Volume 2 No.10, October 2012 ISSN 2224-3577
International Journal of Science and Technology

http://www.ejournalofsciences.org

Implementation of Measurement System Analysis System (MSA): In the Piston Ring Company "Case Study"

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ABSTRACT

In this survey, case study program is evaluated to improve one the Iran khodro company suppliers . And we tried to implement measurement analysis system that is one of the requirements of the automotive companies, leads to powerful increase in product quality and reducing the cost of duplication and external/internal failure and price. In this paper we used a methodology called; MSA along with APQP and designing the test in the form of three inspectors in the final control on one of important characteristics to measure (the AXIAL WIDTH of ring piston), with measurement, instruments capability(variable aspect),and inspector capability (attribute aspect). The MSA action strongly influences the company s general business performance as revealed by the final analysis in the article. In conclusion, the results concerning the first test (GR&R or capability of measuring instrument) was accepted by implementing the required corrective action, And the results for attribute test (inspector capability) and their ability were identified to detect the correct piece, and the inspectors were achieved in organizing arrangements.

Keywords: *Measurement System, Repeatability, Reproducibility, Reference Value*

1. INTRODUCTION

In the last, the calibration was used to determine the quality of measurement instruments. in calibration only measurement instruments in an ideal conditions is investigation in a room with trained people, standard parts, and standard instruction. MSA, to measure system performance in real conditions. Because in inflation and lack of efficient production, the companies have been forced to implement quality management system. The standards include: DIN EN ISO9000 Inspection, Measuring and Test Equip ment QS 9000 4.11.4 Measuring System AnalysisISO/TS 16949 4.11.1.2 Measuring System Analysis[1,2] one of the requirements of the standards mentioned above, is "MSA" the final consumer is prevented from sending the defective product. understanding and managing measurement error generally called measurement system analysis (MSA),is an extremely important function in process improvement[3],if all customer engineering design record and specification requirements are properly understood by the supplier and that the process has the potential to produce product consistently meeting during an actual production run [4]. Total quality management has significantly positive effect on operational and business performance [5].the use of (TQM) as an overall quality program is still prevalent in modern industry ,but many companies are extending this kindof initiative to incorporate strategic and financial issues[6]. After the TQM hyp of the early 1980_s, six sigma ,building on well-proven elements of TQM, can be seen as the current stage of evolution [7] .Six sigma program is a key to successfully implementing a quality management system[8]. Six sigma is a business strategy that seeks to identify and eliminate causes of errors or defects-defined as anything which could lead to customer dissatisfaction [9] or failure in business process by focusing on output that are critical to customer [10], it uses the normal distribution and a strong relationship between product nonconformities, or defects, and product yield, reliability ,cycle time, inventory, etc[11]. Advanced product quality planning (or APQP) is a framework of procedures and techniques used to develop products in industry, particularly the automotive industry. It is quite similar to the concept of Design For Six Sigma (DFSS). It is a defined process for a product development system for General Motors, Ford, Chrysler and their suppliers. According to the Automotive Industry Action Group (AIAG), the purpose of APQP is "to produce a product quality plan which will support development of a product or service that will satisfy the customer. The APQP process, which is part of a series of interrelated documents that the basis for the make-up of a Process Control Plan is included in the APQP Manual. These manuals include**:** AIAG, APQP Manual [12].

1. The FMEA Manual
2. The Production Part Approval Process (PPAP) Manual
3. The Statistical process control (SPC) Manual
4. The Measurement Systems Analysis (MSA) Manual In FMEA, failures are prioritized according to how serious their consequences are, how frequently they occur and how easily they can be detected. An FMEA also documents current knowledge and Below is the list of all 18 elements, and a brief description of them [4].

-Design Records A copy of the drawing. If the customer is design responsible this is a copy of actions about the risks of failures for use in continuous improvement. FMEA is used

during the design stage with an aim to avoid future failures (sometimes called DFMEA in that case). Later it isused for process control, before and during ongoing operation of the process. Ideally, FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product or service. AIAG FMEA Manual [13]. Although initially developed by the military, FMEA methodology is now extensively used in a variety of industries including semiconductor processing, food service, plastics, software, and healthcare. It is integrated into the Automotive Industry Action Group's (AIAG) Advanced Product Quality Planning (APQP) process to provide risk mitigation in both product and process development phases. Each potential cause must be considered for its effect on the product or process and, based on the risk, actions are determined and risks revisited after actions are complete. Toyota has taken this one step further with its Design Review Based on Failure Mode (DRBFM) approach. The method is now supported by the American Society for Quality which provides detailed guides on applying the method.The outcomes of an FMEA development are actions to prevent or reduce the severity or likelihood of failures, starting with the highest-priority ones. It may be used to evaluate risk management priorities for mitigating known threat vulnerabilities. FMEA helps select remedial actions that reduce cumulative impacts of life-cycle consequences (risks) from a systems failure [14]. Is highlighted in Fig.1. It is used in many formal quality systems such as QS-9000 or ISO/TS 16949.

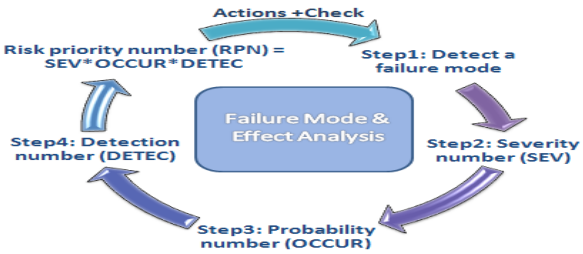

Fig.1: FMEA CYCLE

customer drawing that is sent together with the Purchase Order (PO). If supplier is design responsible this is a released drawing in supplier's release system.

-Authorized Engineering Change (note) Documents A document that shows the detailed description of the change. Usually this document is called "Engineering Change Notice", but it may be covered by the customer PO or any other engineering authorization.

-Engineering Approval This approval is usually the Engineering trial with production parts performed at the customer plant. A "temporary deviation" usually is required to send parts to customer before PPAP. Customer may require other "Engineering Approvals".

.-DFMEA A copy of the Design Failure Mode and Effect Analysis (DFMEA), reviewed and signed-off by supplier and customer. If customer is design responsible, usually customer may not share this document with the supplier. However, the list of all critical or high impact product characteristics should be shared with the supplier, so they can be addressed on the PFMEA and Control Plan.

-Process Flow Diagram A copy of the Process Flow, indicating all steps and sequence in the fabrication process, including incoming components.

-PFMEA A copy of the Process Failure Mode and Effect Analysis (PFMEA), reviewed and signed-off by supplier and customer. The PFMEA follows the Process Flow steps, and indicate "what could go wrong" during the fabrication and assembly of each component.

-Control Plan A copy of the Control Plan, reviewed and signed-off by supplier and customer. The Control Plan follows the PFMEA steps, and provides more details on how the "potential issues" are checked in the incoming quality, assembly process or during inspections of finished products.

-Measurement System Analysis Studies (MSA) MSA usually contains the Gage R&R for the critical or high impact characteristics, and a confirmation that gauges used to measure these characteristics are calibrated.

-Dimensional Results A list of every dimension noted on the ballooned drawing. This list shows the product characteristic, specification, the measurement results and the assessment showing if this dimension is "ok" or "not ok". Usually a minimum of 6 pieces is reported per product/process combination.

.-Records of Material / Performance Tests A summary of every test performed on the part. This summary is usually on a form of DVP&R (Design Verification Plan and Report), which lists each individual test, when it was performed, the specification, results and the assessment pass/fail. If there is an Engineering Specification, usually it is noted on the print. The DVP&R shall be reviewed and signed off by both customer and supplier engineering groups. The quality engineer will look for a customer signature on this document.

In addition, this section lists all material certifications (steel, plastics, plating, etc.), as specified on the print. The material certification shall show compliance to the specific call on the print.

.-Initial Process Studies Usually this section shows all Statistical Process Control charts affecting the most critical characteristics. The intent is to demonstrate that critical

processes have stable variability and that is running near the intended nominal value

-Qualified Laboratory Documentation Copy of all laboratory certifications (e.g. A2LA, TS) of the laboratories that performed the tests reported.

.-Appearance Approval Report A copy of the AAI (Appearance Approval Inspection) form signed by the customer. Applicable for components affecting appearance only

-Sample Production Parts A sample from the same lot of initial production run. The PPAP package usually shows a picture of the sample and where it is kept (customer or supplier).

.-Master Sample A sample signed off by customer and supplier, that usually is used to train operators on subjective inspections such as visual or for noise.

-Checking Aids When there are special tools for checking parts, this section shows a picture of the tool and calibration records, including dimensional report of the tool .

-Customer-Specific Requirements Each customer may have specific requirements to be included on the PPAP package. It is a good practice to ask the customer for PPAP expectations before even quoting for a job. North America auto makers OEM (Original Equipment Manufacturer) requirements are listed on the IATF website.

-Part Submission Warrant (PSW) This is the form that summarizes the whole PPAP package. This form shows the reason for submission (design change, annual revalidation, etc.) and the level of documents submitted to the customer. There is a section that asks for "results meeting all drawing and specification requirements: yes/no" refers to the whole package. If there is any deviations the supplier should note on the warrant or inform that PPAP cannot be submitted. AS a requirement for statistical process control (MSA) implementation , the MSA action has been required to ensure that measured values are correct and relevant for analysis based on SPC, thus ,MSA has been performed for the measuring system used to measure variable values of the most important product quality characteristic, directly related to the majority of nonconformities found in the observed manufacturing system. APQP consists of five phases: [12].

1-Plan and Define Program

2-Product Design and Development Verification

3-Process Design and Development Verification

4-Product and Process Validation

5-Launch, Feedback, Assessment & Corrective Action and according law"1-10-100", if defect is detected before the production stage, it will take a costs once time, in the production stage, it will take a cost equal ten times, finally when it reaches to the customer, we will have a cost equal 100times, in comparison to the first price[15].

2. THE SUBJECT

There are many variables in production processes that lead to the correct misdiagnosis, the process may be measured using improper measuring tools or directional results obtained are not consistent with reality,[16]. A measurement system incapable of detecting process variation can never be trusted to make a decisions on process adjustment [17]. In the repeated measuring different sizes may be read by the operator, or operators are different than each other. Even when measuring devices are properly used, device to measure the wrong displays, MSA focus is on understanding the measurement process, determining the amount of error in the process, and assessing the adequacy of the measurement system for product and process control and promotes understanding and improvement-variation reduction, AIAG,MSA Manual[18]. Measuring equipment and processes must be well controlled and suitable to their application in order to assure accurate data collection [19] . MSA is useful not audit existing measurement system, but also to select the most appropriate ones for a new measurement task [20]. Changes in outcome measures include: AIAG,MSA Manual[18].

1-real changes in product process

2-due to changes in measurement system

Measurement is defined as "the assignment of numbers to material things to represent the relations among them with respect to particular properties. [21,22]. The purpose of this paper is the following fundamental questions to be answered.

1-does the measuring equipment have the capability in the consequent measurement?

2-do all operators have the same efficiency?

3-do the operators have the potential of making errors that may lead to duplication cost and defective product?

4-is there any difference between operators in the consequent measurement?

5-is there any tendency in operators to accept or reject the product?

Volume 2 No.10, October 2012 ISSN 2224-3577
International Journal of Science and Technology

http://www.ejournalofsciences.org

In this research scientific application of (aspects variable &attribute) is carried.

3. THE ROLE OF MSA IN THE PERFORMANCE MANAGEMENT

3-1-The changes are primarily two categories based on following: AIAG,MSA Manual[18]: closeness to the true value or an accepted :Accurate

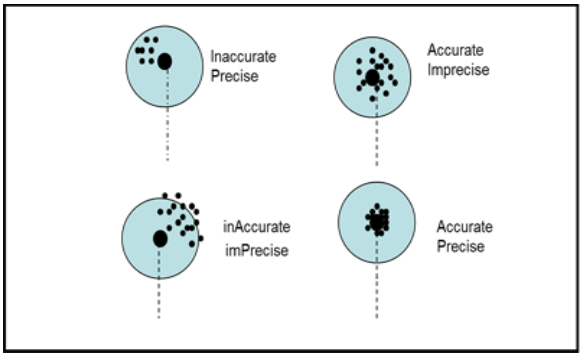

Fig. 2.Illustrates the concept of accuracy and precision

The MSA reference manual defines data quality and error in terms, The following Fig-3

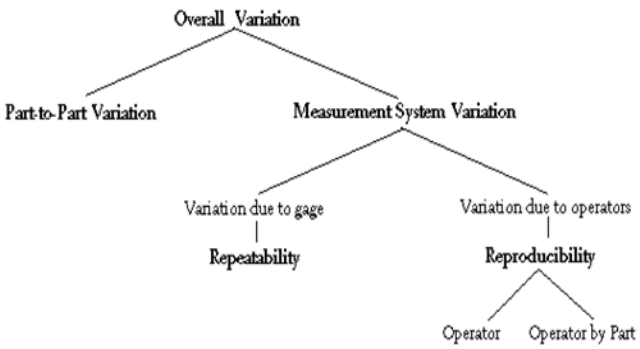

Fig. 3.shows the fluctuations of the system is measured

3-2-the precision of a measurement system includes the following components .AIAG,MSA Manual[18].

Repeatability

- Variation in measurements obtained with one measuring instrument when used several times by an appraiser while measuring the identical characteristic on the same part[23,24]
- The variation in successive (short term) trials under fixed and defined conditions of measurement Commonly referred to as E.V. (following Fig.4)

Is determined by multiplying the average rang ($\bar{\bar{R}}$) by a constant (K1). K1 depends upon the number of trial used in the gage study.

$$EV=\bar{\bar{R}}*K1 \qquad (1\text{-}1)$$

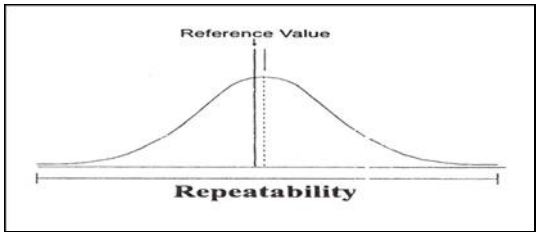

Fig. 4: Equipment Variation or Within-system variation

Reproducibility

Variation in the average of the measurements made by different appraisers using the same gage when measuring a characteristic on one part. For product and process qualification, error may be appraiser, environment (time),or method [18,19].

.Commonly referred to as A.V. Appraiser Variation (following Fig.5)

Therefore, is calculated by :

$$AV= \sqrt{[(\bar{\bar{X}}DIFF*K2)2 -(EV2/nr)]} \qquad (1\text{-}2)$$

K2 depend upon the number of appraisers used in the gage study.
Where n=number of part and, r=number of trials.

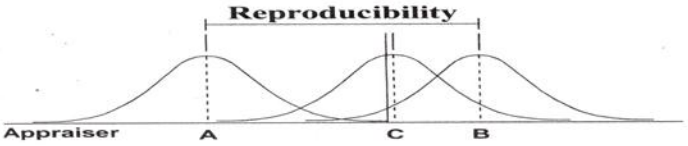

Fig. 5: Appraiser Variation

The measurement system variation for repeatability and reproducibility (GR&R) is calculated by adding the square of the equipment variation and square of the appraiser variation and taking the square root as follows Fig-6

$$R\&R=\sqrt{[(EV2)+(AV2)]} \qquad (1\text{-}3)$$

OR

$$\sigma^2_{GRR} = \sigma^2_{\text{Reproducibility}} + \sigma^2_{\text{Repeatability}}$$

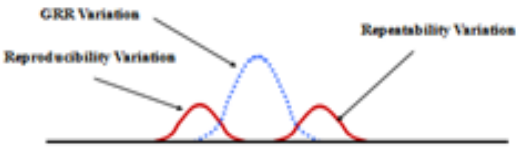

Fig. 6: Gage R&R or GRR

Part Variation

In determining measurement systems error(R&R), is acceptable or not, we should compare it with a criterion. Is determined by multiplying the rang of part averages (RP) by a constant (K3).

K3 depends upon the number of part used in the gage study.

$$PV = RP * K3 \quad (1\text{-}4)$$

Total variation (TV)

It is calculated by summing the square of both the repeatability and reproducibility variation and the part to part variation (PV) and taking the square root as follows:

$$TV = \sqrt{[(R\&R2+PV2)} \quad (1\text{-}5)$$

For measurement system whose purpose is to analyze a process, a general rule of thumb for measurement system acceptability is as following：(AIAG, MSA Manual [18]).
if R&R:

-under 10 percent error generally considered to be an acceptable measurement system.

-10 percent to 30 percent error may be acceptable based upon importance of application, cost of measurement device. Cost of repair, etc.

-over 30 percent considered to be not acceptable every effort should be made to improve the measurement system.

4. CONDUCT RESEARCH

In evaluate the measurement system analysis in parts manufacturing company piston ring, after organizing the quality assurance department, the experimental was designed in the final control. the company started a quality improvement project through APQP methodology implementation, aiming to reduce process variability and waste(defects/nonconformities)and improve business performances.

With implementing of APQP phases studying of related documents from OEM, and with using people who are expert in the ring industry we obtained DFMEA that gave us role and performance of part all failure mode ,potential effect failure has been recognized, and the DFMEA became as basis of developing of (PFMEA -control plan) for controlling the process .(Table.2).
Recognizing the importance of the characteristic following table details the major product is described as well as the degree of its importance.(Table.1). The AXIAL WIDTH of the ring was identified as important characteristics.

4.1 Case Study

Ring piston is a Cylindrical piece of metal with a spring capability and high strain, which is inserted in grooves in the top part of piston. The goals of rings are sealing the space between piston and cylinder and discharging the combustion gases.

Overall, the main tasks of the combustion engine piston ring are:

1. Compress the air in the cylinder.
2. Prevent to penetration of oil into the combustion chamber.

Due to the nature of these two functions piston rings are made with AXIAL WIDTH precision. otherwise fuel consumption will be increased, the oil leaking into the combustion chamber or low engine compress. in the top of piston, the ring is located in the grooves where are built for this purpose. the piston outer is not circle complete. One of the most mechanical role of ring is interaction between piston and bush. if the (AXIAL WIDTH) height of the ring goes up, it will be stuck in butt and cylinder &bush will be damaged. when The AXIAL WIDTH of the ring goes down, ring to be looses in butt, and finally breaks. The characteristic processes in two steps to close to the numbers of the map(1.48mm:iso-6621-2:2003) the equipments that used in the production process is called “DUS” machine, besides the equipments that can measure the height of ring is named “micrometer or measuring-time”

Table 1: Important Characteristics

CODE :RKP –FR-EN-03	PAGE:1	SPECIAL CHARACTERISTICS	
REV NR:00	DATE:2012/6/5		

DRAWINGNr:R011122-00 :	PRODUCTNAME:FIRST RING(XU7)
APQP TEAM:	CODE:001-Z-CR-P-KV1

1	AXIAL WIDTH	A	TU = 1.47 mm . TO = 1.49 mm
2	RADIAL WALL THICKNESS	A	TO =3.6 mm , TU = 3.3 mm
3	TANGENTIAL LOAD	B	TO=11.2N ,TU=16.8
4	LIGHT TIGHTNESS	A	100%
5	DIAMETERE	A	(83)
6	ROUGH NESS	B	RZ= 4µm
7	GAP CLEARANCE	A	TO =0.2 mm TU = 0.35 mm
8	COATING THICKNESS	C	μ Max= 2
9	COATING COHESION AND RESISTANCE	C	ACCORDING TO GOETZE

DOC NO:	REV:	**Table 2-** POTENTIAL FAILURE MODE&EFFECTS ANALYSIS (PFMEA)	
PART/PRODUCT NAME:RING PISTON	PART NO: 9624507980		
DATE:	PROCESS:RING PISTON		

ACT RESULT					Recommended action	RPN	Detection(d)	Current control		Occurance (o)	Potential cause of failure	class	Severity (s)	Potential effect failure	Process failure mode	process
RPN	D	O	S	Actions taken				preention	detection							
27	3	1	9	Performing of msa in final controlling for improving of production process- (R&R),E,pMISS ,PFALSE Cp,cpk=1.62-1.55	implementing MSA After that implenting SPC And capability process	162	3	Operating and controlling of parameters In accordance with instruction	clock	6	Not functioning properly in purification and cool equipment	B	9	Duplicating (rework)	The height of AXIAl WIDTH goes up	
27	3	1	9	"	""	162	3	Daily op-supervisor controlling	indicator	6	Not setting of magnet surface	*A	9	wasting	The height of AXIAl WIDTH goes down	DUS-1 DUS-2
				"	""	162	3	"	thermometer	6	inappropriate of solution temperature					
						80	5	Setting first shift(dressing)	Daily controlling of height by operator	2	inappropriate the space between stone to magnet	B	8	Not functioning properly	Not uniformed height	
						80	5	"	"	2	Not prospering the angle between two stone	*A	8	wasting	breaking	
						6	2	Daily supervisor controlling	Warning system	2	Cutting out or lacking of Debi cooling solution	C	2	appearance	The surface of parts changes blue	

5. METHODOLOGY AND NUMERICAL CALCULATIONS

AIAG,MSA Manual[18]. Refer to the GRR data sheet in Tables. 3,4 the detailed procedure is as follows:

1. Obtain a sample of 10 parts that represent the actual or expected range of process variation. Refer to the appraisers as A,B,C .so that number are not visible to the appraisers
2. Instrument was calibrated.

3. Let appraiser A measure 10 parts in a random order and enter the results in row 1.
4. Let appraisers B and C measure the same 10 parts without seeing Each other reading ;then enter the results in rows 6 and 11,respectively.
5. Repeat the cycle using a different random order of measurement enter data in rows 2,7 and 12.record the data in the appropriate column.
6. Subtract the smallest reading from the largest in rows1,2,3;enter the result in row 5. Do the same for rows 6,7, and 8; and 11,12,and 13 and enter results in rows 10 and15 ,respectively.
7. Total row 5 and divide the total by the number of parts sampled to obtain the average range for the first appraisers trials $\overline{Ra}$ Do the same for rows 10 and 15 to obtain $\overline{Rb}$,$\overline{Rc}$.
8. Transfer the averages of rows 5,10 and 15($\overline{\text{Ra}}, \overline{\text{Rb}}$,$\overline{\text{Rc}}$)to row 17.add them together and divide by the number of appraisers and enter results $\overline{\overline{\text{R}}}$(average of all ranges).
9. Enter $\overline{\overline{\text{R}}}$ (average value)in rows 19 and 20and multiply by D_4 To get the lower and upper control limits .note D_4 *is 3.27* if two trials are used the value of the upper control limit UCL_R of the individual ranges is entered in row 19.the value of lower control limit UCL_R for less than seven trials equal to zero.
10. Sum the rows 1,2,3,6,7,8,11,12,13.divide the sum in each row by the number of parts sampled and enter these values in the right most column labeled ”average”.
11. Add the average in rows 1,2,3 and divide the total by the number of trials and enter the value in row 4 in the $\overline{\text{Xa}}$ Blocks .repeat this for rows 6,7,8 ;and11,12,13 and enter the results in the blocks for $\overline{\text{X}}_{\text{b}}$,$\overline{\text{X}}_{\text{c}}$,in rows 9,14,respectively.
12. Enter the maximum and minimum average of rows 4,9 and14 in the appropriate space in row 18 and determine the differences ,Enter this difference in the space labeled $\overline{\text{X}}$DIFF in row 18.
13. Sum the measurements for each trial, for each part ,and divide the total by the number of measurement .enter the results in row 16 in the spaces provided for part average.
14. Subtract the smallest part average from the largest part average and enter the result in the space labeled RP in row 16 . RP is the range of part averages.
15. Transfer the calculated values of $\overline{\overline{\text{R}}}$,$\overline{\text{X}}_{\text{DIFF}}$,R_{P} to the blanks provided on the report side of the form.

Table 3: Gage Repeatability and Reproducibility Data Collection Sheet

	Appraiser/trial	part										Average
		1	2	3	4	5	6	7	8	9	10	
1	A 1	1.13	1. 48	1.33	1.33	1.03	1.48	1.43	1.33	1.48	1.08	
2	2	1.08	1.48	1.28	1.43	0.93	1.48	1.43	1.28	1.48	1.18	
3	3											
4	AVE	1.11	1.48	1.13	1.38	0.98	1.48	1.43	1.31	1.48	1.13	$\overline{\text{X}}_{\text{a=1.31}}$
5	RNG	0.05	0.00	0.05	0.1	0.1	0.00	0.00	0.05	0.00	0.1	$\overline{\text{R}}_{\text{a=0.05}}$
6	B 1	1.03	1.53	1.28	1.28	0.88	1.48	1.43	1.23	1.48	1.03	
7	2	1.03	1.43	1.23	1.23	0.88	1.53	1.38	1.18	1.43	0.98	
8	3											
9	AVE	1.03	1.48	1.26	1.26	0.88	1.51	1.41	1.21	1.46	1.01	$\overline{\text{X}}_{\text{b=1.25}}$
10	RNG	0.00	0.1	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.05	$\overline{\text{R}}_{\text{b=0.05}}$
11	C 1	0.98	1.53	1.28	1.28	0.93	1.48	1.43	1.28	1.53	1.33	
12	2	1.03	1.48	1.28	1.28	0.98	1.53	1.43	1.28	1.53	1.28	
13	3											
14	AVE	1.01	1.51	1.28	1.28	0.96	1.51	1.43	1.28	1.53	1.31	$\overline{\text{X}}_{\text{c=1.31}}$
15	RNG	0.05	0.05	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.05	$\overline{\text{R}}_{\text{c=0.03}}$
	16 PART	1.05	1.49	1.28	1.31	0.94	1.5	1.42	1.27	1.49	1.15	$\overline{\overline{\text{X}}}_{=}$

AVE($\overline{Xp}$)											RP=0.56
17	[$\overline{\overline{R}}_a$= 0.005			+$\overline{\overline{R}}_b$= 0.005			+$\overline{\overline{R}}_C$=0.03]/ OF OPERATOR=3]=				$\overline{\overline{\overline{R}}}$=0.004
18	[max= 1.31		-min$\overline{X}$=1.25	]= $\overline{X}_{DIFF}$							0.06
19	[$\overline{\overline{\overline{R}}}$=0.04 *	D4= 3.27	]= .UCLR								0.13
				D3=0 to seven test			D4=2.58 for 3 trials			D4=3.27 for 2 trials	
20	[$\overline{\overline{\overline{R}}}$=0.04 *	D3= 0.00	] = LCLR								0.00

Table 4: Calculation (R&R)

NAME PART:PISTON RING	N.O TOOLS: DM/QA/0012 measuring-time TECHNICAL SPECIFICATION:1.48MM			INSTRUMENT:
Repeatability=Equipment variation (EV) EV=$\overline{\overline{R}}$*K1 =0.04*4.56=0.18		trials	K1	%EV=100(EV/TV)= =100[0.18/0.93] =18.7%
		2	4.56	
		3	3.05	
Reproducibility=Apprasier variation (AV) AV= $\sqrt{[(\overline{X}_{DIFF}*K_2)^2 - (EV^2/nr)]}$ =$\sqrt{(0.06 * 2.70)^2 - (0.18^2/10*2)}$ =0.16	operator	2	3	%AV=100(AV/TV) 100[0.16/0.93] =16.8% N=number of parts r=number of trials
	K_2	3.65	2.70	
	Repeatability &Reproducibility (R&R) R&R=$\sqrt{(EV^2+AV^2)}$ $\sqrt{(0.18^2+0.16^2)}$ =0.24			R&R=100[R&R/TV]% =100[0.24/0.93] =25.8%
Part variation(PV) PV= RP * K3 =0.56*1.62 =0.90		parts	K_3	%PV=100[PV/TV] =100[0.9/0.93] =96.8%
TOTAL VARIATION(TV) TV=$\sqrt{(R\&R^2+PV^2)}$ =$\sqrt{(0.24^2+0.90^2)}$ =0.93		2	3.65	
		3	2.70	
		4	2.30	
		5	2.08	
		6	1.93	
		7	1.82	
		8	1.74	
		9	1.67	
		10	1.62	

5. Emphasis in attribute studies, on the ability of the operator or their efficiency in indentifying conformity and unconformity the parts and their willingness to accept or reject the piece.

5.1 Conduct Research

Defects that were identified by methodology of APQP, 14 pieces were selected by the engineering division (8 conformity and 6 nonconformity) each piece was inspected three times and the results were recorded in the Table-5.

Table 5: Data Analysis System Measured using Attribute Data

number	*C or N*	*Operator A*			*Operator B*			*Operator C*		
		1	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
1	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*
2	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*
3	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*
4	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*
5	*N*	*N*	*N*	*N*	*N*	*C*	*N*	*N*	*N*	*N*
6	*C*	*N*	*N*	*N*	*C*	*C*	*C*	*C*	*C*	*C*
7	*C*	*N*	*C*	*N*	*C*	*C*	*C*	*C*	*N*	*C*
8	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*
9	*N*	*N*	*N*	*N*	*C*	*C*	*C*	*C*	*C*	*C*
10	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*
11	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*
12	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*
13	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*
14	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*

As a column (C,N) displayed containing the identity of the real part.
C , means conformity , N , means nonconformity.
Analysis is performed based on counting .see Table-6

Table 6: Attribute Work Sheet

OPERATOR	GOOD CORRECT (1)	BAD CORRECT (2)	TOTAL CORRECT (3)	FALSE ALARMS (4)	MISSES (5)	GRAND TOTAL (6)
A	19	18	37	5	0	42
B	24	14	38	0	4	42
C	23	15	38	1	3	42

5.2 Test Operators in Identifying Parts

Column1: good correct, indicate the number of conformity parts that have been correctly diagnosed by operator, in this experiment there were conformity pieces 8, that were inspected three times, 24 0pportunities for the correct diagnosis was conformity parts.

Column2: bad correct, indicate the number of nonconformity that have been correctly diagnosed by operators. In this test there were nonconformity pieces 6, inspected three times, therefore 18 0pportunities for correct diagnosis was conformity parts.

Column3: is equal to the sum of column 1,2 and used to calculate the efficiency .

Column4: indicate the number of false alarm for each operator.

The operator A has 5 times false alarm, three times for sample of six and two times for sample of 8.

Column5: indicate the number of nonconformity parts that declared conformity. operator B has four times failed to recognize.

Column6: is the sum of column 3,4,5 that must be equal to total number of inspections(14 parts *three times for each inspector ,it should be 42).

5.3 Introduce iIndicators to Evaluate the Ability of Operators (Attribute). AIAG,MSA Manual[18].

1. Efficiency: an operator can diagnose conformity and nonconformity parts correctly .

$$E=\frac{\text{number of correct decisions}}{\text{total opportunities for a decision}} \quad (1\text{-}6)$$

2. The probability of indiscrimination fail to detect nonconformity. (1-7)

$$PMISS=\frac{\text{the number of times that a piece hasnt been dignosed}}{\text{total opportunities for a decision(nonconformity)}}$$

3. False Alarm

$$P(FA)=\frac{\text{number of times that correct parts are rejected}}{\text{total opportunities for a decision of being rejected}} \quad (1\text{-}8)$$

5.4 The Calculation based on the above Evaluation Indicators

see table-*7*

Table 7: Calculation Based on Indicators

operator	E *(3)/(6)*	P(F) (4)/(1)+(4)	P(MISS) (5)/(2)+(5)
A	37/42=0.88	5/24=0.21	0/18=0
B	38/42=0.90	0/24=0	4/18=0.22
C	38/42=0.90	1/24=0.04	3/18=0.17

5.5 The Reference Standard for Acceptable Results.

see table-8

Table 8: Guidelines for each Appraiser Results

unacceptable	marginally	acceptable	index
$<.0.8$	0.8-0.9	≥ 0.9	E
>0.1	0.1-0.05	≤ 0.05	P(FA)
>0.05	0.05-0.2	≤ 0.02	P(MISS)

1.5 More than 0.5 less, than	1.5-1.2 or 0.8-0.5	1.2-0.8	b=p(fa)/pmiss

It is necessary to explain:

When, b=1 there is no tendency.

When, b< 1 there is a willingness to accept parts.

When, b> 1 there is a willingness to rejecting parts..

6. ANALYSIS (GR&R STUDY)

If repeatability (EV) is large compared to reproducibility (AV). See Table -4

The reason may be:

The instrument needs maintenance.

The gage may need to be redesigned to be more rigid.

The clamping or location for gauging need to be emperor. There is excessive within part variation.

Taking into consideration all relevant factors (cost of measurement device, cost of repair, etc), the observed measuring system may be accepted since operators and equipment cause 25.8% (<30%) of measuring variation [25] . Because PV was much larger than EV, indicate that 50% of the average measured outside the control means. AIAG,MSA Manual(2010). Therefore PV is valid. Considering, R&R=25.8% , According to Table 4, measurement system is approved. In order to further improve the measurement system, Operator is required daily to clean the measuring-time and calibrate it by gauge block. Increasing in the number of meeting with personnel in production line, the factors that caused reduction in motivation have been studied and deleted as possible. Ensuring that evaluation equipment is clean, it has been cleaned twice in a week before but now it should be cleaned after each shift. The uniformization of testing methods. Retraining of evaluation instructions and emphasizing to operator in correct implementation of instructions and controlling and surveying of operator method in comparing with instructions.

7. ANALYSIS (ATTRIBUTE STUDY)

To sum up all the information we already had, the team come up with this Table(7,8). First operator(A), relatively acceptable performance and the lack of recognition in conformity parts, the company will increase the cost of inspection ,and tendency error is calculated by, b=P(FA)/p(miss), in this case we should consider only, P(FA) error. The operator does not have any tendency to accept or reject product. Operator (A) was trained for a correct diagnosis (conformity parts) and the reference samples were reviewed.

Operator(A)

E=37/42=0.88 , P(MISS)=0 , P(FA)=5/24=0.21

Operator(B)

E=38/42=0.90 ,P(MISS)=4/18=0.22 ,P(FA)=0

The operator (B) does not have any error detection, ability is very high.

Operator(C)

E=38/42=0.90 , P(F)=1/24=0.04 , P(MISS)=3/18=0.17

Then b=P(FA)/P(MISS)

b=0.04/0.17=0.24

Operator(C) is willing to accept parts(since operator should reject some of those parts). It was decided, that the operator(C) is used for the inspection process or characteristic that is less important.

8. STATISTICAL PROCESS CONTROL(SPC)

After implementing of MSA in final control station and identifying the ability and disability of operators in the identification of parts, and recognizing the ability of equipment evaluation and implementing it in production process, the testing of ability process has been implemented and its results are as follow in Fig.7

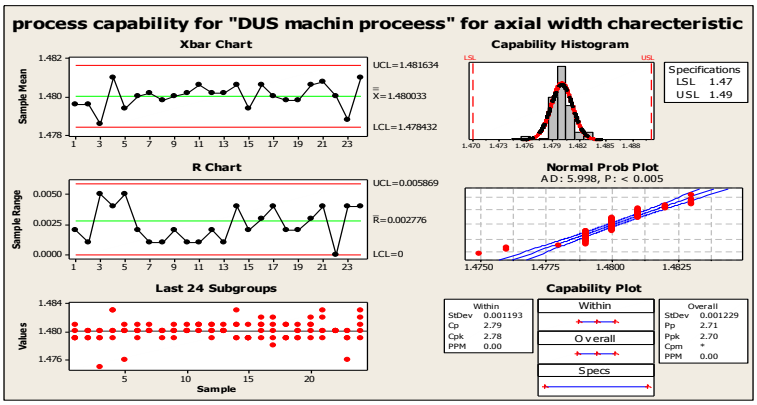

Fig 7: Results of Process Capability

9. CONCLUSION AND SUGGESTION

Although there were some considerations in regard to variability of the measurement (Gage R&R), this measuring System was accepted for the measurement of ring piston AXIAL which presents the pre-request for the implementation of analyzing and controlling of automatic AXIAL WIDTH process. According to preliminary results, significant financial benefit was achieved in a relatively short period of time. This allowed the quantity of nonconformities (defects) to be reduced by nearly 7.5%,which presents direct financial gains .In addition, direct financial gain caused by significant reduction of the number of nonconformities related to Ring AXIAL WIDTH caused a chain reaction in which efficiency and effectiveness runtime and overall process Were increased, the quality of product was improved and reworking and inspecting were reduced, having been evaluating of process capability according as Fig.7,we will have cp, cpk, pp, ppk >2. In implementing of MSA of parts produced in the lower level of tolerance, and therefore with corrective actions that were required and the evaluation of equipment precision with operators, process capability located in middle tolerance. By implementing and analyzing of measurement systems in spare-part-company, the senior managers and employers found better understanding of this system and its efficiency and benefits. Concerning on MSA and having no information on effective factors in measurement process can impose much more costs to the organization. This analysis that caused to reduce some related costs and to prevent shipping nonconformity products, and in three times evaluations by OEM there was no form of notice issued had been received for spare-part company. In particular, very good results have been achieved in the improvement of the overall performance of company through implementation of APQP and MSA methodology. This paper presents a case study of MSA within APQP, demonstrating how the effective introduction and implementation of statistical tools can lead to detailed understanding of the components of variation during measuring process and evaluation if a measurement system is suitable for a specific application measurement of the products most critical quality characteristic. For the case study analyzed in this article, further studies need to be performed. In order to improve and absolutely accept this measuring system for ring piston measurement, we suggest to all companies to follow this measurement system. Despite this, it is recommended to investigate method as well as with fuzzy logic, be investigated in future.

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