ANALYSIS OF HIGH TENSILE FASTENER OF TRANSMISSION SYSTEM

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ABSTRACT

Transmission system problems are a complicated which automobile manufacturers have confronted for decades. Customer complaints result in affecting yearly warranty costs. More importantly, customer dissatisfaction may result in rejection. In order to produce quality automobiles that can compete in today's marketplace, the occurrence of the transmission system problem must be reduced. The purpose of this report is to discuss transmission system problem and solution for the problems occur. The different tools are used to solving the problems of transmission system. Failure modes of the system are different like braking, noise, jerking, wear & leakage all these reasons of failure. The criticality is depending on the how the problem is affect to system. Also, there are many methods to find the criticality of problem in the whole system by the severity, occurrence and detection as used in a FMEA. When the failure modes have been ranked, corrective action should first be directed at the highest ranked concerns and critical items. If the causes are not fully understood, a recommended action might be determined by Design of Experiment.

Keywords: Transmission System, Braking, Design of Experiment, Criticality Analysis, Failure Mode.

I INTRODUCTION

Engine failure is loss or non-conformance of an expected functional performance due to malfunctioning of a subsystem or component.Every product or process has modes of failure. Several systematic methodologies have been developing to quantify the effect and impact of failures. Failure analysis performs dew to product and process development.

In product development

1) Prevent product malfunctions.
2) Insure product life.
3) Prevent safety hazards while using the product.

In process development

1) Insure product quality.
2) Achieve process reliability.

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3) Prevent customer dissatisfaction.
4) Prevent safety or environmental hazards.

Fig.1Types of Failure

1.1 Literature Review

Literature related to 4-stroke Spark Ignition Engine for single cylinder and alsoit's effect of transmission system problem on engine performance. Different techniques of optimization are referredlike six sigma and shainin DOE. Researchers worked on many different techniques to find the root causes and the solution of the problem by using the different technique of Engine. Some researcher need for a transmission system and the working principle of CVT has been discussed in depth. An attempt has been made to understand the contribution of Hydraulic Actuators, which is an integral part of a CVT [5]. Some studied product malfunctions in service are addressed by service centres that diagnose the problem and make decisions on component repair or replacement actions. To develop analytical model of service centres decision making process as IF-THEN decision rules which link repair actions with product pedigree[1]. Some studied optical microscopy and scanning electron microscopy were used for micro chemical and micro structural analysis [2]. Some worked on the injectors and the fuel was investigated in order to know the reasons of the failure and to improve the operation of the engine. The investigation revealed different causes, including plastic deformation and clogging of the injector's passages, as well as micro cracks, erosion and cavitation's damage [3]. Some achieve goal of this experiment was to investigate and demonstrate the potential of CVT for diesel engines hybrid electric vehicles (HEVs) in fuel economy and emissions [4]. Literature helps to find the problem root cause and also history records are useful for these.

1.2Aim

To improve the overall performance of 4-stroke Spark Ignition Engine by Studying the transmission system detail and identify the failure mode of the system. To reduces the failure mode and possibility of failure parts by taking references of history records, using different tool and minimize the problem occurring in transmission system for improving the performance of 4-Stroke Spark Ignition Engine.

II METHODOLOGY

1) To study & define the various problems occurring regarding transmission system.
2) To study different activities as all previous problems occur are divided into three groups.
3) To study the phenomenon of all previous problems occur.

4) Basic changes in processes and implementation required in such activities & parts.

5) To changes the system, parts and method to improve the performance and minimizes the problem of the system.

6) Validation of Results on a mass scale.

To fulfil this above objectives the tools used for the reduce the problems are Six sigma & DOE (Design of experiments).

III TRANSMISSION SYSTEM PROBLEM

3.1 Introduction to problem

There are number problem of transmission system is occurred in industry on basis of it's criticality failure of high tensile fastener is found more critical.

3.2High Tensile Fastenerget cracked

Engine failure is loss or non-conformance of an expected functional performance due to malfunctioning of a subsystem or component. High tensile fastener is fail in field that can cause to stop engine at running condition.Transmission system is fail to rotate because of failure of high tensile fastener the impeller touches the transmission cover and it's also get cracked so transmission system is failed.This problem is critical for transmission system.

3.3 Location of High Tensile Fastener

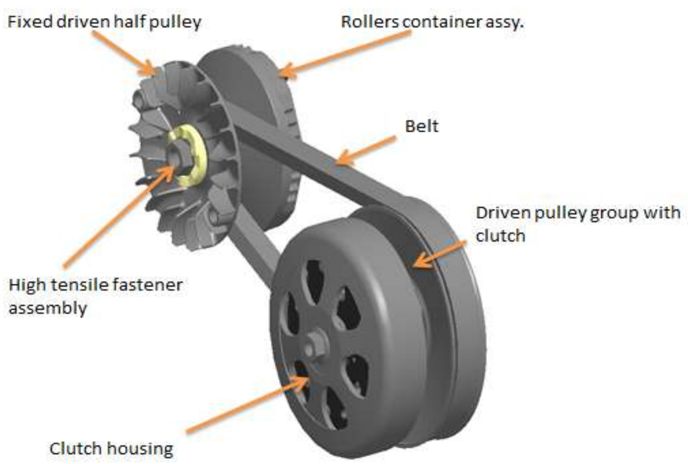

Fig.2 High tensile fastener location in transmission

3.4 Causes of failure of high tensile fastener

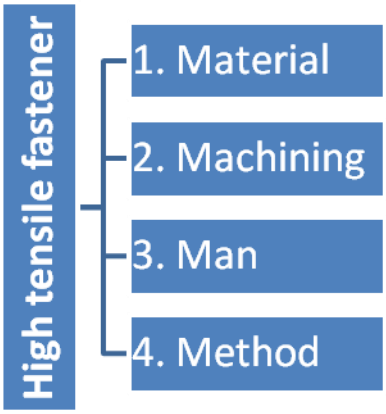

Fig.3 Causes of failure

3.4.1 Material

Material used for high tensile fastener is Aluminum C60 of zinc plating material. Chemical composition of C60 given below.

Table 1:Chemical Composition

Chemical Composition in Weight%								
C	Si	Mn	Cr	Mo	Ni	V	W	Others
0.61	Max 0.40	0.75	Max 0.40	Max 0.40	Max 0.40	-	-	(Cr+Mo+ Ni)= Max 0.63

As, Zinc Plating material used for High tensile fastener and it running 52-58 Nm torque.Plated materials are mostly used in an automobile industry in transmission system.Plating material can induce hydrogen Embrittlement.The hydrogen Embrittlement can causes the martial braking tendency.

Failure Modes of Material

Plating of high tensile fastener may lead to create a hydrogen gas in plating surface that leads to create crack.Embrittlement is a phenomenon that causes loss of ductility in a material, thus making it brittle. There are a number of different forms including:

1) Environmentally Induced Cracking.
2) Stress Corrosion Cracking.
3) Hydrogen Embrittlement.
4) Corrosion Fatigue.
5) Liquid Metal Embrittlement.

Out of these, hydrogen embrittlement is responsible for a surprising number of delayed failures.

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Table 2:Hydrogen Bake-Out Requirements for High Strength Parts

Tensile Strength		Hardness (HRC)	Time (hrs.) Post Plate Bake out at 375^{0}- 430^{0}F (190^{0}- 220^{0})C
MPa N/mm2	Ksi		
1700-1800	247-261	49-51	22+
1600-1700	232-247	47-49	20+
1500-1600	218-232	45-47	18+
1400-1500	203-218	43-45	16+
1300-1400	190-203	39-43	14+
1200-1300	174-190	36-39	12+
1100-1200	160-174	33-36	10+
1000-1100	145-160	31-33	8+

If zinc plated material running at 7600 rpm of having 52-58 Nm torque can fail less than 6 hours dew to hydrogen embrittlement phenomenon.

Hydrogen Embrittlement Phenomenon

How Hydrogen Gets In?

It is generally agreed that hydrogen, in atomic form, will enter and diffuse through a metal surface whether at elevated temperatures or ambient temperature. Once absorbed, dissolved hydrogen may be present either as atomic or molecular hydrogen or in combined molecular form (e.g., methane). Since these molecules are too large to diffuse through the metal, pressure builds at crystallographic defects (dislocations and vacancies) or discontinuities (voids, inclusion/matrix interfaces) causing minute cracks to form. Whether this absorbed hydrogen causes cracking or not is a complex interaction of material strength, external stresses and temperature. Sources of hydrogen include heat treating atmospheres, breakdown of organic lubricants, the steelmaking process (e.g., electric arc melting of damp scrap), the working environment, arc welding (with damp electrodes), dissociation of high pressure hydrogen gas and even grinding (in a wet environment). Parts that are undergoing electrochemical surface treatments such as etching, pickling, phosphate coating, corrosion removal, paint stripping and electroplating are especially susceptible. Of these, acid cleaning is the most severe, followed by electroplating at high current (these are less efficient and create more hydrogen even though they produce a better plated structure), electrolysis plating and conversion coatings.

How Hydrogen Gets Out?

Hydrogen absorption need not be a permanent condition. If cracking does not occur and the environmental conditions are changed so that no hydrogen is generated on the surface of the metal, the hydrogen can re-diffuse out of the steel, and ductility is restored. Some of the key variables include temperature, time at temperature, and concentration gradient. For example, electroplating provides a source of hydrogen during the cleaning and pickling cycles, but by far the most significant source is cathodic inefficiency.

Observation

To avoid the hydrogen embrittlement phenomenon and reducing the washer braking tendency can plating must be replaced. To reducing hydrogen embrittlement zinc plating material is replaced by geomatecoating. Geomate coating is most easy coating technique.

Geomet Coating

Geomet General Properties

1) Thin dry film
2) Water based chemistry
3) None electrolytically applied.
4) Chromium free
5) Passivated zinc and aluminum flakes in an inorganic binder, patented chemistry.
6) Metallic silver grey appearance.

Characteristics and Performance

1) Does not induce hydrogen embrittlement (suitable for high tensile fasteners)
2) Performance maintained at elevated temperatures (300º C)
3) Electrically conductive, suitable for most applications.
4) Bimetallic compatibility with aluminum
5) Good mechanical damage and chemical resistance.
6) Can be used with or without topcoats.
7) Less parts sticking together when coating in bulk.

Hydrogen Embrittlement Checking Procedure

First, take a beaker and keep sample parts into it carefully so that parts can't touch the wall of breaker then, pour Ethylene Glycol into the breaker until the parts totally immersedin the Ethylene Glycol solution. Then switch on the fume hood chamber and put the beaker at the heater and heat it until the temperature reaches upto$150^0 c$. As temp reaches $150^0 c$ off the heater and take the beaker out of the fume heater and check sample part. Checking is depends on the bubble formation on the surface of material If bubble forming on the washer surface then washer fail and if not form bubble then it is ok.

Hardness Testing Result

Table 3: Hardness Testing Result

Sr No	Parameters	Specification	Observations	
			Zinc Plating	Geomate Coating
1	Chemical Composition	C60	-	-
2	Hardness	40-48 HRC	40.5-41.1 HRC	43.7-44.1 HRC
3	Micro-structure	Tempered Martensite	Tempered Martensite	Tempered Martensite

3.4.2 Machining

In assembly, there are six parts on crank shaft transmission side.All contributing parts behind washer if any part is having less accuracy than prescribed then surface contact of the washer to claw coupling may change.The Machining process is done on claw coupling if surface of claw coupling not finished properly that can lead to creating the gap between the washer and claw coupling.Due to this possibility gap analysis was done by using software.

Analysis Stages

Washer failure analysis is done by using HYPERMESH soft. The checking different condition for detecting washer failure. The analysis is by two different conditions by keeping load constant and by keeping % of contact surface area constant.

Condition 1:52 Nm constant torque increasing % of contact surface area.

Condition 2: % of fixed surface constant increasing torque.

High Tensile Fastener Assembly

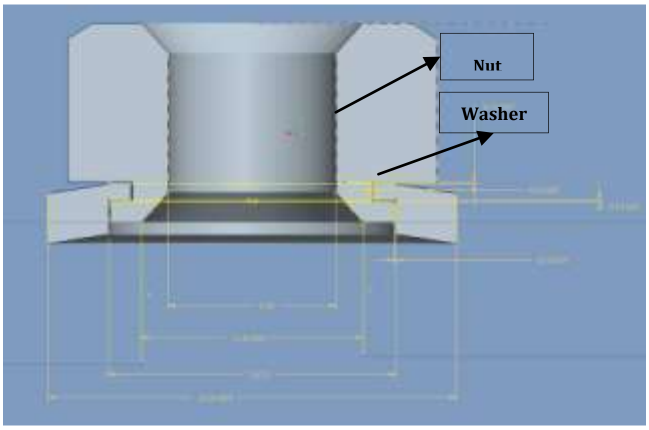

Fig.4: High Tensile Fastener Figure

Contact Surface Area Analysis

Analysis Condition:- 52 N-m Torque & 10 % Contact Surface Area

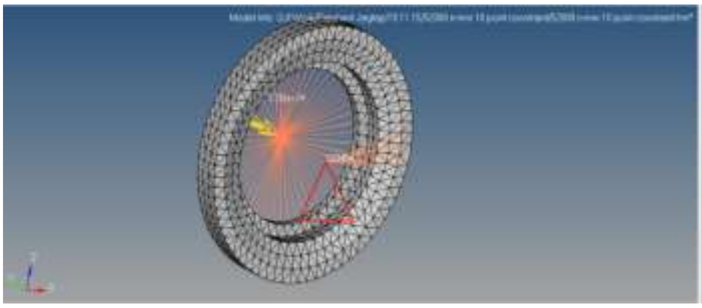

Fig.5: Boundary Condition of Washer

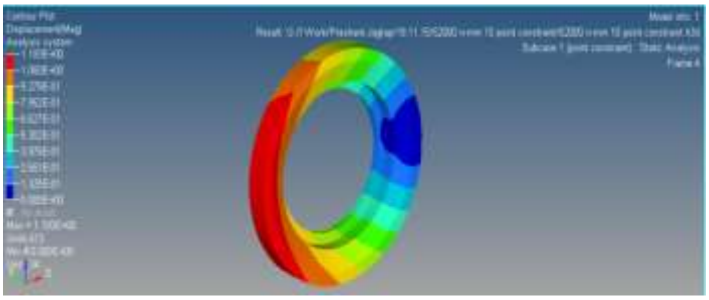

Fig.6: Displacement of washer

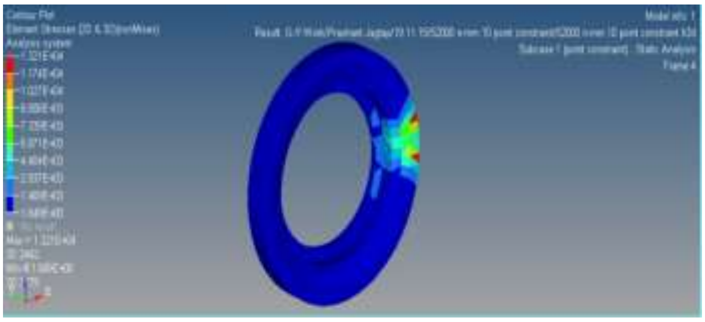

Fig.7: Stresses in washer

Analysis Result

Table 4 Washer Analysis Result for Constant Torque

Torque(Nm)	Contact Surface Area (%)	Result
52	10	Fail
52	20	Fail
52	30	Fail
52	40	Fail
52	50	Safe

As the above table indicates that analysis is performed by keeping torque constant and increasing % of fixed surface.It is clearly shown that, if min 50% or more contact surface area of washer fixed or touches claw coupling surfaces then washer safe at 52 Nm torque.

Table 5 Washer Analysis Result for Constant % Surface

Torque(Nm)	Contact Surface Area (%)	Result
52	>50	Safe
60	>50	Safe
65	>50	Safe
75	>50	Safe
100	>70	Safe

As the above table indicates that analysis is perform by keeping % of contact surface area constant and increasing torque. It is clearly shows that, if min 50% or more contact surface area of washer fixed or touches claw coupling surfaces then washer safe at 52 Nm,60Nm, 65 Nm torque & 75 Nm torque . It is clearly shows that, if min 70% or more contact surface area of washer fixed or touches claw coupling surfaces then washer safe at 100 Nm torque.

3.4.3Manual Cause

The worker who assigns for assembly is responsible for the failure occurring in the system becausehe may not follow all the standard instruction while doing assembly. The wrong assembly of system may cause failure of the system.

3.4.4Method

During the assembly of any engine part, the torque must be given by the pneumatic gun with specified torque range. If pneumatic gun gives more torque than that prescribed one then the chances of part failure increases.

IV CONCLUSIONS

Failure in the High tensile fastener is enhanced by the plating characteristics. The problems encountered during the running or at the steady engine condition due to the inappropriate plating of the material. All zinc plated high strength material lead to hydrogen embrittlement so it is preferredto geomatethe coating for all plated parts.High accuracy tools are used for the tightening system.All parts contributing to assembly must possess high accuracy.The alertness is given to concerns worker for alignment and assembly procedure.Assembly is done by a proper procedure. The hardness of Geomate coating also increased than that of plating high tensile fastener.

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