To Reduce Pointer Sticky Problem by the use of Failure Mode & Effect Analysis (FMEA) Technique

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ABSTRACT **- FMEA is needed to identify potential failure modes that may adversely affect safety, government regulations compliance or customer satisfaction and the rate of severity of the effects for failure mode.**

According to Juan, FMEAs were designed to be a team effort where the experience of the team would evaluate new work with a view to preventing previous mistakes occurring again. It was found that dealing with the design and manufacturing aspects together encompassed too many areas. The separation of the FMEA teams into Design and Process allowed for a fuller analysis of the situation. The necessary experts in each team utilized the skill and ability that previously limited the full potential.

To carry this methodology perquisite must be understood and followed. All problems are not same. Not all problems are equally important. This perhaps is the most fundamental concept of entire methodology. The FMEA will help in identifying priority. Customer requirements must be known before one undertakes the responsibility of conducting the FMEA. It is imperative that the customer requirements are to be defined. Traditionally the definition of customer is thought of the end user. A customer also may be viewed the subsequent or downstream operation as well.

It was never assumed to be the panacea to all situations. However, what started out as an initial attempt to reduce mistakes soon enabled predictions of other unforeseen problems. Developing the technique to expand upon this facet required a more structured approach.

I. INTRODUCTION

Post war developments in the aerospace industry, particularly in jet engines, offered new and exciting designs that would outperform all previous types. Coupled with the cold war, the race to have the superior air force resulted in an expansion of these industries. Unlike previous aircraft of the Second World War, the technology required enormous budgets to develop and test.

Closer investigation revealed that on numerous occasions, the experience gained was not carried forward and mistakes were being repeatedly made. On large investments, especially research, this can run into seven figure values. Naturally, this had to be stopped - or reduced dramatically. Reliability engineering was a science in its infancy whose aims were to achieve improvements by quantitative and qualitative approaches. Using mathematical models it is possible to determine the probability of a failure, but this requires statistical evidence to support the data. Where no such data exists other methods are necessary. FMEA is one such technique.

The risk analysis has a fundamental purpose as to sort probable wrong things and if something goes wrong the probability of its happening and consequences must be known. Today the paradigm has shifted and the focus is on preventing.

Old Way	New Way
Solution of problem	Prevention of problem
Quantification of reliability	Reduction of unreliability

Table 1 Old and new FMEA method

The fundamental corner stone of FMEA is improvement. This has become the impetus for modification, improvements and/or complete change. But any transformation or change brings uncertainty and risk. FMEA is simple, yet systematic methodology used to approach for problem, concerns, and challenges in order to seek answers for improvement.

II. LITERATURE SURVEY

Failure mode and effect analysis is one of the quality system requirement supplements. The FEMA can be defined as a methodical group of activities intended to

- Recognize and evaluate the potential failure of a product/ process and its effects

- Identify actions which could eliminate or reduce the chance of the potential failure according, and
- Document the process.

Types of FMEA

- Concept or System FMEA
- Design FMEA
- Process FMEA
- Service FMEA

Purpose of FMEA

FMEA is needed to identify potential failure modes that may adversely affect safely, government regulations compliance or customer satisfaction and the rate of severity of their effects, the purpose of FMEA is

- To identify critical characteristics and significant characteristics
- To concentrate engineers focus on eliminating product and process defects and prevent problem from occurrence.
- To identify potential design deficiencies before releasing hardware for production.
- To identify potential process deficiencies before production begins.
- To rank order potential design & process deficiencies for prioritizing corrective actions.

Conducting FMEA

- The team approach to conduct FMEA is recommended to cross functional team of knowledgeable individual with expertise and design, manufacturing, assembly, service and quality.
- The responsible system, product or manufacturing / assembly engineer leads the FMEA tool.
- The responsible design or process engineer is expected as a representative from all the affected activities. Team members will various the concept, product and process design matures.
- For proprietary designs suppliers are responsible.
- FMEA stimulate the interchange of ideas between the function affected and thus promote a team approach.

Initiation of FMEA

Concept of design FMEA is initiated by an engineer from responsible design activity.

- An engineer from responsible process engineering activity initiates process FMEA.
- FMEA is updated by the responsible system, product and assembly or manufacturing engineers.
- Suppliers keeps there FMEA up-to-date.

Time for initiating FMEA

- The concept of FMEA is a recommended process to translate customer functional requirements and provide system design specifications for the design FMEA process.
- When fully implemented, the FMEA disciplines requires design FMEA for all new parts, change parts and carry over parts in new application of environments.
- An FMEA discipline requires a process FMEA for all new parts / processes, change parts/ process in new applications or environments.
- When new systems products, processes designed.
- When existing designs or processors are changed.
- When carryover designs / processors will be used in new applications, or new environments.
- After implementing a R&D study (to prevent the recurrence of problem)

Updating FMEA

Whenever a change is being considered to a product design, application, environment, material environment and material, FMEA update should occur when world class timing events or locals timings requirements dictates.

Completion of FMEA

The FMEA is the living document and in that sense must be updated whenever significant changes occur in the design or when the risk priority number comes within 40 then FMEA is declared as completed. The various steps in completion are as follows.

- Concept FMEA – It is considered completed when the system design specification are frozen and design specification are defined.
- Design FMEA – It is considered completed when the product is released for production.
- Process FMEA – It is considered completed when all operations are considered when all

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critical and significant characteristics have been addressed and when the control plans have been completed.

- Service FMEA - It is considered completed when the System or process FMEA error is mitigated before product reach to customer.

III. METHODOLOGY OF FMEA

A failure mode and effect analysis (FMEA) is an engineering technique used to eliminate potential failures, problems and errors in the system and determine their effects on the operation of the product. It could be a design, manufacturing process and services of products before it reaches to the customers.

The analysis of the evolution may take two courses of action. First using historical data, there may be analysis of similar data for similar products and/or services, warranty data, customer complaints and any other appropriate information available to define failure. Secondly inferential statistics, mathematical modeling and simulations, concurrent engineering and reliability engineering may be used to identify and define the failure. Using the FMEA does not mean that one approach is better than the other or that one is more accurate than the other. Both can be efficient, accurate and correct if used properly and appropriately (8).

This chapter focuses on generic concern of what the FMEA is, what it can do what it means, how it is conducted and how it compares with other tools available. Any FMEA conducted properly and appropriately will provide the practitioner with useful information that can reduce risk (work) load in the lad system, design, process and service. This is because it is logical and a progressive potential failure analysis method (technique) that allows the task to be performed more effectively. FMEA is one of the most important early preventive actions is system, design, process or service, which will prevent failure and errors occurring and reaching to the customer.

This early warning and preventive technique provides the designer with a methodical way of studying the causes and its effects of failure before the system, design or service is finalized. In essence the FMEA provides a systematic method of examining all the ways in which a failure can occur,. For each failure an estimate is made of its effect on the total system, design, process or service of its seriousness of its occurrence (frequency) and its detection(8).

FMEA Program should start in a situation

- When a system, design and products, processes or services are designed
- When existing system, design, products, processes or services are about to change regardless of reason.
- When new applications are found for the existing conditions of the system, design, products, processes or the services.

After the FMEA begins it becomes a living document and is never really complete. It is a true dynamic tool or improvement (as opposed to static) because regardless of the beginning phase, it will use information to improve the system, design, products, processes or services. It is continually updated as often as necessary.

Interpretation of FMEA

The essence of the FMEA is to identify and prevent known and potential problems from reaching to the customer. To do the same, it has made some assumptions, one of which is that the problems have different priorities. There are three components that can help to define the priority of failures (7).

- Occurrence (O)
- Severity (S)
- Detection (D)

Occurrence is the frequency of failure. Severity is the seriousness of the failure and detection is the ability to detect the failure before it reaches to the customers.

OCCURRENCE

Occurrence is an assessment of the likelihood that a particular cause will occur and result in the failure mode during the intended life and use of the product.

The occurrence rating number has the meaning rather than the value. It is estimated on a ‘1 to 10’ scale. Occurrence ranking can be affected through a design change bye removing controlling one or more causes or mechanisms.

To determine occurrence ranking, ask

- What is the service history and field quality experience with similar components or sub systems?
- Is the component carryover or similar to a previous level component or subsystem?
- How significant are the changes from a previous level component or subsystem?
- Is the component radically different from a previous level component?
- Is the component completely new?

The “design life possible failure rates” are based on the number of failures that can be anticipated during the design of the component, subsystem or system. The “occurrence Rating Number” is related to rating scale and does not reflect the actual likelihood of the occurrence. Possible failure rates are generally based on historical data and field experience with similar or surrogate parts; occurrence rating should be entered after the design action is implemented.

SEVERITY

Severity is the assessment of the seriousness of the effect of the potential failure mode on the next component, subsystem, or customer if it occurs. Reduction in severity ranking index can be affected only though a design change. Severity should be estimated on a “1 to 10” scale. Assess the seriousness of each effect on the part, next assembly,

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system, vehicle, customer and government regulations. The team should consensus on severity ratings for each effect listed using severity-rating table for design FMEA.

DETECTION

It is an assessment of the ability of the proposed design controls to detect the potential causes too failure mode, of the failure mode before the component, system or subsystem is released for production. When several controls are listed for the particular failure mode, estimate a detection rating for each control. Enter the lowest rating. While estimating the effectiveness of each design control, consider the following categories. The degree of effectiveness is listed from high to low in each category.

Risk Priority Number (RPN)

The risk priority no. is the product of the severity (s), occurrence (O) and detection (D) Ratings.
(RPN= S x O x D)
This product is a measure of design risk. Rating and RPN have no value or meaning themselves. Rating and RPN should be used only to rank the potential design, Weakness for consideration of possible design control to reduce critically and/or make the design more robust. Values for RPN can range from 1-1000. For higher RPN, the team undertakes the efforts to reduce this calculated risk through the corrective actions. Regardless of the resulting RPN, special attention should be give when severity is high.

Resulting RPN

After the corrective actions have been completed, estimate and record the occurrence, severity and detention rankings. If no actions are taken, leave the columns blank. The design engineer will review the revise RPN and determine if further design actions are necessary. There are many ways to define the value of these components. The usual way is to use numerical scales. These guidelines can be qualitative and/or quantitative.

If the guideline is qualitative, then it must follow theoretical (expected) behavior of the components. For example in the case of occurrence the expected behavior is normality. This behavior is expected because frequency is over time in a normal fashion. Thus the normal guideline should follow the normal distribution. In case of severity, the expected behavior is lognormal. This behavior is expected because the failure that occurred should be the nuisance category as opposed to critical catastrophic.

Thus, the guidelines should follow a distribution that skews to the right. In the case of detection expected behavior is that of a discrete distribution. This is expected because there is more concern if the failure is within the organization. Therefore there is a discrete outcome (internal organization versus customer) in the detection. Thus the guidelines should follow a distribution with a gap between the values. If the guidelines are quantitative, it must be specific. It must follow actual data, statistical process control data, historic data or similar or surrogate data for the evolution. The guidelines do not have to follow the theoretical behavior. If it does, it is strictly a coincidence.

The ranking for the criteria can have any value. There is no standard for such value, however there are two very common rankings used in all industries today. One is the ranking based on 1 to 5 scales and secondly on 1 to 10 scales. The ranking of 1 to 5 is limited in nature, but it offers expediency and case. It does not provide for sensitivity (accuracy) of specific quantification, because it reflects a uniform distribution. The ranking of 1 to 10 is used widely and in fact is highly recommended because it provides ease of interpretation, accuracy and precision in the quantification of the ranking. Ranking of higher than 1 to 10 scales are not recommended because they are difficult to interpret and lose their effectiveness.
The priority of the problem is articled via the risk priority number. This number is the product of occurrence, severity and detection. The value by itself should be used only to rank order and concerns of the system design, product and services. All the RPN have no other value or meaning.
After the RPN has been determined the evaluation begins based on the definition of the risk. Usually the team as minor, moderate, high and critical defines the risk. It may be changed to reflect different situation.

- Under minor risk, no action is taken.
- Under moderate risk some action may take place.
- Under high risk, definition action will take place.
- Under critical risk, definite action will take place and extensive changes are required in the system, design, process and/or service.

After completion of FMEA

Following are the steps that team must follow:

Review the FMEA

- Make sure that function; purpose and objective have been met. Make sure that all loose ends have been addressed and the appropriate action has been recommended and implemented.

Highlight the high risk areas

A visual inspection of critical column, the severity column, and the RPN column will identify the high-risk areas in the critical column. The high-risk items may be identified as such, in the severity column the high-risk usually will have a number higher or equal to 7, and in the RPN column usually a number higher or equal to 1000(on 1 to 10 scale) will indicate that there might be a high-risk item.

Identify the critical, significant and major characteristics

Upon completion of the FMEA a visual check of RPN and critical column should identify the critical, significant and major characteristics. Make sure that there is a direct co-relation between the columns. Great care should be taken while reviewing the RPN because these numbers will indicate whether or no action is initiated.

Ensure that a control plan exists and is being followed

As previously mentioned the idea of performing FMEA is too eliminated and/ or reduce known potential failures before they reach to the customer. In this step, make sure that all critical, significant and major characteristics have

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documented in plan for controlling the proving and/or handling changes. The control plan is the man that will allow practitioners to make the product and/or service acceptable to the customer. Although the FMEA identifies the vital signs of the process and/or services, the control plan monitors those vital signs of the process and/or service.

III. REDUCTION of POINTER STICKY PROBLEM IN MECHANICAL CLUSTER

Mechanical Speedometer working principal

Mechanical speedometer function is to show the vehicle speed and running distance. To get efficiently speedometer assembly include various parts like Speedo dial, Pointer & NS system. A moving cable is required to rotate NS system. Cable is connected to the vehicle tyre hub from one side in two-wheeler & and in NS system from another side.

Speedometer Parts description:-

(1) Speedo dial: - Speedo dial is printed dial which include printing of the speed Km/h value.

Figure 1 Speedo Dial

Speedo dial has a cut section which shows odometer, which is a part of NS system.

Figure 2 Speedo dial with odometer

(2) Pointer: - Pointer is connected from NS system & rotates on dial & represents speed of running vehicle at the time.

Figure 3 Speedo Dial with pointer

(3) NS System: - It is a very important part of any speedometer, which includes odometer also. A moving cable gives the rotation to the axle of NS system and axle give the rotation to the pointer, which shows speed on Speedo dial. Odometer shows running distance.

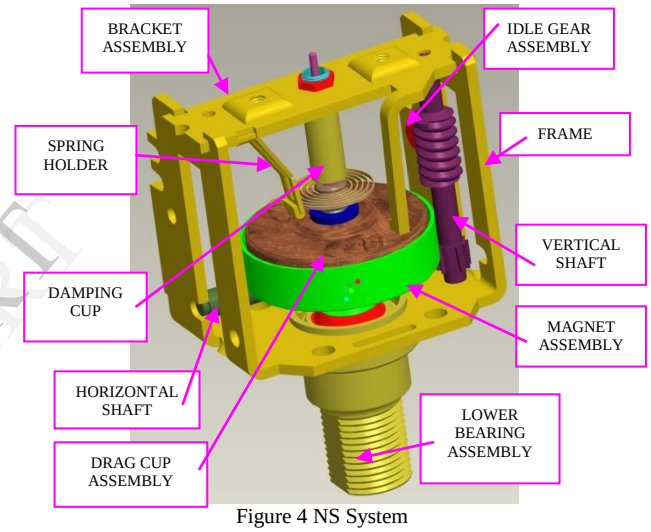

Figure 4 NS System

All the above parts in a NS system have important role. NS system is body of the speedometer, if any part in the body is not working properly, so, speedometer working will be affected.

A moving cable gives rotation to the Magnet assembly through lower bearing assembly which transfers to the Drag Cup assembly, Drag cup assembly rotates & gives rotation to the pointer which moves on Speedo dial & shows the speed of moving vehicle.

The moving cable is connected to hub of moving vehicle tyre. Diagram is shown below-

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Figure 5 Hub assembly with cable

Figure 6 Another side cable assembly

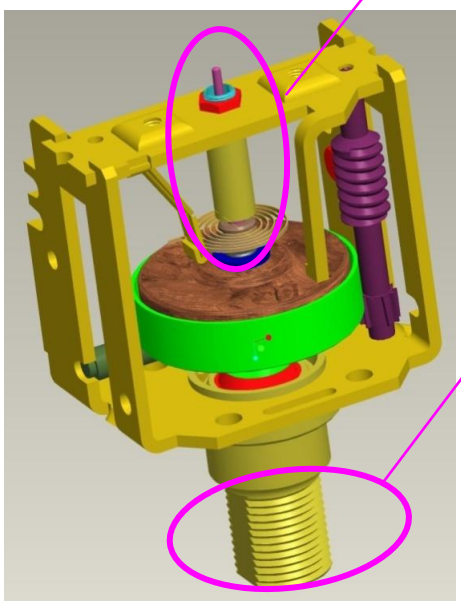

Figure 7 Cable assembly in lower bearing assembly

Figure 8 Moving pointer with Speedo dial

Figure 9 Speedo Cable

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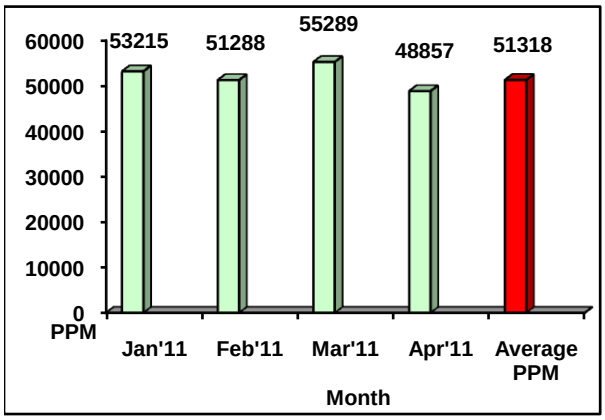
We have seen above speedometer is the assembly of child parts & NS subassembly. NS system is the assembly of child parts & various sub assemblies. So, every part in NS system affects the speedometer pointer movement on Speedo dial.

The study concentrates on speedometer pointer sticky problem due to lower bearing assembly problem which is the part of NS system. Pointer sticky means pointer movement stuck during rotation at any position on dial. So, by applying the concept of FMEA explore the region behind the speedometer pointer sticky problem to reduce the internal rejection of speedometer. There is number of regions but what most critical region to affect the speedometer, in this Study Failure mode of a speedometer related to condition in which speedometer pointer will be stuck during rotation of pointer on Speedo dial. Speedometer PPM is related to the pointer sticky, to reduce internal rejection or to reduce pointer sticky will reduce PPM of company.

Mechanical cluster pointer sticky data is collected between periods January 2011 to April 2011 for internal rejection.

Figure 10 Pointer sticky



Graph 1 Speedometer pointer sticky

On the analysis of last four months Speedo pointer sticky records, we classify the most possible causes of the pointer sticky according to the team members and select potential causes to give appropriate RPN to that causes of failure.
In below picture all possible causes of Speedo pointer sticky are shown. We verify one by one all possible causes & finally we find 4 potential causes which can affect the pointer movement in speedometer.

(1) Lower bearing assembly loose during crimping.

(2) Burr or dust between magnet cover & magnet.

(3) Bend in axle pointer.

(4) More free play of spindle assembly.

After brainstorming of team above four causes are effectively playing big role in speedometer pointer sticky problem. We give the RPN number to these causes & get resultant root cause of the Speedo pointer sticky problem.

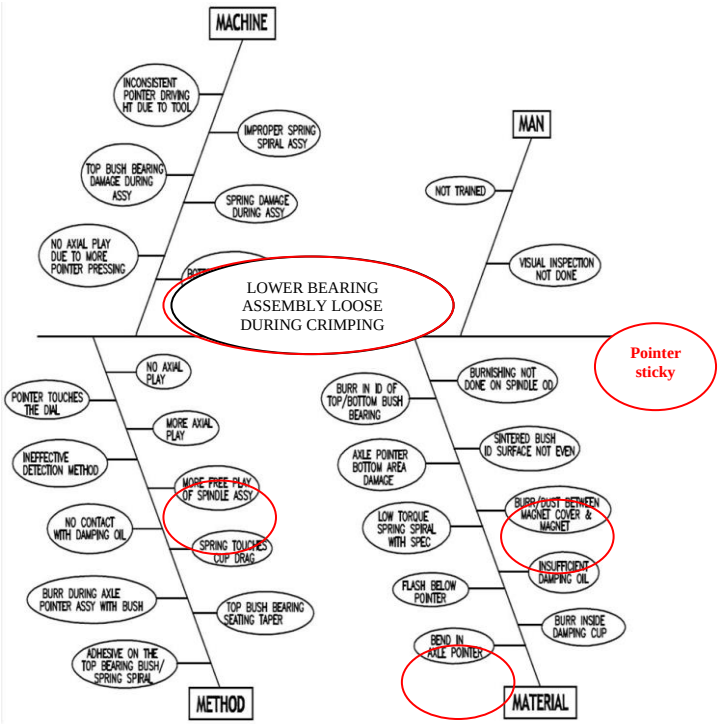


Figure 11 Pointer sticky analysis

We calculate RPN no. of the above causes from FMEA. FMEA for potential failure mode sticky problem is shown here:-

POTENTIAL FAILURE MODE	POTENTIAL EFFECT OF FAILURE	SEVERITY	POTENTIAL CAUSE	OCCURENCE	CONTROL PROCESS DETECTION	DETECTI	RPN
Pointer Sticky problem	Parts rejected at final inspection stage	7	Lower bearing assembly loose during crimping	5	1. 100% visual inspection	7	245
			Burr or dust between magnet cover & magnet	2	1. 100% visual inspection	7	98
			Bend in axle pointer	2	1.100% inspection by dial gauge for axle length 2. 100% visual inspection	5	70
			More free play of spindle assembly	2	1.100% inspection by dial gauge for free play of spindle	5	70

Table 2 FMEA calculation

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RPN Number before implementation of FMEA form above table

RPN of each cause of the failure is calculated (S X O X D) from these rankings. The problem of Speedo pointer sticky due to "burr or dust between magnet cover & magnet", the team member agree on severity ranking as 7, occurrence rating 2, and detection rating as 7.
Thus for Severity = 7, Occurrence = 2, & Detection = 7
RPN = S X O X D = 7 X 2 X 7 = 98
As this one, RPN of all the causes of the problems are calculated.

CONCLUSION

On the basis of RPN calculation it is observed that cause of Speedo pointer sticky with high RPN is due to

1. *Lower bearing assembly loose during crimping.*

So, we will analysis this cause to reduce the pointer sticky problem.

Lower bearing assembly loose during crimping -

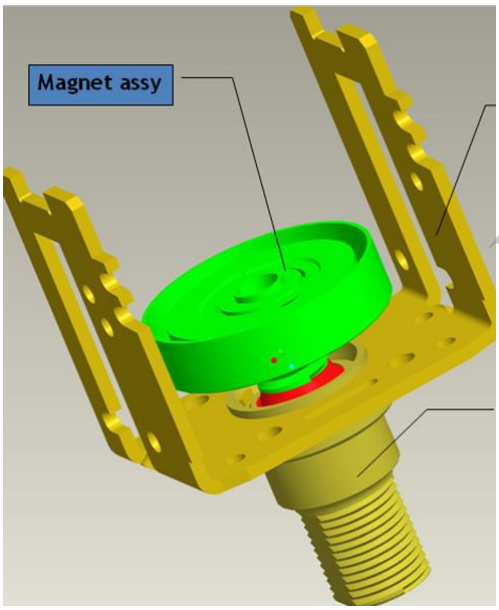

Figure 12 Lower bearing assembly in crimping system

As we know the lower bearing assembly will transfer the motion from the cable to the Speedo / odo meter & ensures the smooth movement / stability of the pointer. But due to loose crimping of lower bearing assembly, transfer of motion will be interrupted. So, lower bearing assembly crimping were observed for five days (03.05.2011 to 07.05.2011) to understand process variable (Air pressure) and effects on lower bearing assembly.

Day	*Air pressure*	*Parts produced in a day*	*OK parts*	*NG Parts*	*Rej %*
1	3.3 Kg/cm²	2013	1916	97	4.81
2	3.4 Kg/cm²	1975	1874	101	5.12
3	3.1 Kg/cm²	2007	1908	99	4.93
4	3.5 Kg/cm²	1896	1800	96	5.06
5	3.8 Kg/cm²	2034	1938	96	4.71

Table 3 Air pressure effect

During process setup N.G. parts were analyzed and found crimping NG in frame (Compare shape with master sample

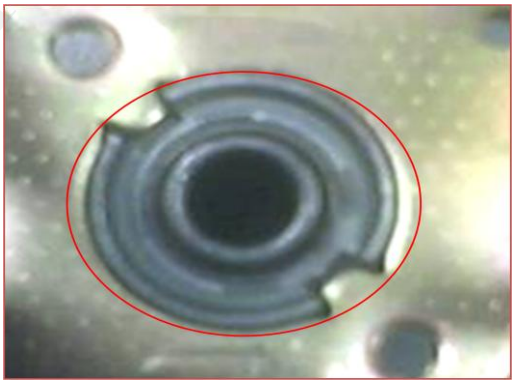

Figure 13 Gap observed between frame & Lower bearing assembly

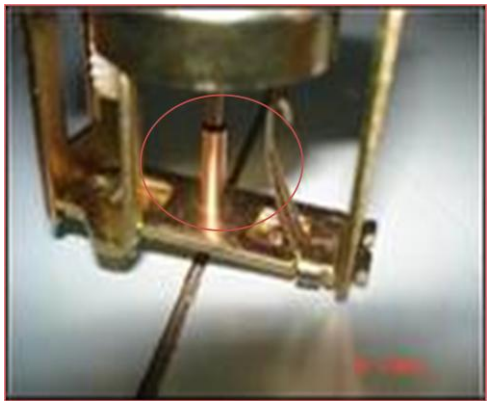

Figure 14 Axle bends & touches upper bearing

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Establish & check action

To accomplish the proper crimping, air pressure re-validate for process.

Process verification/ Qualification					
Process :- Boss cauking with Main Frame					09.05.2011
Air Pressure specification- 2 - 4 kg/cm2					
Criteria :- Cauking should be Ok.					
Air pressure	1	2	3	4	5
1.6	NG	NG	NG	Ok	
1.8	Ok	NG	Ok	Ok	Ok
2	Ok	Ok	Ok	Ok	Ok
2.2	Ok	Ok	Ok	Ok	Ok
2.4	Ok	Ok	Ok	Ok	Ok
2.6	Ok	Ok	Ok	Ok	Ok
2.8	Ok	Ok	Ok	Ok	Ok
3	Ok	Ok	Ok	Ok	Ok
3.2	NG	Ok	Ok	Ok	
3.4	NG	Ok	NG		
3.6	NG	NG	NG		
Conclusion :- Pressure range specification 2-3 kg/cm2.					
Done By : Mahender Yadav			Checked By :Pankaj Malik		

Table 4 Validation of Boss caulking process

CONCLUSION

Air pressure optimized (2-3 Kgf/Cm2) for crimping of lower bearing assembly in frame & hence we achieve desired result to reduce the Speedo pointer sticky problem. After improvement the picture shown as:-

Figure 15 No gap

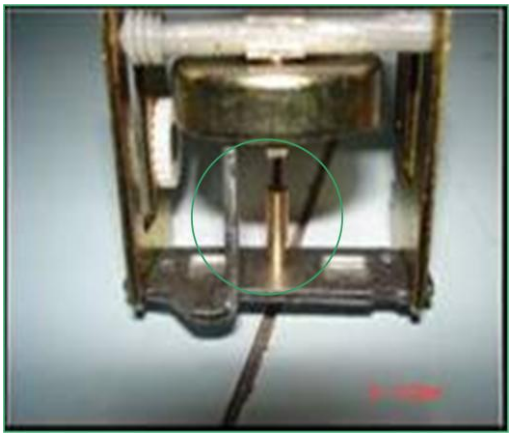
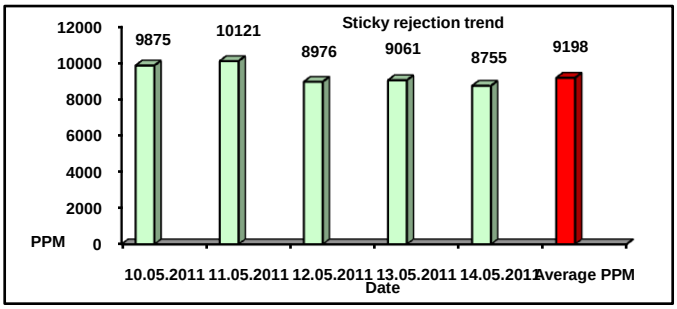


Figure 16 Axle in centre of upper bearing

As per above shown pictures, crimping is proper & axle does not touches upper bush bearing.

RESULT

After implementing the FMEA between period 10/05/2011 to 14/05/2011



Graph 2 Sticky rejection trend

Potential Failure	Severity	Occurrence	Detection	New RPN Number	Old RPN Number
Speedo pointer sticky	**7**	**2**	**7**	**98**	**245**

Table 5 Resultant RPN

Review the FMEA:-

FMEA is reviewed by the team to make sure that the objective, function, & purpose of FMEA has met. After the results have been recorded, the team evaluates the success of FMEA. The evaluation is done on the basis of three basic questions.

1. Is the situation better than before?
2. Is the situation worse than before?
3. Is the situation the same as before?

In the present study the results after implementation of the recommendations are reviewed in terms of RPN & compared with old RPN as shown in table. The new RPN is reduced as compared to old RPN as the rate of occurrence of the problem is reduced due to implementation of recommended actions and thus reduced the failure.

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