, Das S, Mathur J .2015. Metallurgical investigation of wirebreakage of tyre bead grade. Case Stud Eng Failure Anal 4:83–87

[6].Chen KS, Chen SC, Li RK .2002." Process quality analysis of products". Int J Adv Manuf Technol 19(8):623–628.

[7]. Doradla, Arun Kumar.2005."FAILURE MODE OF THE WEFTLESS BEAD AND EVALUATION OF IMPROVED CONTINUOUS SINGLE WIRE BASED BEAD" .University of Kentucky Master's Theses. Paper 337.

[8].Daimler Chrysler Corporation, Ford Motor Company, General Motor Corporation. 2002. "MEASUREMENT SYSTEM ANALYSIS" reference manual 4th edition.

[9].Kooshan Farhad .2012. "Implementation of Measurement System Analysis System (MSA): In the Piston Ring Company", International Journal of Science and Technology, Volume 2 No.10.

[10]. Georgia A. Louka, George J. Besseris .2010. "Gauge R&R for an Optical Micrometer Industrial Type Machine", International Journal for Quality research, Vol.4, No. 4.

[11]. Minitab 16. www.minitab.com.

[12]. Abolfazl Kazemi et al. 2010. Developing a Method for Increasing Accuracy and Precision in Measurement System Analysis: A Fuzzy Approach. Journal of Industrial Engineering 6(2010) 25-32.

[13]. A. Al- Refaie, N. Bata, 2010. Evaluating measurement and process capabilities by GR&R with four quality measures. Measurement, 43, 842–851, 2010.

[14]. Arifianto, Anto Hendri, Agustina Verawati, Ria Anggraini. 2009. Motode Penelitian Pendidikan. Fakultas Keguruan dan Ilmu Pendidikan Universitas Jambi, Muara Bulian.

[15]. Filino. 2011. Modul VII Psikologi Eksperimen. Pusat Pengembangan Bahan Ajar Universitas Mercubuana. Jakarta.

[16]. Vincent Gaspersz.1998. Statistical Process Control, Penerapan Teknik-teknik Statistikal dalam Manajemen Bisnis Total PT. Gramedia Pustaka Utama. Jakarta.

[17]. Vincent Gaspersz. 2001. Metode Analisis Untuk Peningkatan Kualitas. PT. Gramedia Pustaka Utama.Jakarta.

[18]. Chandana (Last updated September 11, 2017). Normality Test in Minitab: Minitab with Statistics. https://www.simplilearn.com/normality-test-in-minitab-article