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Decrease in the Down Time for Air Duct Systems Used in Automobile by FMEA Implementation in Its Manufacturing

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Abstract:

This paper is emphasis on identification of potential failures; failures may be encountered in future, during the manufacturing of the product – automotive air conditioning ducts and preparing mitigation plan for the potential failures. After the complete study of the manufacturing process and production data – failure causes, failure rate, & other relevant data etc, FMEA discovered the weak processes in the form of higher risk priority number in the manufacturing of product, which required reducing by identifying and implementing mitigation actions and this will improve the process and product quality & productivity. After execution of process FMEA for center duct of air conditioning product, It is identified that major area of failure of center duct during manufacturing are as follows:

1. ***De-flashing during manual process***
2. ***Moulding defects left out during inspection***

Hence it provided the potential failures of the product so preventive steps can be taken to improve quality of product and productivity.

Keywords: Production Planning, FMEA, Automotive AC air duct, Blow moulding.

I. INTRODUCTION

1.1 IMPORTANCE OF FMEA IN QUALITY ENHANCEMENT[4]:

Traditionally, reliability has been achieved through extensive testing and use of techniques such as probabilistic reliability modeling. These are techniques done in the late stages of development. The challenge is to design in quality and reliability early in the development cycle. Therefore engineers introduced Failure Modes and Effects Analysis (FMEA). FMEA is a methodology for analyzing potential reliability problems early in the development cycle where it is easier to take actions to overcome these issues, thereby enhancing reliability through design. FMEA is used to identify potential failure modes, determine their effect on the operation of the product, and identify actions to mitigate the failures. A crucial step is anticipating what might go wrong with a product. While anticipating every failure mode is not possible, the development team should formulate as extensive a list of potential failure modes as possible. The early and consistent use of FMEA in the design process allows the engineer to design out failures and produce reliable, safe, and customer pleasing products. FMEA does also capture historical information for use in future product improvement.
A subject of research is automotive air conditioning system air duct products of company deals with OEM. Production of those air ducts is done according to different technical requests and standards of auto industry. Application of FMEA in manufacturing process of the auto air conditioning side air ducts is done, potential failures are identified and pre measures are defined for problems overcoming and quality and lifetime of systems increase.

1.2 IMPORTANCE OF AUTOMOTIVE HVAC AIR MANAGEMENT & ROLE OF FMEA IN ITS MANUFACTURING:

HVAC systems use an air distribution or duct system to circulate heated and/or cooled air to all the passenger compartment. Properly designed duct systems can maintain uniform temperatures throughout the car passenger compartment, efficiently and quietly.

Fig. 1 – Air Ducts for Automotive HVAC air management

The efficiency of air distribution systems has been found to be 60-75% or less in many car because of insufficient and/or poorly installed duct insulation and leaks in the duct system and manufacturing defects of ducts. Properly designed and installed duct systems can have efficiencies of 80% or more for little or no additional cost, potentially saving car owner a $50-100 or more per year in heating and cooling costs. Duct systems that leak and/or do not distribute air properly throughout the car compartment may make some portion concentrated in nature i.e, too hot and others too cold. Leaky and unbalanced duct systems may force conditioned air outside and unconditioned air into the car compartment. This increases heating and cooling costs in context of fuel efficiency and may also draw humidity, dust, mold spores, and other contaminants into a compartment from the atmosphere as well as from engine compartment In extreme cases, poorly designed and installed duct systems can induce back drafting—spillage of waste heat from the engine compartment to the passenger compartment.

All the above stated loop holes can be overcome by controlling manufacturing process systematically through Failure mode and effects analysis prior to that we have to carried out various process study and findings of faults and in later stage we have to carried out FMEA trials.

1.3 MANUFACTURING AND QUALITY IMPROVEMENT PROCESS STUDY:

Company is manufacturing air conditioning ducts for passenger car, the whole duct is comprise of three sub parts, named as center duct, side duct LH & RH. After manufacturing of individual parts they get assembled and then whole product can be supplied to the OEM customer. Sometime OEM customer may order individual parts as well. Here we have studied manufacturing process and conducted FMEA for center duct only.

The F**ig 2.,** is the process flow diagram for center duct manufacturing.

Implementation of FMEA starts with the *FMEA Planning and Cross Functional Team Creation* for FMEA – *Development* and then to the *Evaluation* of the results.

After preparation of team and planning, next step is to detailed study of manufacturing process and identification of each process step and documentation of the same in FMEA sheet. Standard FMEA sheet developed by IATF (International Automotive Task Force) is used and is as below in **Table 01**.

PROCESS FLOW DIAGRAM - Centre Duct

Sr. No.	Operation No.	Process / Operation Description	Incoming Source of Variation	Process Flow				
				Operation	Inspection	Transport	Delay	Storage
1	**10**	Receiving inspection of raw material	Wrong material supply / Wrong grade supply / Lot or batch no. not identified on the bags / Contaminated bags.					
2	**20**	Storage of raw material	Damaged bags / wet bags / mix up bags					
3	**30**	Blow moulding of ducts	Moulding visual defects / Dimentional variation / Component weight variation					
4	**40**	Deflashing	Excessive / under cutting of flashes / visual defects in the part					
5	**50**	Inprocess / online inspection	Moulding & deflashing defect.					
6	**60**	Hole punching operation	Hole punching on wrong location / Hole size wrong					
7	70	Storage of moulded parts	Defective / damaged parts					

Fig – 2 – Process flow of manufacturing of center duct

Table: 01 FMEA sheet

POTENTIAL FAILURE MODES AND EFFECT ANALYSIS
(PROCESS FMEA FOR RADIATOR)

Part no. Process Responsibility Item:
Core team: FMEA date: Prepared by:

#	PROCESS FUNCTION	POTENTIAL FAILURE MODES	POTENTIAL FAILURE EFFECTS	SEVERITY	CLASS	POTENTIAL CAUSE OF FAILURE	OCCURENCE	CONTINOUS PROCESS CONTROL AND DETECTION	DETECTION	RPN	RECOMMENDED ACTION	REPONSIBLE PERSON AND TARGET	ACTION TAKEN	SEVERITY	OCCURENCE	DETECTION	RPN

II. IMPLEMENTATION METHOD FOR FMEA [1]

Then identification of potential failure modes and their effects for each process steps, always input of CFT is very essential to have failure effect from all angles. After that ranking method is used to priories them based on severity, occurrence and detection method as follows:

Severity

Severity is an assessment of the seriousness of the effect and refers directly to the potential failure mode being studied. The Customer in process FMEA is both the internal and where appropriate, external Customer. The severity ranking is also an estimate of how difficult it will be for the subsequent operations to be carried out to its specification in Performance, Cost, and Time. The Ranking and suggested criteria are based on IATF manual of FMEA version 3. A common industry standard scale uses 1 to represent no effect and 10 to indicate very severe with failure affecting system operation and safety without warning.

Causes of failure mode

Identify the *causes for each failure mode*. A failure cause is defined as a design weakness that may result in a failure. The potential causes for each failure mode should be identified and documented. The causes should be listed in technical terms and not in terms of symptoms. Examples of potential causes include improper torque applied, Improper operating conditions, too much solvent, improper alignment, excessive voltage etc.

Occurrence

The *Occurrence* is the assessment of the probability that the specific cause of the Failure mode will occur. A numerical weight should be assigned to each cause that indicates how likely that cause is (probability of the cause occurring).
For that failure history is helpful in increasing the truth of the probability. Therefore historical data stored in databases can be used and questions like the following are very helpful to solve this problem.

- What statistical data is available from previous or similar process designs?
- Is the process a repeat of a previous design, or have there been some changes?
- Is the process design completely new?
- Has the environment in which the process is to operate changeable?
- Have mathematical or engineering studies been used to predict failure?

A common industry standard scale uses 1 to represent unlikely and 10 to indicate inevitable. The Ranking and suggested criteria are based on IATF manual of FMEA version 3.

Detection

Here we have to distinguish between two types of detection. On one hand we have to identify Current Controls (design or process). Current Controls (design or process) are the mechanisms that prevent the cause of the failure mode from occurring or which detect the failure before it reaches the Customer. The engineer should now identify testing, analysis, monitoring, and other techniques that can or have been used on the same or similar products/processes to detect failures.
The other thing is to asses the probability that the proposed process controls will detect a potential cause of failure or a process weakness. Assume the failure has occurred and then assess the ability of the Controls to prevent shipment of the part with that defect. Low Occurrence does not mean Low Detection - the Control should detect the Low Occurrence. The Ranking and suggested criteria are based on IATF manual of FMEA version 3.

Risk Priority Numbers (RPN)

The *Risk Priority Number* is a mathematical product of the numerical Severity, Probability, and Detection ratings:

RPN = (Severity) x (Probability) x (Detection)

The RPN is used to prioritize items than require additional quality planning or action.

Actions

Determine *Recommended Action(s)* to address potential failures that have a high RPN. These actions could include specific inspection, testing or quality procedures; selection of different components or materials; de-rating; limiting

environmental stresses or operating range; redesign of the item to avoid the failure mode; monitoring mechanisms; performing preventative maintenance; and inclusion of back-up systems or redundancy.

After that we have to assign *Responsibility* and a *Target Completion Date* for these actions.

III. EXECUTION OF PROCESS FMEA ON A.C. AIR DUCT IN COMPANY [1]

After the complete study of the air duct manufacturing process for almost one month in the factory's manufacturing area and with help of cross functional team, Process FMEA had been done. Cross functional team (CFT) is very important to identify potential failures that may be occurred in the product & process during manufacturing or in use. FMEA had been done for whole process of manufacturing as per above mention method and criteria, but here one step of process is shown as an example in here in table-2 of FMEA.

Potential Failure Mode and Effects Analysis (Process FMEA)

Component : Nano Centre Duct | Drawing No. : 283468906319 | Process Responsibility : Mr. Dipen Patel | Document No. : - DBP / PFMEA / 01 | Prepared by : Bharat Dogra

Model Year/ Vehicle(s) : Nano 2010 | Revision No. : --- | Key Date : ----- | Rev. No : - 00

Core Team : Dipen Patel, Chirag, Jigar, Bharat | Revision Date. : --- | FMEA Date : 05.08.11 | Rev Date : - 05.08.11 | Delta Blow Pack Industries, Santez, Gandhi Nagar

Process Function / Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Class	Potential cause(s) / Mechanism(s) of Failure	Occur	Current Process controls Prevention	Current Process controls Detection	Dtec	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Action Results: Actions Taken	Sev	Occ	Det	RPN
10 Receiving inspection of raw material	Raw material not as per invoice	**Next Operation** - Difficult to process the material **Assly** - Part get rejected in the assly. **Customer** - Fit and function issues at customer end. **End Customer** - Field failure	7		Wrong material supply	1	--	Visual inspection on the bags as per the invoice details while unloading the material	6	42	Nil	Nil	Nil				
	Raw material not as per specification	**Next Operation** - Difficult to process the material **Assly** - Part get rejected in the assly. **Customer** - Fit and function issues at customer end. **End Customer** - Field failure	7		Wrong grade supply	1	raw material specification sheet	Visual inspection on the bags as per the invoice details while unloading the material	6	42	Nil	Nil	Nil				
	Raw material without identification and traceability	**Next Operation** - Difficult to process the material **Assly** - Part get rejected in the assly. **Customer** - Fit and function issues at customer end. **End Customer** - Field failure	7		Lot no. / batch no. & grade not mentioned on the raw material bags.	1	--	Visual inspection on the bags as per the invoice details while unloading the material	6	42	Nil	Nil	Nil				
	Contaminated raw material	**Next Operation** - Difficult to process the material **Assly** - Part get rejected in due to poor aesthetics. **Customer** - Part get rejected due to poor aesthetics. **End Customer** - Dissatisfaction	4		Mixture of coarse & fine granules / foreign particles / moisture in the raw material.	3	--	A) Incoming inspection of the raw material B) Inspection during the material usage C) Part inspection after moulding.	4	48	Nil	Nil	Nil				
20 Storage of raw material	Damaged bags	**Next Operation** - Difficult to handle the material **Assly** - -- **Customer** - -- **End Customer** - --	5		Improper loading of the material / tranist damage	3	--	Raw material bags checked during unloading at the time of receipt for damages.	4	60							
	Wet bags	**Next Operation** - Difficult to process the material **Assly** - -- **Customer** - -- **End Customer** - --	5		Supplier end improper loading / Material not coverd during transit.	2	--	Raw material bags checked during unloading at the time of receipt.	4	40							
30 Blow moulding of centre duct	Flashes / Parting line Flashes	**Next Operation** - Part may reject / poor appearance. **Assly** - Difficulty in assly with the mating part. **Customer** - Part rejected due to poor apperance. **End Customer** - Dissatisfaction	4		High blow speed / Low holding time and pressure.	4	Standard Process Parameter Sheet	First piece approval and inprocess inspection sheet.	4	64							
	Short Moulding / Fill	**Next Operation** - Part get reject / poor appearance. **Assly** - Difficulty in assly with the mating part. **Customer** - Part rejected due to poor apperance. **End Customer** - Dissatisfaction	4		Blow speed low / Barrel temperature low / Air pressure low / Parision short	4	Standard Process Parameter Sheet	First piece approval and inprocess inspection sheet.	4	64							

IV. IDENTIFICATION OF POTENTIAL FAILURES & ACTIONS [1]

After conducting FMEA, it had been decided to initially take actions for critical failures and need to identify actions to reduce risk rating for critical failures only. All failures effects are considered as critical whose RPN is more than 100. Based on that following are few critical failures identified and their recommended actions with responsibility & target date. (see table 5.)

V. CONCLUSION

After execution of process FMEA for center duct of air conditioning product, it is clear that FMEA is most useful tool to identify potential failures and reduces those effects by implementing control plans. Hence it can heavily improve the quality of product & enhance product performance. FMEA. execution is only presents the potential failures and asks to implement preventive measures to stop occurrence of failure and enhance product and process performance so it identification and implementation of prevention techniques (control plan) for potential failures is very important. But surely FMEA is one of the tool especially for automotive product in competitive environment to improve product & process quality and performance.

Table :3 Identification Of Potential Failures & Actions

Pr													Action Results				
Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Ias s	Potential cause(s) / Mechanism(s) of Failure	ccur	Current Process controls Prevention	Current Process controls Detection	etec	RPN	Recommended Action(s)	& Target Completion Date	Actions Taken	Sev	Occ	Det	RPN
40 Deflashing of the part	Excessive / less deflashing of the parts along parting line / Flashes in the fitment areas.	**Next Operation** - Part get reject / fitment issues / poor appearance. **Assly** - Part get reject / fitment issues / poor appearance. **Customer** - Part get rejected. **End Customer** - Dissatisfaction	6		Unskilled operators / Excessive or less deflashing	3	--	1) Operator awareness and training. 2) Defective sample display. 3) inprocess inspection	4	72	Give training to workers on product quality and rejection parameters	Mr. Chirag 15.09.2011		6	3	3	54
50 Online / Inprocess inspection	Moulding / Dimentional defects in the component	**Next Operation** - Part get reject / fitment issues / poor appearance. **Assly** - Part get reject / fitment issues / poor appearance. **Customer** - Part get rejected. **End Customer** - Dissatisfaction	7		Unskilled operators / Excessive or less deflashing	5			5	175	1) Standard Process Parameter Sheet 2) First piece approval and inprocess inspection. 2) Defective sample display.	Mr. Chirag 15.09.2011		7	2	4	56

VI. FUTURE SCOPE [2]

There is so many improvement opportunities are identified based on FMEA conducted so main those actions can be implemented and monitored for its effectiveness. The company is also into manufacturing of automotive side air duct and assembly, etc, so FMEA can be implemented for all other products manufactured in company to identify potential failures and to enhance product & process. For all new product development and processes, Production part approval process (PPAP) can be developed and implemented now onwards so that all products & processes will be analyzed and approved trough FMEA, SPC, control plan tools.

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