Experimental and Stress Concentration Reduction of Starter Motor Housing Bracket

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Abstract - *Drive end lodging break is the most regular and serious failure method of a car starter in administration. So as to get an adequate information about nature of this failure and make improvement, the drive end lodging of decrease type starter was set for instance to explore. The round corner span r affects anxiety level of drive end lodging of a car starter. Hostile to crack structure improvement which for the most part incorporates improving the round corner range r as extensive as conceivable inside limits was directed. Industry rehearses show that an incredible advancement has been made, appropriate item deals return proportion because of drive end lodging break has decreases some degree. Static structural analysis will be done ANSYS workbench. An existing model will be reverse engineered for testing and analysis purpose. Strain gages will be used and whole setup will be mounted on UTM for application of single loading cycle. Measured strains will be validated with FEA strains. Result and conclusions will be drawn and suitable future scope will be suggested.*

Key Words: **FEA, UTM, Starter motor**

1. INTRODUCTION

In the coming years, the requirement for electrical vitality in a vehicle will ascend at an ever-quicker face. The expanding request for electrical vitality frameworks from the enormous sum of electrical hardware which has become an indispensable part of each current vehicle. The principle capacity of car beginning framework is to flexibly wrenching torque to the driving rod of inward burning motor until a reasonable RPM is accomplished. The wrenching torque gave by the starter engine is a direct or quadratic capacity of the current moving through the starter engine winding by means of starter solenoid. In the vast majority of the starter engine structure a draw in solenoid is utilized for connecting with the pinion to the ring gear of the fly wheel. The draw in solenoid is appropriate for low armature travel and high draw in power. When the pinion is drawn in with the fly wheel the all-out collected voltage is applied to the electric starter engine. The starter engine must be prepared consistently to wrench the motor, and during its course of life should effectively finish thousands of beginning activities. The DC arrangement wound starter engine has four electromagnetic field curls wound around four post shoes and four brushes contact the engine commutator. Starter failure sources are either mechanical or then again electrical. Wear, seizure or cracks of moving parts go under mechanical wellsprings of failures, short or hindered circuit and contact opposition expands go under the electrical wellspring of failures. The basic electrical issues of beginning framework are battery issue, brush flaw, armature issue, cut off, open circuit and solenoid contact opposition fault. The low voltage in car applications requires carbon brushes with low contact opposition, which is especially important for starter engines, which convey top current densities of 1000A/cm^2. Because of expanded contact opposition at the solenoid contact focuses and brush commutator focuses, the current drawn by beginning framework with brush deficiency is not exactly the current drawn by the beginning framework in ordinary or solid condition. In this condition the motor will set aside long turning effort for beginning.

2. LITERATURE REVIEW

Rameshwar Kendre et al. [1] In this paper it presents to perform arbitrary vibration investigation for starter engine mounted on a motor and furthermore discover its transmissibility esteem. FEA and exploratory outcomes are plotted on log-log scale utilizing MATLAB 7.7.0. FEA result shows the most extreme transmissibility when framework arrives at its first basic method of frequency at 328 Hz. While, the tops in experimental result are acquired in the wake of achieving about 250 to 450 Hz which implies framework is arriving at its first essential mode between this scope of frequency. SM will not damage until it comes to the estimation of second basic method of vibration which is at 1057 Hz. It is a long way past the scope of frequency for arbitrary vibration testing which is 500 Hz. The transmissibility of starter engine along vertical bearing is seen as 1.2490. Augmentation in transmissibility is seen when framework begins arriving at its characteristic frequency because of impact of reverberation. This examination gives the procedure to comprehend the vitality ingested and transmitted vertical way by giving a contribution to terms of PSD esteem.
M.Z. Ahmad et al. [2] in this paper it presents the effect of rotor post number on the qualities of external rotor crossover excitation transition exchanging engine

(ORHEFSM) for in-wheel drive electric vehicle (EV) applications. Lately, examines on in-wheel engine for EV drivetrain framework become increasingly mainstream because of their few focal points of autonomous wheel controllability and higher proficiency. At first, the curl course of action tests is inspected to affirm the working rule and extremity of each armature curl period of the proposed engine. Moreover, the profile of motion linkage, prompted voltage, cogging torque and torque qualities at different field excitation current thickness conditions are broke down dependent on 2D-limited component investigation (FEA). The results acquired show that the suitable mix of stator opening rotor post setups are 12S-10P which at first give most noteworthy torque and force thickness. In light of 2-D FEA and by taking a few factors on engine plan, the engine with 12S-10P demonstrates a decent chance to accomplish the objective exhibitions and is chosen to be additionally improved in future.

Zhuoran Zhang et al. [3] This paper deliberately explains the need of the brushless advancement for the LVDC framework. The similar investigations between the brushless Starter Generator (SG) framework with the doubly notable SG framework as the agent and the brushed SG framework are led as far as the framework design and weight, practicality and activity execution. Joined by the chances of the brushless advancement for the airplane LVDC SG, so have the issues and difficulties of further turn of events and use of the brushless LVDC SG risen. These difficulties and comparing key innovations are investigated and the turn of events propensity is explained. A coordinated topology with another brushless machine is proposed and the supporting advances of the brushless transformation are the powerful thickness brushless machine topologies, the warmth opposing and high-solid force hardware, the joining of the machine and its PCU, and the comparing control techniques, the warm administration of the incorporated SG framework.

V. M. Murugesan et al. [4], In this paper it introduces an exploratory investigation of straightforward geometries speaking to the electrical contact in car connectors when current goes through them. The beginning framework comprises of two separate circuits, high amperage circuit (150A - 350A) and low amperage circuit (< 20A). Because of expanded contact obstruction the starter engine may not produce adequate torque and prompts over-loading of battery because of progressive endeavors. This exploration work researched the contact obstruction offered by the new solenoid contact geometry. This new contact geometry is discovered valuable in giving decreased contact opposition when contrasted and existing framework. From the FEA investigation, it is seen that high contact of the starter engine terminal prompts high current thickness (current drawing from the battery) which expands the beginning torque of the car starter engine. Thus, the current drawn from the battery will be guaranteed in first endeavor and maintains a strategic distance from delayed turning and further endeavors of wrenching consequently over-loading of battery is decreased and administration life of battery what's more, administration life of solenoid contact is additionally improved consequently improved starter dependability.

T. Rolvag et. al [5] In this article it presents a multidiscipline dynamic imitation apparatus for fatigue testing. A non-straight limited component plan installing control framework displaying is expanded to incorporate fatigue examination dependent on a scientific portrayal of virtual fragile veneer and strain rosettes. The outcomes anticipate the most basic failure modes during hustling applications just as the life regarding drag laps before failure. The AISI 8620 wrench base material is delicate to the carburizing profundity. A carburizing profundity somewhere in the range of 0.25 and 1 mm, gives a fatigue life expectation among 89 and vast drag laps. Nonetheless, the welds don't profit on the top-notch base material and the anticipated fatigue life is somewhere in the range of 5 and 50 drag laps contingent upon the carburizing treatment. The FTB has demonstrated to be a hearty, precise and proficient instrument for dynamic recreation. The additional weak veneer method, rosette models, quick strain counts and rain flow investigation give a proficient computerized system to exhaustion expectation of race motors. These devices can be utilized in high cycle fatigue forecast and to broaden the strength of future race motors.

3. PROBLEM STATEMENT

In present situation because of high operational expense and durability life existing starter engine lodging section quality and weight has been a worry issue. The reason might be stress concentration at edges so to reduce the effect fillet are to be studied. In this way, it becomes vital need of starter motor housing streamlining.

4. OBJECTIVES

- Modelling of drive end housing of an automotive starter in CATIA V5 software.
- Analyzing for stresses and deformation in drive end housing of an automotive starter using ANSYS software.
- Effect of round corner radius alteration will be investigated using static analysis to study the effect of stress concentration.
- To manufacturing of optimized drive end housing using conventional machining process.
- To perform experimental testing of existing and optimized model of drive end housing using UTM.
- Validation of experimental testing and numerical results.

5. METHODOLOGY

Step 1:- Initially research paper are studied to find out research gap for project then necessary parameters are studied in detail. After going through these papers, we learnt about stress reduction of starter motor.

Step2:- Research gap is studied to understand new objectives for project.

Step 3: - After deciding the components, the 3 D Model and drafting will be done with the help of software.

Step 4: - The components will be manufactured and then Experimental testing too be performed using UTM.

Step 5: -Validation of experimental results and FEA results.

6. DESIGN

6.1 CATIA Model

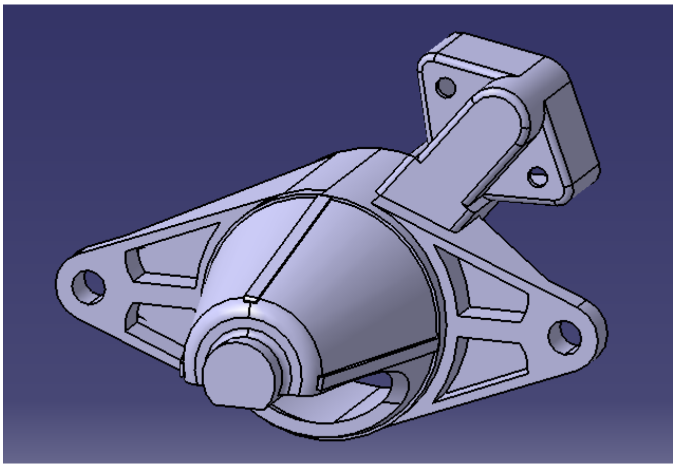


Fig.1. CATIA model of starter motor

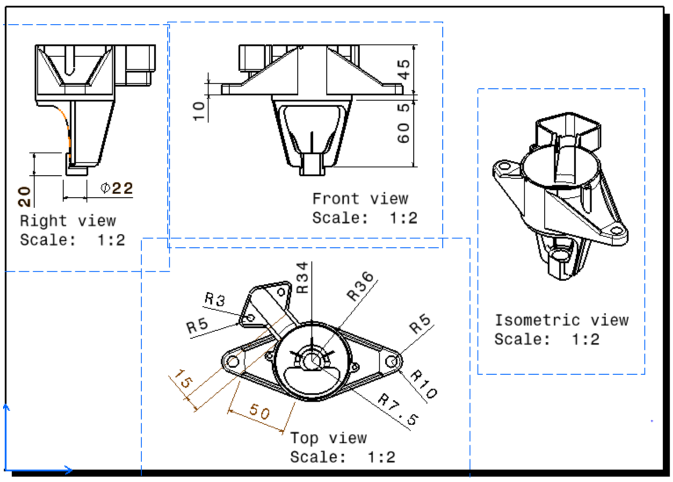


Fig.2. Drafting of starter motor

Properties of Outline Row 4: Aluminum Alloy NL

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	2770	kg m^-3
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and Poisson's R...	
6	Young's Modulus	7.1E+10	Pa
7	Poisson's Ratio	0.33	
8	Bulk Modulus	6.9608E+10	Pa
9	Shear Modulus	2.6692E+10	Pa
10	Bilinear Isotropic Hardening		
11	Yield Strength	2.8E+08	Pa
12	Tangent Modulus	5E+08	Pa

Table.1. Material Properties

6.2 Finite Element Analysis

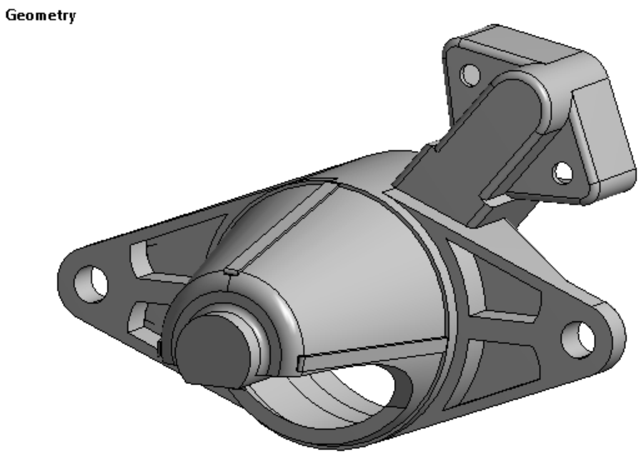
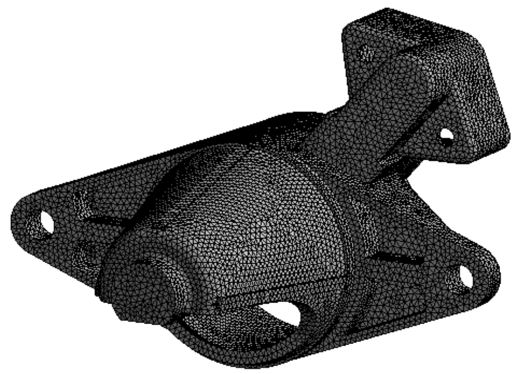


Fig.3. CATIA model imported in ANSYS

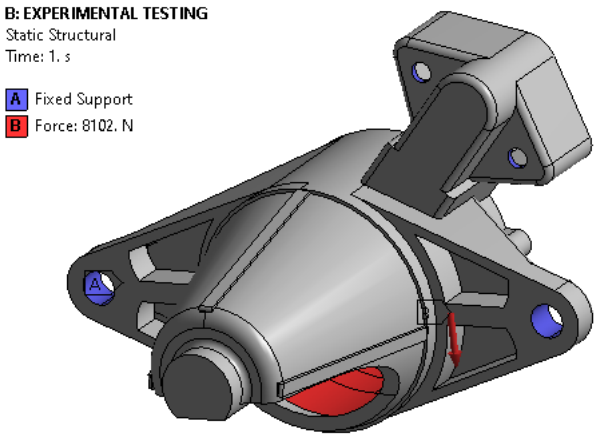
6.3 Mesh

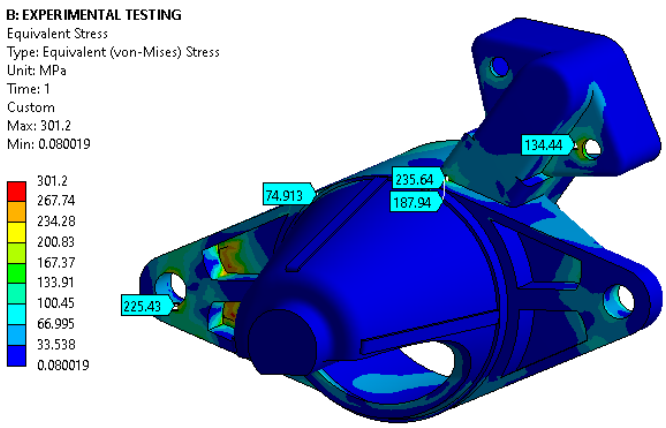
In ANSYS meshing is performed as similar to discretization process in FEA procedure in which it breaks whole components in small elements and nodes. So, in analysis boundary condition equation are solved at this elements and nodes. ANSYS Meshing is a general-purpose, intelligent, automated high-performance product. It produces the most appropriate mesh for accurate, efficient Multiphysics solutions. A mesh well suited for a specific analysis can be generated with a single mouse click for all parts in a model.



Statistics	
Nodes	217347
Elements	134370

Fig.4. Details of meshing of starter motor





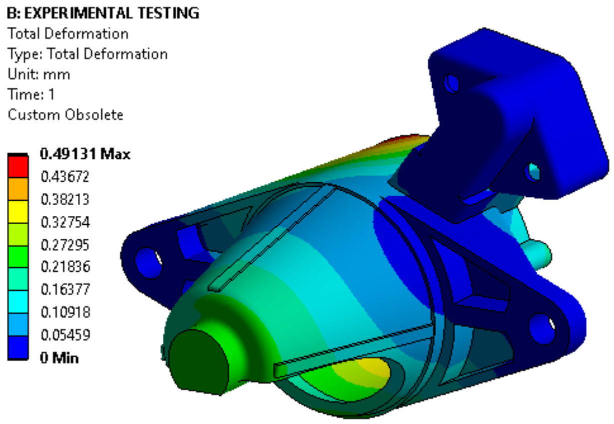


Fig.5. Boundary condition

Boundary condition are applied as per calculation:

- Lock torque (T): 30 Nm
- Pinion pitch circle diameter (d): 20 mm
- Pressure angle (ϕ): 20 deg
- Static safe factor (SF): 2.5
- Bearing load calculation Tangential load
- $F_t = 2*SF* T/d$
- $= 2*2.5*30/20 = 7500$ N
- Radial load $F_r = F_t * \tan(\phi) = 7500 * \tan(20)$
- $= 2729$ N
- Pinion load F = Square root of $(F_r + F_t) = 7981$ N
- Static equilibrium equation: $R_s + R_h = F = 7500$ N
- Moment equilibrium equation: $R_s \times 0 + R_h \times 46 = F \times (46 + 57) = 17870.5$ N (Positive)
- From the static equilibrium equations
- $R_s + R_h = F = 7500$
- $R_s = 9889.5$ N (Negative)

6.4 OPTIMIZED DESIGN

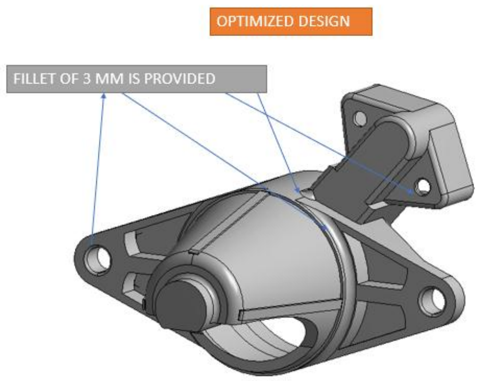


Fig.6. Optimized design for starter motor

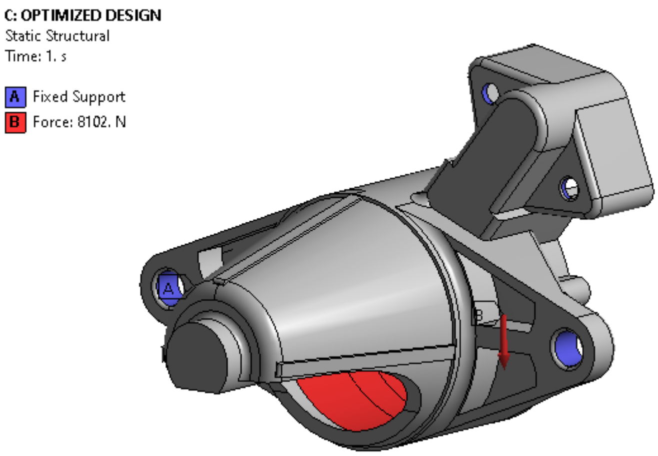


Fig.7. Boundary condition

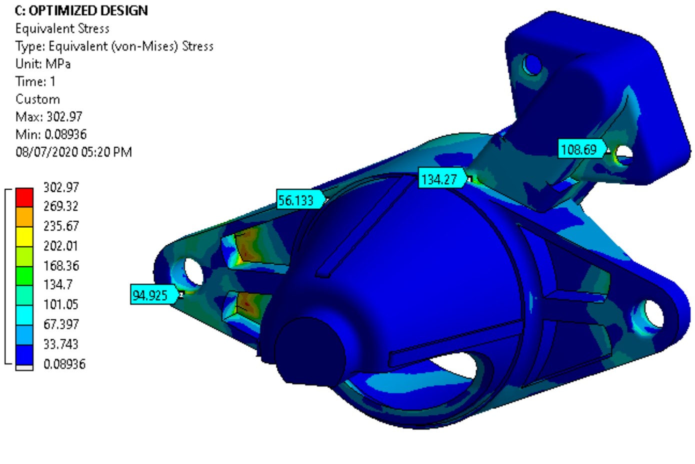


Fig.8. Equivalent stress of optimized starter motor

It is observed from existing design that stress value for optimized design have reduced with application of fillet radius across stress concentrated region.

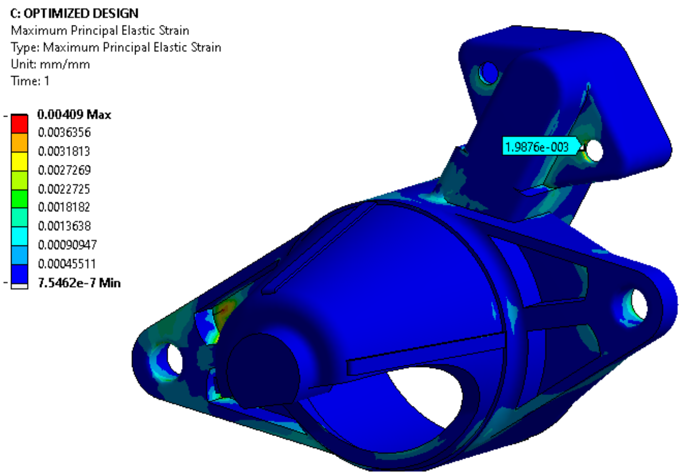


Fig.9. Maximum principal elastic strain for optimized design

Strain is observed around 1987 microns under existing boundary condition.

7. EXPERIMENTAL TEST

A Universal Testing Machine (UTM) is used to test both the tensile and compressive strength of materials. Universal Testing Machines are named as such because they can perform many different varieties of tests on an equally diverse range of materials, components, and structures.

Universal Testing Machines can accommodate many kinds of materials, ranging from hard samples, such as metals and concrete, to flexible samples, such as rubber and textiles. This diversity makes the Universal Testing Machine equally applicable to virtually any manufacturing industry.

The UTM is a versatile and valuable piece of testing equipment that can evaluate materials properties such as tensile strength, elasticity, compression, yield strength, elastic and plastic deformation, bend compression, and strain hardening. Different models of Universal Testing Machines have different load capacities, some as low as 5kN and others as high as 2,000kN.

7.1 Specification of UTM

1	Max Capacity	400KN
2	Measuring range	0-400KN
3	Least Count	0.04KN
4	Clearance for Tensile Test	50-700 mm
5	Clearance for Compression Test	0- 700 mm
6	Clearance Between column	500 mm
7	Ram stroke	200 mm
8	Power supply	3 Phase, 440Volts, 50 cycle. A.C
9	Overall dimension of machine (L*W*H)	2100*800*2060
10	Weight	2300Kg

- Fixture is manufactured according to component designed.
- Single force is applied as per FEA analysis and reanalysis is performed to determine strain by numerical and experimental testing.
- Strain guage is applied as per FEA results to maximum strained region and during experimental testing force is applied as per numerical analysis to check the strain obtained by numerical and experimental results.
- During strain gage experiment two wires connected to strain gage is connected to micro controller through the data acquisition system and DAQ is connected to laptop. Strain gage values are displayed on laptop using DEWESOFT software.

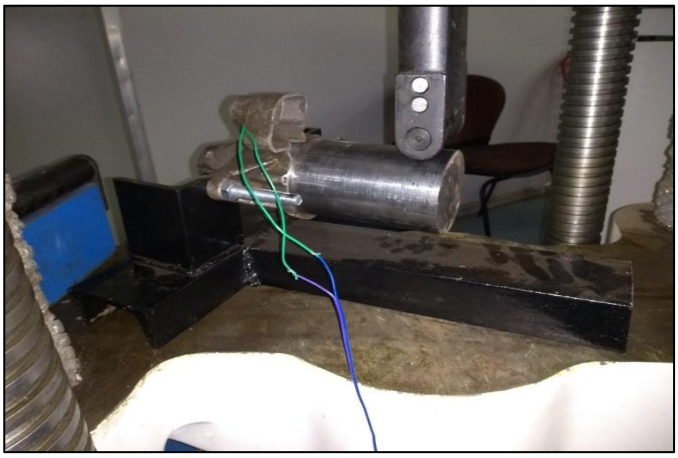


Fig.10. Experimental Setup and Results

8. CONCLUSION

In present research starter motor bracket radius have been varied to reduce the stress concentration at edge. It is observed that providing round corner radius of 2mm and 3mm stress have been reduced.

Strain obtained by FEA and experimental testing are nearly identical.

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