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Failure Mode and Effect Analysis of Transmission Case of a Tractor

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Abstract – A failure mode and effects analysis (FMEA) performed to enhance the transmission case manufacturing process of a tractor. The literature on transmission case process failure mechanisms, failure effects, and failure causes was reviewed. The most important failure modes were ranked according to a comprehensive analysis of the transmission case procedure. On a radial drilling machine, the rejection/failure rate was highest following spot facing and back spot facing operations. Contributing variables associated with failure modes, failure causes, failure impacts, and preventative strategies to mitigate the probability of failure..

Index Terms - Back spot facing, Failure mode and effect analysis, Spot facing, Transmission case

. 1. INTRODUCTION

A transmission for a tractor that includes a transmission case with an opening that is made in a side wall of the transmission case and opens to the outside of the transmission case. The transmission is a speed-changing mechanism installed in the transmission case that delivers power from a tractor's engine to the driven wheel. A speed change device is comprised of a primary speed change device that can vary the speed of driving force from the engine to a number of speeds.

FMEA is an effective method for organizing an investigation of a complex product or system, detecting possible issues, and resolving the most severe failures. The definition of failure is "the inability to function in accordance with the process purpose." Failure modes, failure impacts, failure causes, determining which failures should be handled first, and selecting preventative actions to decrease the probability of failure are all components of the general analysis process..

2. FMEA OF A TRANSMISSION CASE

A simplified variant of a process FMEA was applied to the transmission case based on the process engineer's advice and subject-matter expertise. The goal of the study was to identify transmission case issues, rank them in order of severity, and then examine the most significant failure. In this study, "Transmission Case" refers to the tractor shown in figure 1 as including a speed change mechanism that transfers driving force from a tractor's engine to a driven wheel.

FIGURE- 1

The process failure modes of transmission case of tractor can be categorized into spot face depth o/s (over size) or u/s (under size) during operation and back spot depth o/s or u/s during operation.

The principal consequences or effects of the transmission case failure were fitment problem in assembly for reverse idler gear shaft (R.I.G).

2.1 TRANSMISSION CASE FAILURE EFFECTS

The aforementioned failure modes may have more than one underlying cause, or failure cause. To avoid the onset of failure modes, it is crucial to get an understanding of their root causes. In the transmission situation, it is essential to keep in mind that many failure modes are not brought on by operator error.. Out of the listed causes of failure the travel of spindle by operator was the potential root cause for transmission problems.

2.2 TRANSMISSION CASE FAILURE MODES PRIORITIZED BY CRITICALITY

The criticality of any failure mode is impacted by the likelihood that it would produce the failure effect, the severity of its potential impacts, and the difficulty of detecting the mode prior to the occurrence of the failure effect. In a more formal FMEA, these two components are separated and referred to, respectively, as the incidence, severity, and detection factors. To prioritize failure mode, typically from 1 to 10, ranking values are assigned to each of these elements. The product of these is the "risk priority number" ranking statistic (RPN). FMEA employs the risk priority number to rank failure types in order of importance.

2.3 RISK PRIORITY NUMBER (RPN)

The risk priority number is the product of the severity(S), occurrence (O) and detection (D) ratings.

RPN = S x O x D

The RPN is a metric for process risk and is calculated by multiplying S, O, and D. There is no true value or significance to Rating or RPN. Rating and RPN should only be used to rate potential process weaknesses for the purpose of considering appropriate process action to decrease critically and/or to make the process easier. A random prime number (RPN) between 1 and 1000 will be assigned to you. Teams with a higher RPN take remedial measures to lower this estimated risk. When the severity is great, care must be taken no matter what the RPN.

2.4 RECOMMENDED ACTIONS

The purpose of this action is to eliminate the potential failure modes. Prioritize actions based on following failure modes:

- With affects that have the highest severity ratings.
- With causes that have the highest occurrence rating.
- With the highest RPN.

2.5 DATA COLLECTION

It is necessary to find out the failure/rejection of transmission case during manufacturing. Before starting the study the rejection data for three months has been collected. The data is tabulated and graphically shown in table I and figure II.

Table II clearly indicates that operation-10 is the most critical operation as its average percentage of failure is around 9.8%, whereas for remaining operation i.e. operation-20, 30 and 40 it is around 2.5%. Therefore the focus of work was concentrated on operation-10.

Sr. No.	Rejection Details	Nov. %	Dec. %	Jan. %
1	Operation – 10	9.7	9.7	9.8
2	Operation – 20	1.3	1.4	1.3
3	Operation – 30	0.4	0.3	0.3
4	Operation – 40	0.9	0.8	0.9

TABLE:1 Failure/Rejection Details Of Transmission Case

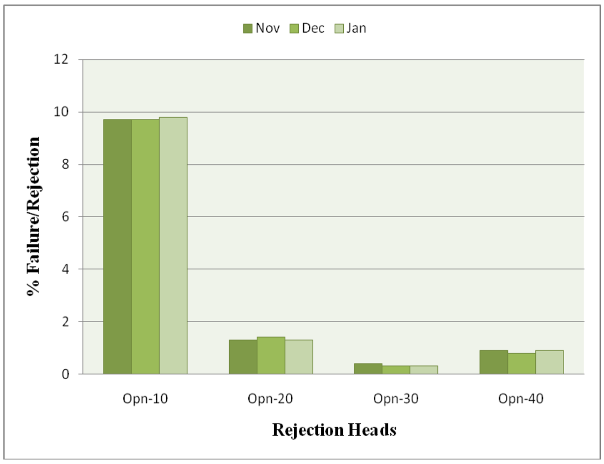

FIGURE 2

2.6 CAUSES OF FAILURE/REJECTION

A) Causes of failure for operation-10 (Back spot face depth o/s or u/s)

- Excess travel of spindle by operator.
- Back spot face cutter not engaged properly in tool holder.
- During tool change or after machine maintenance setting may get disturbed.
- Wear of tool.
- Wear of snap gauge.

B) Causes of failure for operation-10 (Spot face depth o/s or u/s)

- Excess travel of spindle by operator.
- Spot face cutter not engaged properly in tool holder.
- During tool change or after machine maintenance setting may get disturbed.
- Wear of tool.
- Wear of snap gauge.

C) Causes of failure for operation-10 (Spot face & Back spot face front face getting fired)

- Resting pad not cleaned by operator.
- Foreign particle stick on base of transmission case.

D) **Causes of failure for operation-20 (Bore diameter o/s or u/s, Dowel depth o/s or u/s, Dowel diameter o/s or u/s & Co-ordinates of various bores misalign)**

- Grid setting disturbed.
- Tool setting disturbed.
- Tool wear.

E) Causes of failure for operation-30 (NRB/RIG diameter o/s or u/s)

- Tool wear.
- Condition of guide bush.

F) Causes of failure for operation-40 (Misalignment of part while drilling three holes)

- Negligence of the operator.
- Guide pin misalignment.

G) Causes of failure for operation-40 (Three holes diameter o/s)

- Drill worn out.

Sr. No.	Problem Description	% Rej	S	O	D	RPN
1	Back spot face depth o/s or u/s	5.0	9	7	7	441
2	Spot face depth o/s or u/s	4.4	5	6	7	210
3	Spot face & back spot face front face getting fired	0.4	3	5	6	90
4	Bore diameter o/s or u/s	0.5	6	3	5	90
5	NRB/RIG diameter o/s or u/s	0.3	6	2	4	48
6	Misalignment of part while drilling 3 holes	0.7	3	4	6	72

Table: 3

2.7 CAUSES OF FAILURE/REJECTION AT OPERATION-10

In the Table: 3 clearly indicates that in operation-10 the maximum failure or rejection is during spot facing and back spot facing as its average percentage of failure is around 4.7%, whereas for remaining one it is around 0.5%. Therefore the work has been focused on spot facing and back spot facing.

Sr. No.	Problem Description	% Rejection
1	Excess travel of spindle during back spot facing.	2.7
2	Excess travel of spindle during spot facing.	2.1
3	Spot face cutter not engaged properly in tool holder.	0.7
4	Back spot face cutter not engaged properly in tool holder.	0.7
5	During tool change setting may get disturbed.	0.8
6	After machine maintenance setting may get disturbed.	0.7
7	Resting pad not cleaned by operator.	0.4
8	Tool wear.	0.1

Table:4

In the Table:4 clearly indicates that there are eight causes of failure/rejection of transmission case at operatio-10. The major contribution to failure among the mentioned eight causes is the excess travel of spindle during spot facing and back spot facing. Therefore the focus of work was concentrated on to minimize or eliminate excess travel of spindle.

2.8 RECOMMENDATION TO REDUCE THE FAILURE / REJECTION

The problem of excess travel of spindle was studied in depth. To reduce or eliminate the excess travel of spindle during spot facing and back spot facing various methods are suggested.

Finally it was recommended to use the stopper of metal of required height to avoid the excess travel of spindle

Sr. No.	Problem Description	% Rej	Old RPN No	S	O	D	New RPN
1	Back spot face depth o/s or u/s	1.4	441	9	7	3	189
2	Spot face depth o/s or u/s	0.9	210	5	4	6	120
3	Spot face & back spot face front face getting fired	0.3	90	3	4	6	72
4	Bore diameter o/s or u/s	0.5	90	6	3	5	90
5	NRB/RIG diameter o/s or u/s	0.3	48	6	2	4	48
6	Misalignment of part while drilling 3 holes	0.7	72	3	4	6	72

Table:5

3. CONCLUSION

Failure mode and effect analysis is the process of collecting and analyzing data to determine the cause of a failure and how to prevent it from reoccurring.

By using FMEA analysis technique, the failure/rejection of “Transmission Case” was studied. RPN no. was calculated for each machining operation.

Causes for failure/rejection of each operation were analyzed. The process with highest RPN no. was selected for FMEA application. It was noticed that excess travel of spindle during spot facing and back spot facing operation-10 at radial drilling machine which contributes nearly 4.8% for its rejection.

After effective implementation of FMEA for operation 10, the RPN no was reduced from 441to189, 210 to 120 and thereby the total failure was reduced from 11.3% to 4.1%.

Thus it can be concluded that, FMEA can serve as an important tool in the manufacturing of transmission case to reduce its percent rejection.

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