Analysis Of Steerting Wheel Armature For Static Loading

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***Abstract* - The main objective of this project is to analyse and modify the present import steering wheel Armature to meet Regulatory Standards. In order to reduce the cost of Steering wheel Armature, localization of part production and to find an alternative raw material initiative was taken up. The Material Selection Process of finding an alternative Raw Material and its behaviour to the existing design is to analysed. In order to carry out the finite element analysis, 3D model is created by using Catia V6 cad software. Meshing and Boundary conditions are set using Hypermesh. The solver used is LS Dyna. In this project we are focusing only on Static loading condition as it plays a vital in Product Validation. During the Static Loading analysis of steering wheel armature for the Selected alternative Raw material and with the existing design, the Armature is unable to meet to the safety regulations as defined in the standards(JASO C-713,refer appendix-1). Modifications is done for the existing Steering wheel Armature by increasing the width of the spoke to rim joining section as it the most loading baring section of armature in order to make the newly selected Raw material meet the tests . And the modifications done to improve the stiffness have to be within the customer defined Mass Moment of Inertia. After the design modifications, the armature is now meeting the regulations, it is to be validated experimentally through axial stiffness test, no cracks under a displacement of 50mm. The is validated for static and found OK.**

***keywords* - Material Selelction, Steering wheel armature, Static tests, deisng modification, Catia**

I. INTRODUCTION

A steering wheel (additionally called a driving wheel or a hand wheel) is a sort of guiding control in vehicles. Directing wheels are utilized in most current land vehicles, including all large scale manufacturing autos, just as transports, light and overwhelming trucks, and tractors. The controlling wheel is the piece of the directing framework that is controlled by the driver; the remainder of the guiding framework reacts to such driver inputs. This can be through direct mechanical contact as in recycling ball or rack and pinion guiding riggings, without or with the help of pressure driven power directing, HPS, or as in some cutting edge creation vehicles with the help of PC controlled engines, known as Electric Power Steering.

An armature of a steering wheel that can be used for various steering wheels by changing a position of a spoke when assembling with a hub and a rim. An exemplary embodiment provides an armature of a steering wheel, including a rim; a hub disposed in a middle portion of the rim; and at least one spoke having one end portion combined with the hub and the other end portion combined with the rim, wherein, when the spoke is combined with the rim and the hub, the number and the location of the spoke can be changed

Steering wheel armature is the load bearing member of the steering wheel, its design determines the behaviour of steering wheel in real world conditions. Steering wheels has a set safety regulations that has to be been before the design is considered safe for mass productions. In this Project we will be looking into localization of steering wheel armature by changing the raw material used for moulding and design modifications to meet the safety standards for static loading conditions.

The steering wheel armature constituents of:

- Spokes
- Rim
- Hub
- Base plate

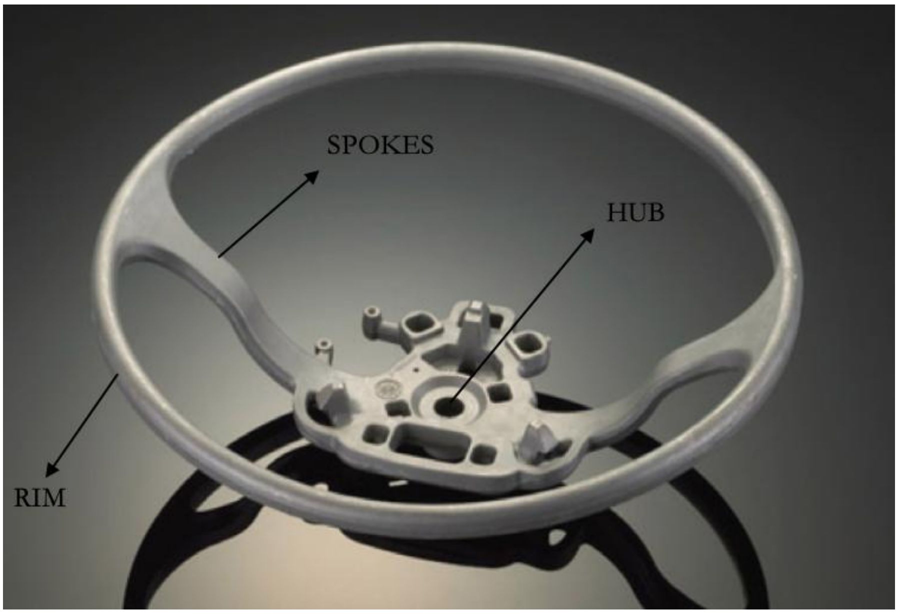

Fig 1: Steering wheel Armature

Steering wheel armature Types

Here are three types of steering wheel armature are used in passenger vehicles like car, tractor and light trucks are

- Two spoke steering wheel armature
- Three Spoke steering wheel armature
- Four Spoke steering wheel armature

Design Thoughts in Steering Wheel armature

For static loading analysis of steering wheel armature, most of the load is subjected in the sections where the spokes and rim meet in the armature. In static loading condition the hub is fixed at a given length which is defined by the customer or vehicle mounting condition and load is applied applied at 12:00 clock and 3:00 clock regions of the armature. The obtained graph of Force Vs Displacement to see the behaviour of the armature.

II. LITERATURE REVIEW

The subsequent literature survey gives a preview and glimpse of the work related to design and modelling, finite element analysis of steering arm of tractor using in the steering system of various kinds of automobile vehicle considered by the authors/researches for investigating of stress, displacement and fatigue life estimation under different materials.

Modeling of an Advanced Steering Wheel and Column Assembly for Frontal and Side Impact Simulations(Jan-2014)- Eric Beckhold [1]: This paper presents the last period of an investigation to build up the demonstrating procedure for a propelled controlling gathering with a security improved guiding haggle versatile vitality engrossing directing section. For traveler vehicles worked before the 1960s, the guiding segment was intended to control vehicle heading with a straightforward unbending pole. In extreme frontal crashes, this sort of configuration would frequently be dislodged rearward toward the driver because of front-end smash of the vehicle. Thus, collapsible, separable, and other vitality retaining controlling sections rose to address this sort of kinematics. These wellbeing upgraded controlling segments permit frontal effect vitality to be consumed by crumbling or breaking the directing sections, accordingly decreasing the potential for rearward segment development in extreme accidents. As of late, further developed directing segment plans have been built up that can adjust to various accident conditions including crash seriousness, tenant mass/size, seat position, and safety belt use. These propelled guiding segments consolidate versatile highlights, precisely or pyrotechnically actuated, to include adaptability in retaining sway vitality of various levels. Notwithstanding following security guidelines for controlling segments (e.g., FMVSS 203 and 204), these propelled directing section structures can deal with various burden conditions.

Using quality mapping to predict spatial variation in local properties and component performance in Mg alloy thin-walled high-pressure die casting(2011). [2]: This paper investigates the utilization of value mapping for the expectation of the spatial variety in nearby properties of the magnesium compound AM60. The work examines the job of throwing boundaries on neighborhood pliability and yield quality and presents a model for anticipating nearby flexibility and yield quality in a cast part. A structure of examination (DOE) was made to inspect the job of different throwing boundaries on neighborhood properties, for example, pliability and yield quality. More than 1,200 elastic examples were extracted from cast parts and tried. Throwing reenactments were likewise directed for each test condition. Neighborhood properties were anticipated, and the nearby property (quality guide) model was contrasted and a model creation segment. The aftereffects of this model were utilized as contribution to a presentation reenactment programming code to recreate the segment level conduct under two diverse stacking conditions. In this examination, the creators avoided the conventional Integrated Computational Materials Engineering approach for a semi-experimental quality mapping way to deal with give assessments of assembling delicate neighborhood properties for use in procedure and segment structure.

Harrison, D. Torsion Pendulum Experiment Published October 2002 [3]: This document introduces the Torsion Pendulum experiment from the Physics laboratory at the University of Toronto. It is intended to be used before you begin the experiment. The Preparatory Questions at the end of this document should be answered and turned in to your Demonstrator before you begin to work on the experiment. In the above picture, we see two instances of Simple Harmonic Motion. On the left a mass swinging from a spring is swaying vertically; we call its vertical dislodging from its harmony position y. On the privilege an empty chamber dangling from a wire is wavering in the level plane; we call its precise uprooting from its harmony position . As the slider in the middle shows, in spite of the fact that the frameworks are very unique their removals as an element of time are indistinguishable.

William Altenhof, and Saverio Paonessa(Department of Mechanical, Automotive, and Materials Engineering) 1992 [4]: Numerical diversion of the starter framework has also been composed by LS DYNA. Steering wheel armature limited part models (utilizing both Mg & Al alloys) have been made and replicated under relative conditions which were driven most likely. Appraisals between tests at 6 indisputable effect conditions with impacts between the Steering wheel armature and an inflexible plate are demonstrated at this moment. Too, appraisal of the limited portion model is considered by researching changes in the fragment organizing related with the armature. The test and numerical perceptions show that the reasonable furthest reaches of the aluminum material model are perfect made over the magnesium material model. Additionally, choice of the limited portion plan from a general perspective effects the numerical outcomes.

1997 in K.S. Centoco Ltd., related to the College of Windsor, built up a testing machine for impact stacking on coordinating wheels. Planning Wheel Armature. The controlling wheel armature is the skeleton of the organizing wheel. It strengthens all bits of the controlling wheel (airbag, driver controls, and so forth.) and is the most essential partner segment of the overseeing wheel.

The segment edge tends to the specific development from a level reference line to inside line of the controlling bit. A coordinating wrangle bodyfonn which are utilized to portray the fragment edge. In assessing the region point, positive attributes are taken from a clockwise viewpoint from the level reference line. Also, a zero degree parcel point addresses inside line of the organizing area according to the level reference line..

Investigating the Relation Between the Period and the Mass Moment of Inertia by Determining the Torsion Constant of A Wire By: Charisse De Castro [5]: The depictions of idleness "I" and the period for ocillation influencing T of four particular things were assessed and decided. Using straight association among "T2" and "I", a graph of "T2" versus "I" was drawn to choose the inclination, which is comparing to the torsion steady of a given wire.

Using the weight and estimations of the things, the inertia (I) were resolved with the conditions in Figure 1 for the four models. The ordinary time for twenty movements (20T) of everything in excess of five starters was dictated by including the events and parceling the entire by five. The contraption used to check the items\' time of influencing.

Society of Automotive Engineers, Steering Control System - Passenger Car - Laboratory Test Procedure - SAE J944, 1992 SAE Handbook, Volume 4, Warrendale, PA., U.S.A., (1992), pp. 34.230-34.232 [6]: For the motivations behind this suggested practice, the controlling control framework is characterized as that segment of the vehicle directing system that may influence the tenant effect qualities. Any test gear is good which can create the ideal body obstruct to-guiding control framework sway speed and which protects that the body square is moving corresponding to the vehicle flat reference, with translational (not rotational) movement, in side view at sway. The heading of effect speed, in the arrangement see, is corresponding to the longitudinal vehicle pivot. The controlling control framework will be mounted in the real vehicle.

Jones, N., Structural Impact, Cambridge University Press, Cambridge, United Kingdom, (1991) [7]: This article examines the dynamic plastic insecurity of different fundamental basic individuals, exposed to enormous pivotal effect loads, which is pertinent to the fields of basic effect and auxiliary crashworthiness. Specifically, concentrates on the dynamic pivotal reaction of admired versatile plastic models, bars, round and hollow shells and square cylinders, is talked about in some detail. The examinations for a portion of the bars, shells and cylinders hold the concurrent impact of versatile and plastic pressure waves (hub inactivity) and the auxiliary reaction (parallel idleness). The expectations uncover the significant impact of pressure wave engendering wonders which clarify the qualities of a large number of the trial results acquired in labs throughout the years. These progressively complete examinations are fundamental for the higher speed sway situations experienced progressively in structures and for contrasting appropriately the overall benefits of various flexible materials in potential vitality retaining frameworks.

Material selection by Michael F Ashby, Department of Cambridge university, England-1991 [8]: An Ashby plot, named for Michael Ashby of Cambridge University, is a disperse plot which appears at any rate two properties of various materials or classes of materials. These plots are important to investigate the extent between different properties. For the instance of the firm/light part inspected above would have Young's modulus on one center point and thickness on the diverse center, with one data point on the chart for each contender material. On such a plot, it is definitely not hard to find not simply the material with the most significant solidness. Plot of Young's modulus versus thickness with log-log scaling. The tints address gatherings of materials. The chief plot on the right shows thickness and Young's modulus, in an immediate scale. The ensuing plot shows comparable materials attributes in a log-log scale. Materials families (polymers, froths, metals, etc.) are perceived by tints.

Literature Summary

A testing, mounting conditions along with the column angle has been stressed in the above mentioned literatures. It is also evident that aluminum alloy is good alternative for magnesium alloy as stated in the first literature. Mg is almost similar to Al in terms of mechanical property. The same can also be evidenced in ashby's chart. Mass moment of inertia can also be calculated to ensure that the modifications done is within the customer specified requirement..

III. PROBLEM DESCRIPTION

In the present car industry, all enterprises are concentrating on creating cars which are light weight, eco-friendly, fit in with a degree of wellbeing sketched out by government guidelines, and are accessible to the customer at a sensible expense. The car business has set a lot of time and research financing into creating vehicles which can meet these prerequisites. Localization of steering wheel armature is a major leap for company. The current design of steering wheel is made of Magnesium, the availability of Magnesium is not so much as compared to China. Aluminum is an element which India is Exporting to other countries as it is most available in this country. We narrowed down to Aluminum alloy as an alternative to Magnesium Alloy, explanation will be given as we proceed on with this project. Every steering wheel armature has to meet the Standard's specification or requirement in-order to be safe design wise. Below shared are the SBR-1 and SBR-2 behavior of existing armature which is currently being used in parts imported from China with Magnesium alloy along with proposed RM

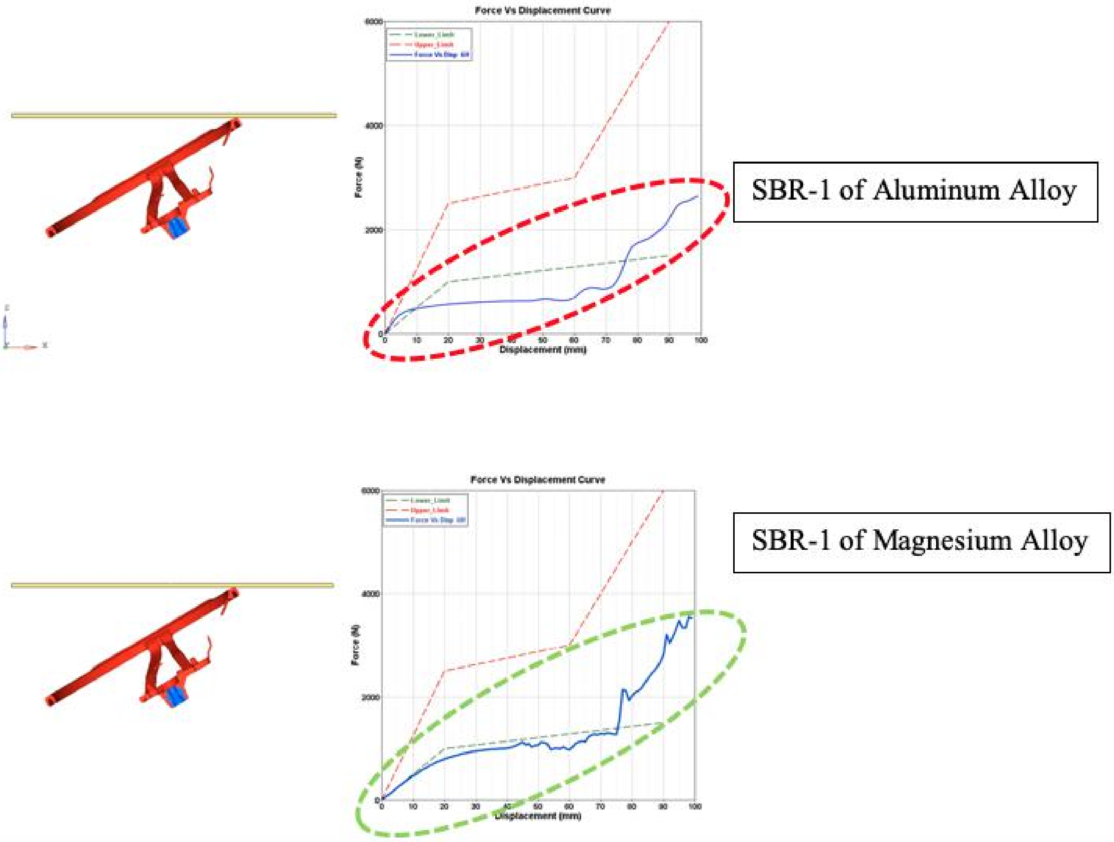

Fig 2: Comparison of SBR-1 between new RM and old RM

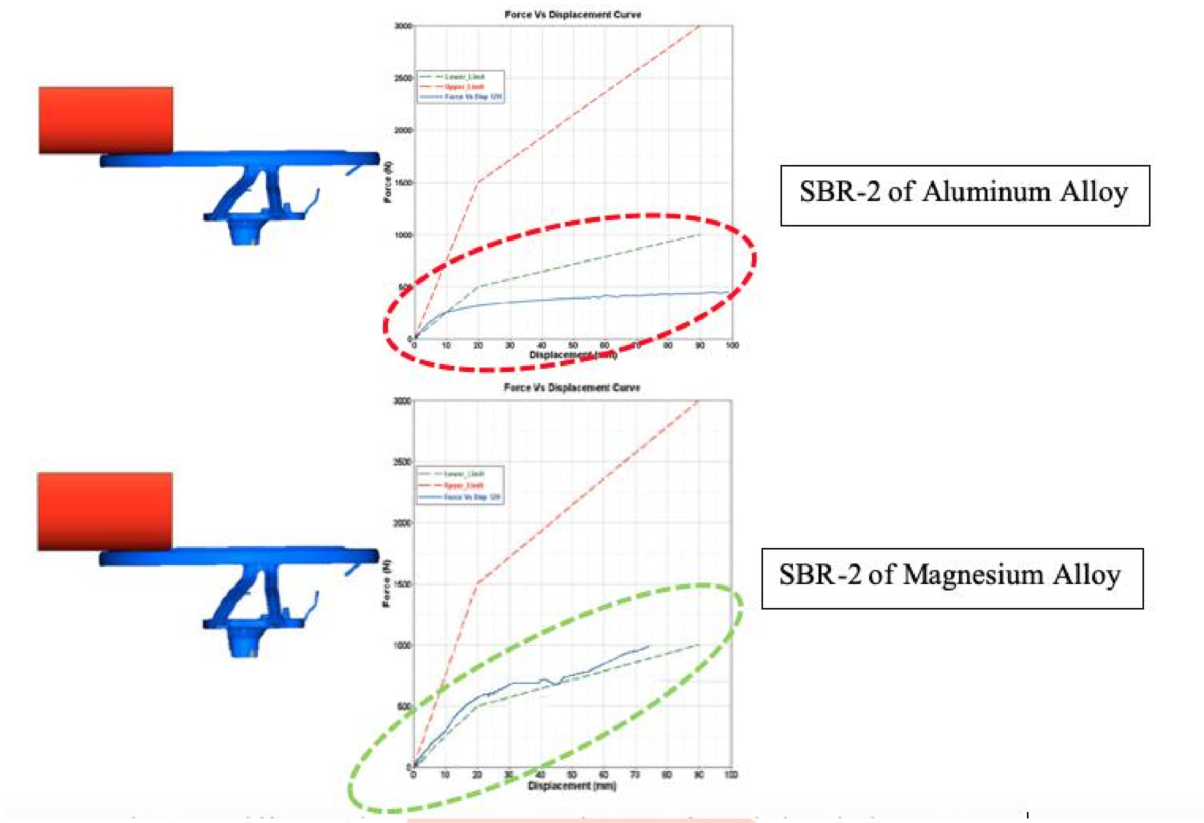

Fig 3: Comparison of SBR-2 between new RM and old RM

Objective:

- Design modification to meet the Government safety requirement:-
  - There are few safety regulations have to been before the armature is considered as being safe for regular production. Since ther is change in raw material there will be need to modify the existing design to meet those regulations
- Cost reduction
  - Cost reduction will automatically be achieved due to the localization activity and also due to the fact that there is change in raw material.
- To meet the customer specified Mass moment of inertia.
  - Mass moment of inertia is the customer required parameter, we must ensure that the modifications done to the steering wheel armature not excess the spec given by them.

IV. METHODOLOGY

This find out about has been observed steering Arm parts. First part of this learn about includes modelling of direction-finding prominences component and exploration of stresses beneath authentic load environments. CAD simulations of lower deck knob remained developed in 3D modelling by CATIA V5. While the second phase is of the models had been then bought and compared the usage of finite issue evaluation (FEA) by way of ANSYS workbench15.0 Simulation software. Approach of this study is shown in Fig4.1.

Design a CAD Modelling

The layout procedure were began by means of preliminary learn about on the modern-day direction-finding lump arm module used for the preceding race vehicle such as inspecting the obtainable steering Arm graph of formulation SAE. The plan also desires to comply with the standards and regulations drawn by way of Massey Ferguson, which the size should be broadly.

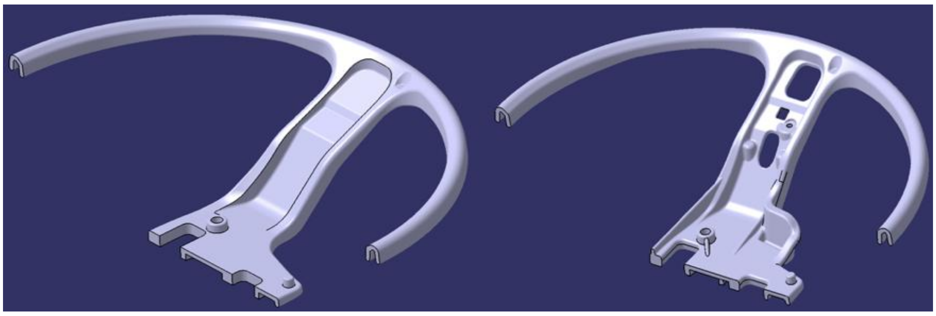

Fig 4: Modelling of armature

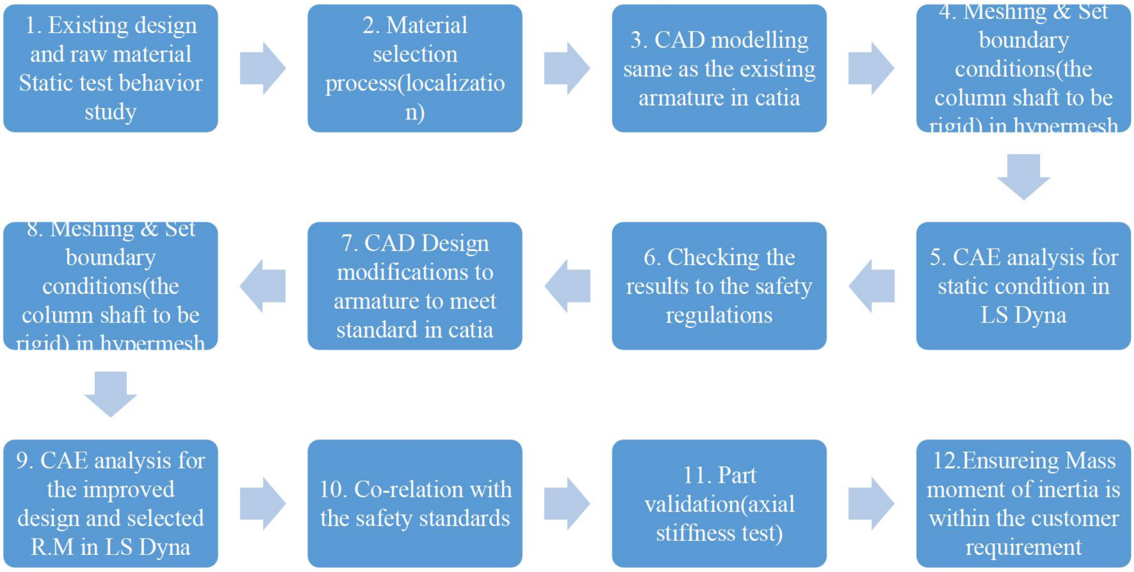

Fig 5: Design Methodology Process Flowchart

V. MATERIAL SELECTION

Using an "Ashby graph" is a typical technique for picking the fitting material. Initial, three distinct arrangements of factors are distinguished:

- ➢Material factors are the intrinsic properties of a material, for example, thickness, modulus, yield pressure, and numerous others.
- ➢Free factors are amounts that can change during the stacking cycle, for instance, applied power.
- ➢Design factors are limits forced on the structure, for example, how thick the bar can be or the amount it can avoid

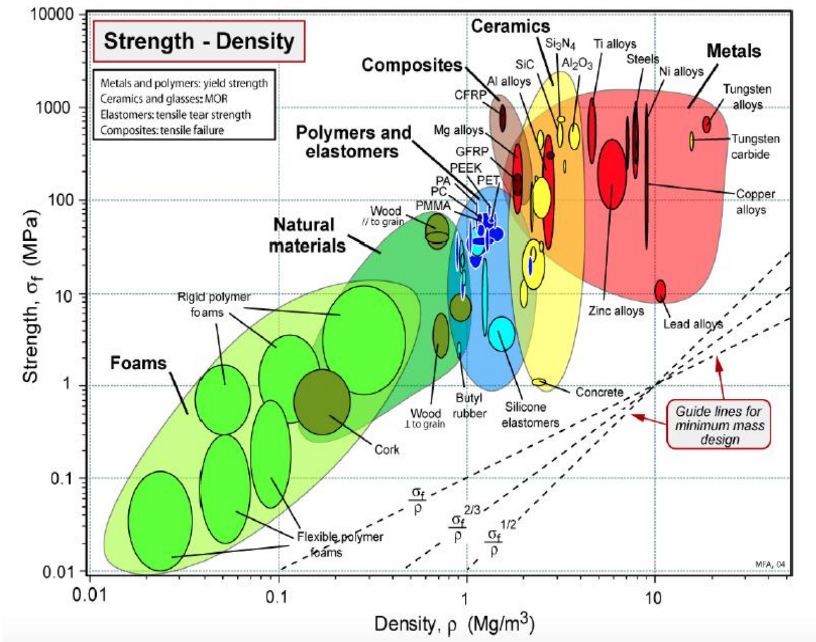

Fig 6 : Ashby's chart for Strength and Density

This chart is very which useful as strength VS density is a important parameter which determines the behavior of the design and helps to narrow down to the right raw material with the right weight. In this is it a plot of Strength of the material in MPa along Y-axis and Density of raw material in Mg/m^3 along the X-axis. Currently the Alloy used in the import steering wheel is of Magnesium. In the above chart, among the metals the closest raw material alloys is Aluminum alloys. Since India is the largest exporter of aluminum it is very much favorable. But there are many other factors which need to be addressed before arrowing down to Aluminum. Density and design of the armature is what determines the Mass moment of inertia. Since the mass moment of inertia is a customer driven requirement, it is best to choose material for the same.

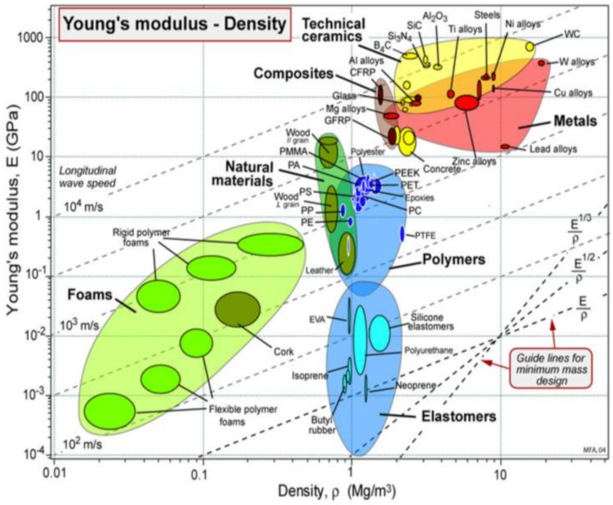

Fig 7 : Ashby's chart for Young's Modulus and Density

In this is it a plot of Young's modulus of the material in GPa along Y-axis and Density of raw material in Mg/m^3 along the X-axis. Young's Modulus is very crucial in static tests of steering wheel armarutre as it determines the stiffness of raw material. Higher the young's modulus higher will the stiffness of the raw material, low the young's modulus flexible will be the raw material. Mg Alloy has low density and lower stiffness when compared to aluminum. Since aluminum has high density than Magnesium, focus needs to be given on moment of inertia to ensure that it does not exceed the customer driven requirement

And aluminum is also used in die casting of steering wheel armature in Europe and other countries. Based on discussions and lessons learnt with other interplant facilities, Aluminum alloy is selected as the new raw material for the localization of steering wheel in India.

MESHING & BOUNDARY CONDITIONS

CAD model of part converted into STEP file. This model is imported into Ansys Workbench simulation. Geometry cleanup was performed prior to meshing of model. Optistruct is used as solver. For better quality of mesh fine element size is selected.

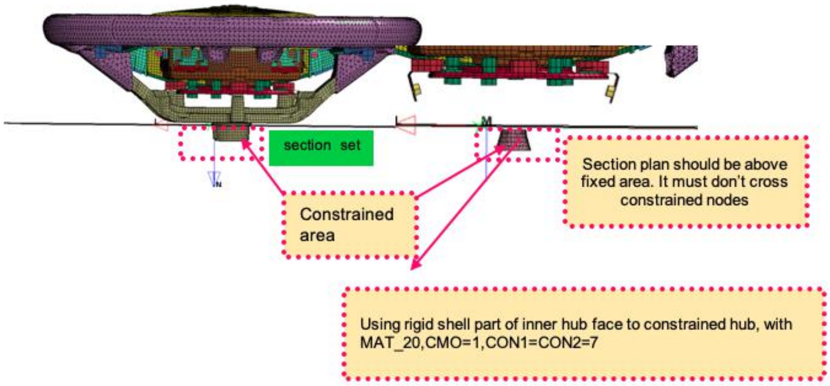

Fig 8: loading and boundary condition

In static analysis we have to consider the force acting on the component and boundary it means where the component is stationary. By observing the displacement contour the maximum deformation at the small eye end of steering arm and here the blue colour contour indicates the minimum displacement and red colour indicates the maximum.

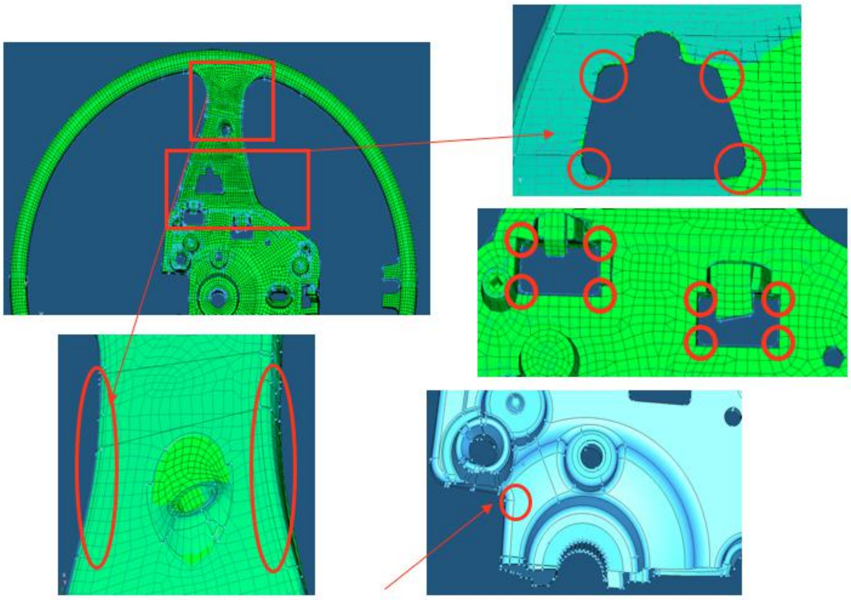

Fig 9: Meshing defects to avoid

Before Design Modification with New Raw material(Aluminium Alloy)

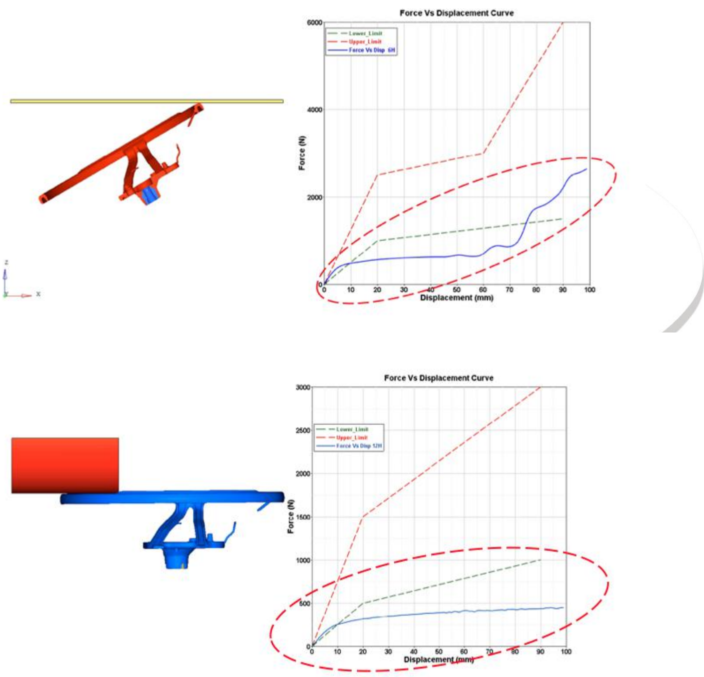

Fig 10: SBR 1 & 2 of old design with new RM

The newly selected raw material is tested for SBR-1 and SBR-2. As showed above is fig: the force VS displacement curve is not meeting the standard/safety. Design modification is to be done to make design suitable to meet the requirement.

Optimization

Optimization is accepted out by solid thinking; single of industrial format software program for 3D modelling and execution as successful as recognized as a simulation-driven diagram instrument. In overall, the most important resolve of optimization method is to achieve the acceptable use of solid for a body, includes optimizing the circulation of cloth thus exploiting the construction difficulty for a usual of load. In the present-day study, the intention is to moderate mass and form of the steerage prominence model in a best possible situation except moving toughness of perfect designed.

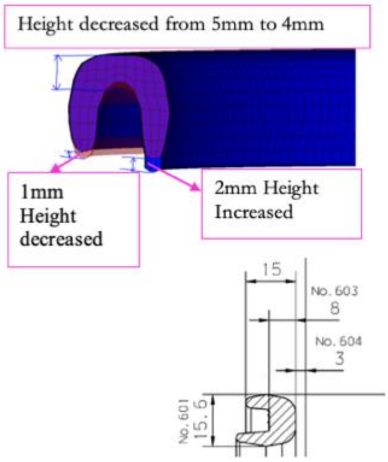

Fig 11: Design modifications to meet SBR 1 & 2 for new RM

From this stress contour the most stress at the small eye neck radius area will be the high stress attention and this can be reduced via optimizing the mannequin thinking about the neck region radius of the component.

In the first trail of the both material done with the static analysis from this we found the stress concentration of the both material will high than the yield strength of the materials. Hence the modification of the model is necessary for further optimization process.

It is 2.8% of the original weight of the model (1.1895 kg). The weight of the part among all the trail some of the best trial selected for manufacturing of the part as shown in the above table 7.Hence the maximum stress induced in the part is 391.26 MPa at the loading condition.

VI. RESULT

After design modifications and change in material from magnesium to Aluminum below are the results of Static Bending Rigidity-1 & Static Bending Rigidity -2 and with the correlation of mass moment of inertia with respect to CAE and mathematical calculations

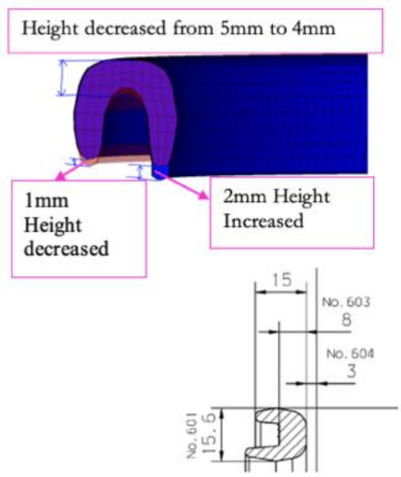

Fig 12: Design modifications

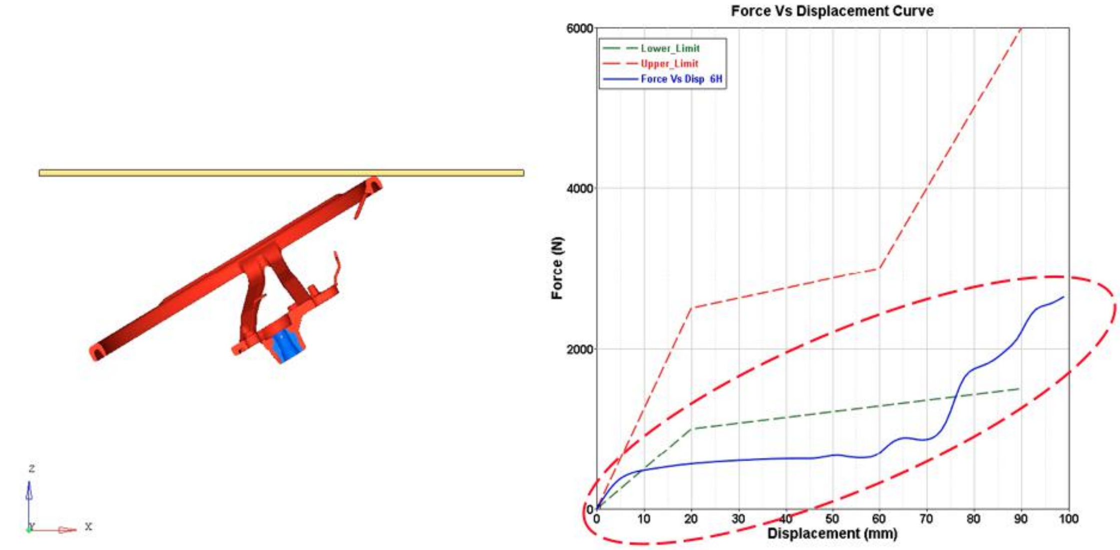

Fig 13 : SBR-1 of AL alloy before design optimization

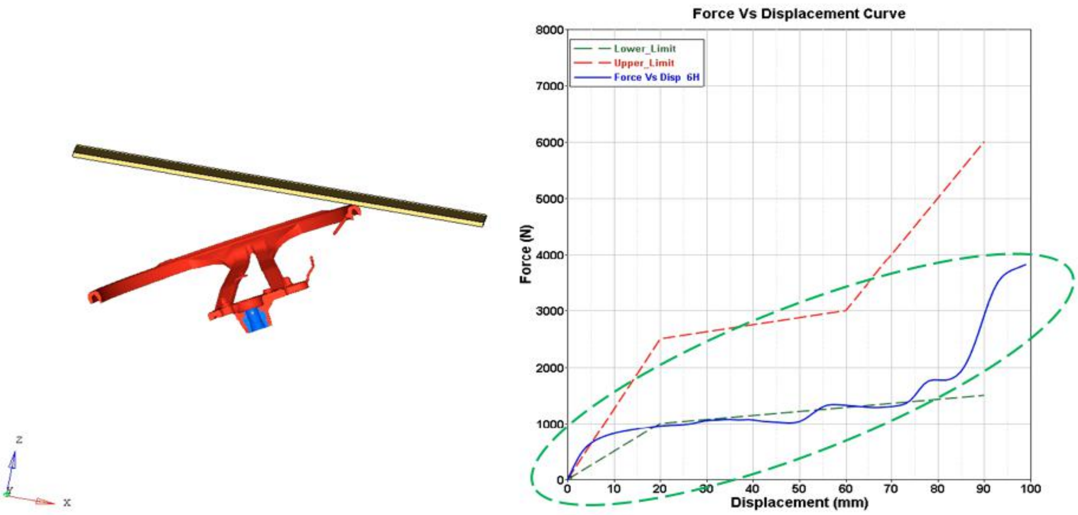

Fig 14 : SBR-1 of AL alloy after design optimization

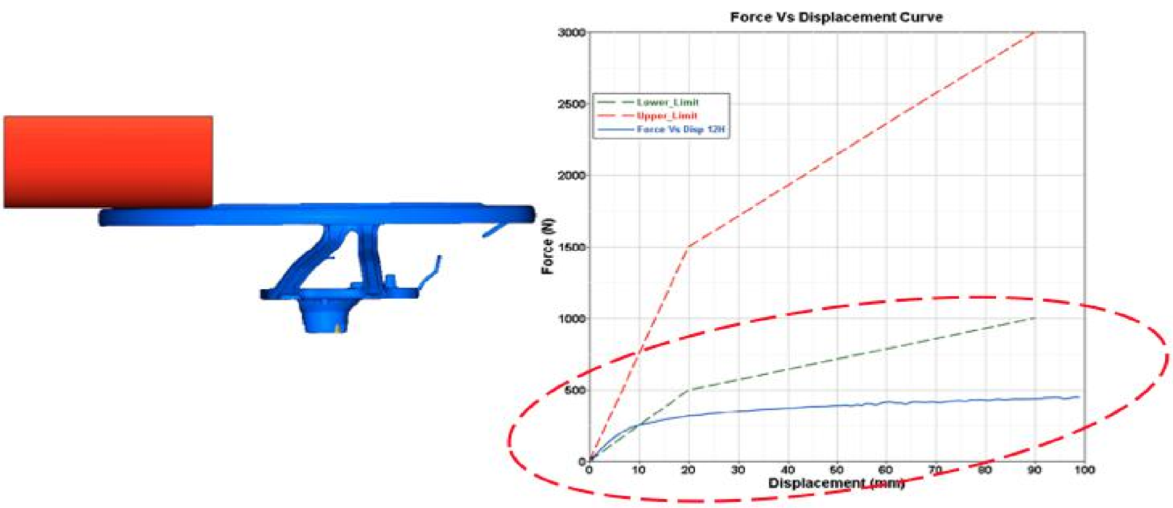

Fig 15 : SBR-2 of AL alloy before optimization

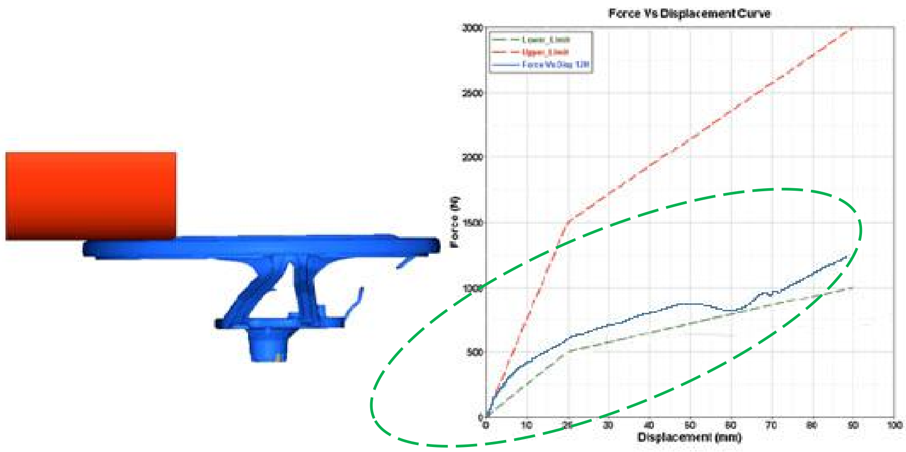

Fig 16 : SBR-2 of AL alloy after optimization

The width and additional material was added around the spoke area to increase the load barring capacity of the armature as the material was capable of withstanding even more load, which ensure that there will be no failure of armature in real world condition. The added material and other modifications are to not exceed the mass moment of interia set by the customer. In CAE the moment of inertia is measuring 16.662 g*m^2 for the modified design along with aluminum alloy as its raw material. Pendulum experiment was conducted for the modified armature and it is observed to measure 15.83 g*m^2.

CAE Aluminum alloy armature MOI	16.662 g*m^2
Calculated Aluminum alloy armature MOI	15.83 g*m^2

Table 1: CAE and calculated MOI of Al alloy results

Part Name	Armature							
Material	Magnesium alloy			Aluminum alloy				
	Imported Mg alloy				New RM before design optimization		New RM after design optimization	
Mechanical Property	Limit	SBR-1	SBR-2	Limit	SBR-1	SBR-2	SBR-1	SBR-2
Stress(MPa)	240	212	192	198	140	132	150	144
Strain(%)	9	7.41	5	14.8	6.58	4.8	9.7	7.4

Table 2 : Comparison of test results(before of after modification)

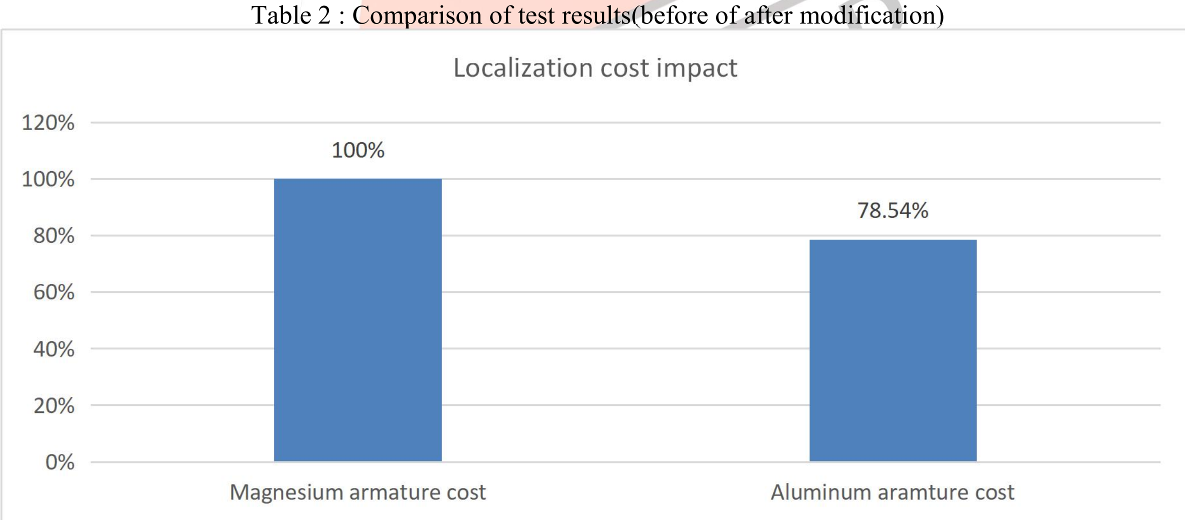

Fig 17: Cost saving and comparison due to localization

Due to the localization of steering wheel armature and by changing the raw material in process has shown a drastic reduction per part. The reason was localization is due to the fact the import taxes are expensive and the raw material change is because of the reason that aluminum is exported to other countries as it is available more in india.

CONCLUSION

Steering wheel armature is structural member of the assembly. It is the loading bearing member of the lot, every production steering wheel has to meet a set of standards and customer specific requirement in order to get approval from the customer.

Apart from the aspect of strength of the material, weight is a critical part to be kept into consideration while designing a armature. Customer specifies as set moment of inertia within which the steering has to be designed to meet both the weight and safety regulations. Here, in this project, we are localizing the production of armature from China to India. During this process, the raw material of the armature has been changed as the availability of Magnesium is very low but Aluminum is available in abundance

The width of spokes of the armature has to be increased by keeping weight into consideration. As armature spokes is the region subjected to most of the stresses. Further the profile of the armature ring has been changed to enhance grip after PU molding.

Doing the above mentions modifications enables the armature to meet the requirements of JACO C 713-96. Design is now considered safe for production.

- Mesh model of Aramture satisfied all quality criteria's hence the results are accurate.
- Typical real conditions are considered for the loading. Loads and boundary conditions are accurately simulated to obtain the realistic loading conditions.
- Performing experimental tests on Armature helped in validating the simulation results by correlating them with the test data to accurately determine the Moment of inertia.
- As modeling assumptions are so sensitive that a small variation in density and elasticity modulus

SCOPE OF FUTURE WORK

Scope of improvement is need for every idea or technique. By varying the composition of Aluminum alloy, like reduction the Silica content and increasing the Magnesium %, we further will reduce the other all weight of the Raw material which gives us room to further refine the design and meet higher strength bearing Capacity.

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