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ELIMINATION OF WATER INGRESS FAILURE ON SEALED VERSION GEAR REDUCTION STARTERS

R. Dharani Kumar[1], R. Kesavan[2]
[1*2*]*(Department of Production Engineering Madras Institute of Technology, Chennai, India)*

Abstract: *An auto electrical parts manufacturing company located in Padi, Chennai, is manufacturing sealed version gear reduction starters to various customers for their trucks & buses applications. The demand requirements for these starters are slowly growing up. The reason is they are low in weight, when compared to a direct drive starter with same output performance. The starter will be placed very close to the engine so that it can trigger the engine through it's flywheel upon switching on the ignition key. But the starter mounting position will get varied from customer to customer as per their mounting requirement. Hence the splashing of water from the road to the starter motor is inevitable. Now the firm is facing water ingress issue on these sealed version starters as field failures (warranty issue) leading to loss in business. This paper focuses on elimination of water ingress failure on sealed version gear reduction starters. An analysis has been made in order to find the root cause for the failure & to eliminate it. The methodology adopted for the analysis includes the Root cause analysis using Cause and effect diagram and through the Process Failure Mode Effect Analysis. Application of these tools helped in improving the knowledge base of the assembly process and also helped narrowing down to the root cause or a number of root causes in quick span of time.*

Keywords: *Gear Reduction Starter, Cause & Effect analysis, Process Failure Mode Effect Analysis, Air Leak testing, Error proofing and Rapid detection.*

I. INTRODUCTION

The Electric Starter Motor is a DC motor, converts electrical current into rotary motion. In doing so it converts electrical energy into mechanical energy. The interaction of two magnetic fields produces this rotational force.The field coils (either electromagnetic or permanent) located in the housing produce magnetic flux lines. Within the stationary field coils is the armature, a loop of wire (a conductor) with one end connected to B+, the other to B-. When current is applied to the armature flux lines circle the loop in one direction on one side and in the opposite direction on the other side. The interaction of the flux lines on the armature and the flux lines from the field coil cause the armature to rotate. The armature will only rotate to the point where the magnetic force is equal on both sides. (Armature 90º to magnetic flux lines of field) For the armature to continue to rotate, the polarity or direction of current flow must be reversed.Through the brushes and the commutator, the current flow is reversed as the magnetic forces become equal, causing the armature to continue to rotate.This constant reversal of current flow in the armature provides continual rotation.

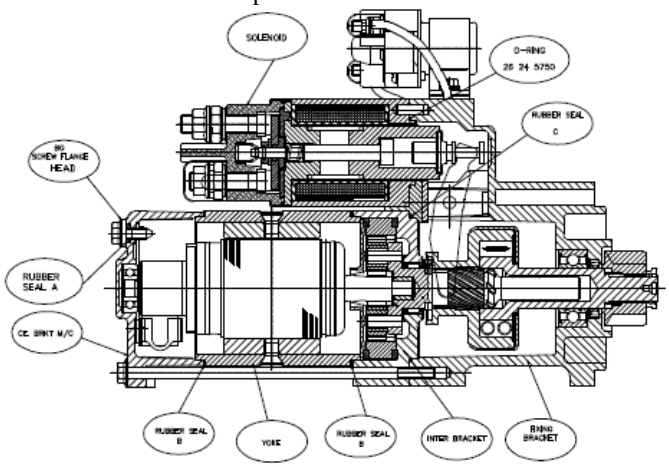

Fig. 1.1 Gear Reduction Starter Sectional view

This heavy duty Gear Reduction Starter motors was introduced in the market as sealed version starters, one of the major features. Sealed against entry of water & dust, but in recent years customer end failures & field failures have been recorded for water ingress into the starter motor assembly. Because of this major setback a heavy business loss was accounted in the Gear reduction starter segment, an emerging technology in market replacing all direct drive starters. Hence to retain the business condition & to maintain consistent quality levels there is a need to find & eliminate all possible root causes of this water ingress failure.

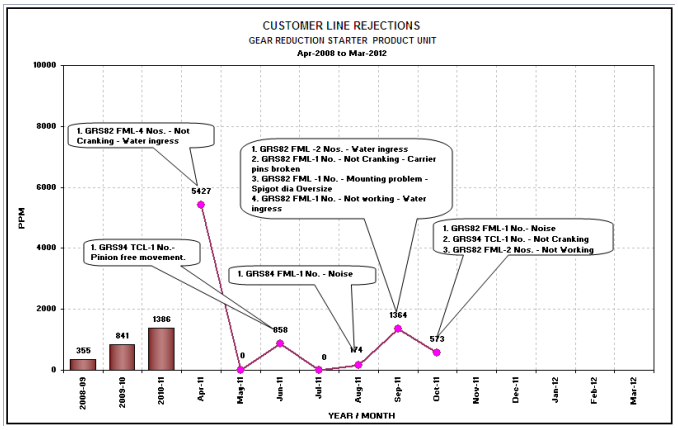

Fig. 1.2 Customer line rejection trend

II. PROBLEM ANALYSIS

The probable reasons for the water ingress in Gear reduction starters were listed & also grouped as into categories. It was decided to not to concern with the environment as there are no contributions identified.

Man

The human (manual operation) errors that can lead to water ingress on the GRS during the assembly operations are listed as follows,
Missing of operations,
Missing of Rubber seal A (2 off) on CE bracket
Missing of Rubber seal B (2 off) on Yoke assembly
Missing of Rubber seal C (1 off) on Inter bracket assembly & Missing of O-ring (1 off) on Solenoid assembly to Fixing bracket assembly.

Methods

The error that can lead to water ingress on the GRS, by the way of process design are listed as follows,
Insufficient BG screw tightening torque
Insufficient Through bolt tightening torque
Insufficient Solenoid fixing screw tightening torque.
Inconsistent Sealant application & curing process.

Materials

The following deviations in the incoming materials can lead to water ingress on the GRS,
Bottom face flatness of BG screw
CE bracket flatness on BG screw seating area
Rubber seal A, B, C material, diameter & total length
Thread details of BG screw to BG ring
Spigot face flatness on CE bracket
Flatness on butting face of CE bracket to Yoke spigot face
CE bracket to Yoke butting face with rubber seal A land
Yoke top face flatness
Alignment of through bolt to inter bracket tap hole.

Flatness of inter bracket to yoke butting face.
Yoke groove detail on inter bracket area.
Inter bracket to fixing bracket mating face flatness
Pole piece thread details & thread seal on pole screw
Solenoid switch assy to fixing bracket assy, O-ring seating diameter & O-ring material.
Material of sealant applied on joining portions
As per the present practice if the above errors are observed on any of the incoming part, then it would have get rejected on the Incoming inspection bythe supplier quality engineer itself.

Machine / Measurement

The absence of test rig at the end of production line to ensure that the GRS built is made water tight arrangement could be a major cause for failure. Since with its presence the customer failure could have been averted & also the measurement of leakage will provide the scope of improvements in the product design aspects.

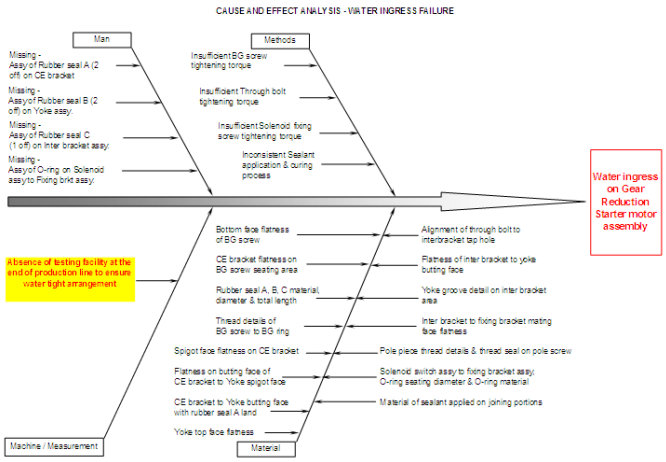

Fig. 2.1 Cause and effect analysis

2.1 Process Failure Mode and Effect Analysis:

The potential effects of each failure mode are not the same. Since there are many kinds of effects for each failure mode and some are very severe & some are not that severe. It is important to know the potential effects of each failure mode to assess the risk involved.

(Ref. Annexure 2.2 PFMEA, issue: 02 dt. 28.01.2014)

III. COUNTERMEASURES

3.1 Air leak testing:

Based on the PFMEA reviewed by the CFT & as observed in the cause & effect analysis, it is made clearly that a 100 % (should be tested for all starters) testing facility is required to ensure the sealed version of starter configuration. It is impossible to conduct a water spray test for each & every starter assembled in line. Moreover by doing so the product it self will be degraded at the manufacturing site.Hence it is planned to have an Air Leak testing facility as the end of line testing for these starters.

Air leak detectors are used to test the air-tightness of parts on production lines. They are specially adapted for automatic and semiautomatic workbenches. The method used is based on the measurement of a small variation or drop in differential pressure between the test and reference parts, when both are filled to an identical pressure.

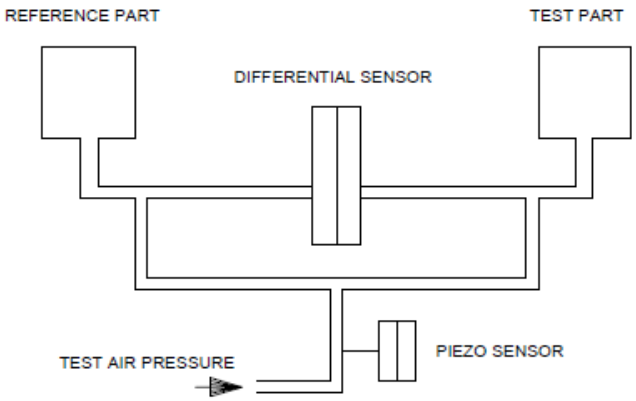

Figure 3.1 Concept of air leak testing

3.2. SEALED COMPONENT MEASUREMENT

This test is for hermetically sealed parts, which can not be filled. They are placed inside a bell which is pressurized. The first and the third measurements may be carried out in comparison with a reference.Methods available are test with reference, without reference or in central zero.

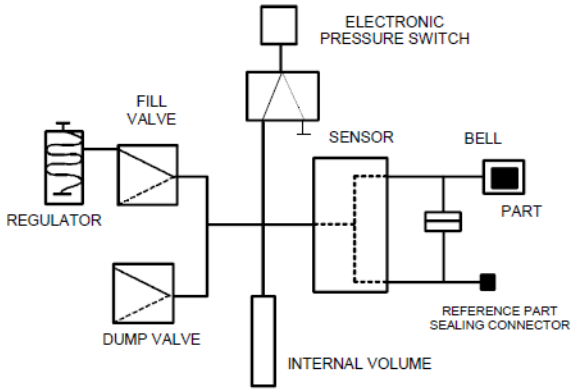

Figure 3.2 Sealed component measurement

Test with reference

Measurement of a pressure variation between a test part and a reference part is carried over. The ideal measurement conditions are: part and reference part identical and identical connections to both parts (identical lengths, diameters, and type of pipes). A measurement taken with a reference part saves time because the pressure equalization is more rapid. It is valid for parts which cannot be deformed and which mimic thermal and mechanical effects.

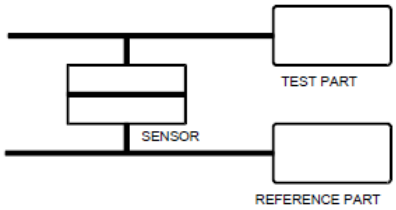

Figure 3.3 Test with reference

IV. CONCLUSION

The failure modes & their causes that lead to the water ingress in the Gear Reduction Starters are analyzed. It was observed that requirement of testing equipment at the end of production line to certify that the starters meet the sealed version configuration is mandatory. Since the part needs to be tested in fully assembled condition it is decided to proceed with the air leak testing under sealed component measurement under test with reference. Test rig was manufactured &trials were conducted to arrive on the test specifications using process window. Established run at rate & yield rate for the test rig. Arrived on product design changes for further scrutinizing of test specification.

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