Geometrical Optimisation of Housing of Laddu Making Machine By Using Topology Optimimization

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Abstract- *this paper is about a cost reduction of Housing by geometrical optimisation. The housing of Laddu making machine used for holding all accessories during the pressing operation. It has one lever having one end at pressing die for making a circular shape of laddu and another end having spring for returning die to the position. Reduction in a cost is achieved by using low-a cost material as well as optimised geometrical design using topology optimisation. Housing has been modeled using solid work, here we first conducted analysis on existing housing after calculating forces acting on housing in order to find out Max. Disp.lacement and stress induced. For analysis purpose Altair Hyper works is used and solver used is Opti struct. Finally, we conducted topology optimisation with change in material as grey cast iron. And from result of topology IGES model is created by using Ossmooth tools from which CAD model is prepared as per topology suggestion. Post analysis of housing is carried out having a material as cast iron. From result it is found that optimised design is safe also saves material a cost of component. Topology optimisation analysis is carried out in HyperWorks which yielded in optimised design.*

Keywords- Laddu making machine, Housing, Hyper works, Opti struct, Topology optimisation, material a cost.

I. INTRODUCTION

Laddu making machine is a machine used for making Laddus of round shape. This machine mostly used in bakery, catering service provider to make laddus in mass production. So it is mostly demanded machine in food processing industry.

Nowadays manufacturing organization are trying developed product having in optimised manner, because due to increase in price of natural resources a cost of producing mechanical components is going to increase. On the other side, number of competitors entering in the market having policy of lower competitive prices, so here it is a big problem of maintaining sales number of the product. So to achieve fast product development and a cost effective product, manufacturing industries are continuously striving for various design tricks and geometrical optimisation tools.

Geometrical Optimisation helps in a number of ways to reduce material a cost, to ensure better service of components, to increase production rate and many such other parameters. Geometrical Optimisation is a method of obtaining the best result under the given circumstances. It plays a vital role in mechanical components because it gives design in an optimal manner. Geometrical optimisation includes various types such as geometry, size & shape optimisation. In which geometrical optimisation has become an active research field to perform innovative and efficient conceptual design because they can help engineers to think out of the box to generate innovative design ideas, even for those designs of already highly engineered products. Furthermore, geometrical optimisation is efficient because automated optimisation processes are employed to generate the conceptual designs instead of the conventional trial-and-error approach.

By using this geometrical optimisation method we are going to develop housing having optimised geometrical design so we can reduce material a cost of product. Finally it will help company to decrease manufacturing a cost, so here benefit to company is increase in sale by lowering a cost with maintaining same performance also overall reduced load on environmental resources and carbon emission in the environment. Topology Optimisation is defined as finding out the best possible material distribution in selected design space with considering the given sets of objective, design response and design constraints. For solving any topology optimisation problem have to specify parameters that are Design Variables, responses, Design objective and design constraints also consideration of manufacturing constraints.

Hence in order to accomplish the objective of a cost reduction through optimised structure and lowa cost material over existing design, Finite Element Analysis method is used. Since from last decade a powerful FEA packages have proven good to analysis. Hence we used finite element analysis software for geometrical optimisation. In which Hypermesh is preprocessor. Opti struct is solver which now days much famous in industry and Hyperview is Post-processor. After we did FEA analysis of optimised model and checked stress, disp.lacement of optimised model did not find exceed in magnitude of initial model. This paper deals with 3D modelling of housing. Calculation of force, Analysis, optimisation, getting IGES model from Opti struct (OSsmooth) and Make appropriate change in that model for manufacturing point of view and cross-check value of displacement within range.

II. LITERATURE REVIEW

[1] Liu et.al. In this survey of manufacturing oriented topology optimisation methods is intended to provide useful insight classification and expert comments for the community. First, the traditional manufacturing methods of machining and injection molding/casting are reviewed, because the majority of engineering parts are manufactured through these methods and complex design requirements are associated. Next, the challenges and opportunities related to the emerging additive manufacturing (AM) are highlighted. SIMP (Solid Isotropic Material with Penalization) and level set are the concerned topology optimisation methods because the majority of manufacturing oriented extensions have been made based on these two methods [2016].

[2] Vatanabe et al: In this paper addresses manufacturing constraints by means of a unified projection-based approach restricting the range of solutions to the topology optimisation problem. A domain of design variables is considered, which is projected in a pseudo-density domain to obtain the solution. The relation between domains is defined by the projection and variable mappings according to each manufacturing constraint of interest. The following constraints are considered: minimum member size, minimum hole size, symmetry, extrusion, pattern repetition, turning, casting, forging, and rolling. [2016].

[3]Vinchurkar et al. This paper contains the study of Design and Optimisation of an engine mounting bracket and comparison between existing and optimised engine mounting bracket. CAD model has been generated through reverse engineering. The bracket of Mahindra Scorpio Engine is to be taken for study. After analysing the engine mounting bracket of Mahindra Scorpio, Optimisation is done. From the Finite element analysis of existing bracket, we observed that the maximum stress value comes out to be 65.16 N/mm2 but after optimisation, it is observed that 67.16 N/mm2. The deformation for existing and optimised engine mounting bracket is same as 0.03 mm which is also very less. The calculated mass of existing engine mounting bracket is 2.83 kg, but after optimisation it observed that 2.73 kg. for this work catia used for modelling Hypermesh for pre-processing and ansys has solver.[2016].

[4] Dumbre et al In this paper is about weight reduction of the vehicle which is real need of today's automotive industry. The weight of the vehicle is going on increasing due to additional luxurious and safety features. In this work Steering knuckle has taken for study. Steering knuckle is one of critical & important component of vehicle. It links to suspension, steering system, wheel hub and brake to the chassis. So there is scope to reduce the unsprung weight vehicle. Steering Knuckle is a non-standard part and subjected to various loads at different conditions. Weight reduction of steering knuckle is the objective of this exercise for optimisation. Typically, the finite element software like Opti struct (Hyper Works) is utilized to achieve this purpose. The targeted weight or mass reduction for this exercise is about 5% without compromising on the structural strength. [2014].

[5] Patel et al carried out Parametric Optimisation of Eicher 11.10 Chassis Frame to reduce weight. The chassis serves as a backbone for supporting the body and different parts of the automobile. It should be rigid enough to withstand the shock, twist, vibration, bending and other stresses. The chassis frame model is to be developed in Solid works and analyzed using Ansys. Taguchi designs experiments used especially for constructed tables known as "orthogonal arrays" (OA). The use of these tables makes the design of experiments very easy and consistent. The shear stress and deflection are measured for each set of parameter using FEA in ANSYS, Finally 13.01% reduction in weight of chassis frame. [2013].

[6] Kulkarni et al studied forces acting on lower wishbone arm while vehicle subjected to critical loading conditions (Braking, Cornering and descending though slope). Suspension geometry and suitable materials for the suspension arm has been identified. Lower arm suspension has been modeled using Pro-Engineer. Von-mises stress –strain is carried out in order to find out maximum induced stress and strain, while modal analysis is done for finding out natural frequencies and mode shapes of component. These analyses were carried using Altair HyperWorks and solver used is Radioss. From the analyzed results, design parameters were compared for two different materials and best on was taken out. From result obtained it was found that current design is safe and is somewhat overdesign. So in order to save material and reduce weight of component, Topology optimisation analysis is carried out in HyperWorks which yielded in optimised shape. [2014].

[7] Chauhan et al carried out weight reduction of Hydraulic Modular Trailer frame by Parametric Optimisation using ANSYS (APDL). Whole modelling, analysis and optimisation has done using ANSYS APDL which stands for ANSYS Parametric Design Language, a scripting language

that can use to automate common tasks or even build model in terms of parameters (variables). Here attempt is made to size optimisation of trailer frame. Reduction in volume is taken as objective function. Von- Mises stress and deflection are taken as constraints. Finally frame optimised and feasible design was obtained with 52 % reduction in mass. [2011].

[8] Prabaharan et al carried out Structural Optimisation of 5 Ton Hydraulic Press and Scrap Baling Press for A cost Reduction by Topology. It explains method of weight reduction through topology optimisation by using ANSYS software. Model has created in PRO-E. Suitable loads and constraints are applied on the initial design space of the components in ANSYS software. At the end, optimised design model compared with the Actual part. Same method of Optimisation has been applied on various components of scrap baling press and 5Ton hydraulic press machine. Finally optimised design model is compared with initial model. The result shows that 26.26 percent a cost reduction in scrap baling press and fabricated 5ton hydraulic press with a cost reduction of 24.54 percent. [2011].

III. METHODOLOGY

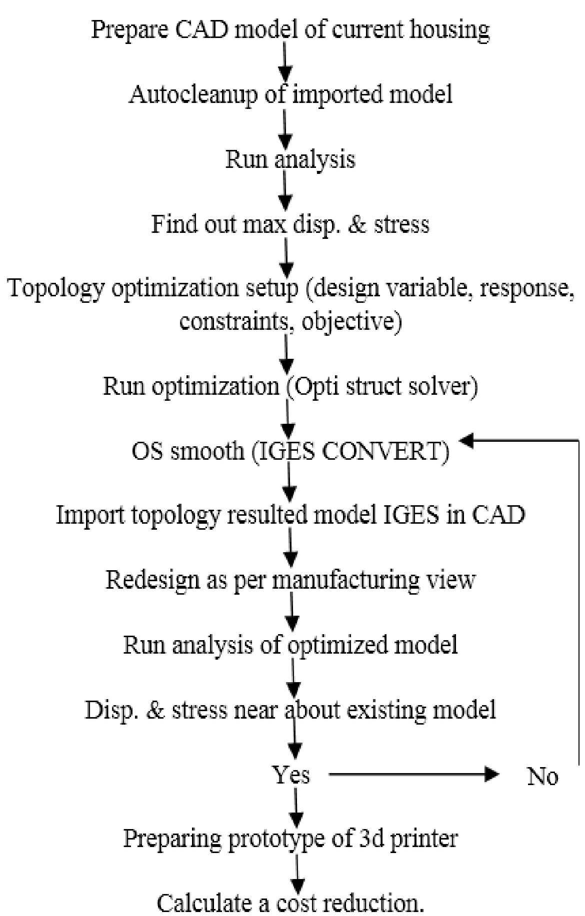

Figure 1. Work flow diagram

Above diagram show workflow of project work. First we took CAD model from company of housing and imported in solid works and did analysis in Hypermesh. Then geometric cleanup and meshing by using autocleanup. Meshed model housing has 3D Tetra mesh (volume mesh). Tetra elements give enhanced result as compared to other types of elements, therefore the elements used in this analysis is tetra elements. Aluminium material is used for housing. Calculated forces and boundary conditions were applied on meshed model in Hypermesh as shown in figure 2. Static analysis was performed by using Opti struct. Results were viewed in Hyperview.

IV. DESIGN

All specification such as material property and result are shown in table 1.

Design parameters

1) Forces acting on housing:
Here we calculate total force applying on housing.
F=20*9.8 =196 N
Maximum load applied on fix housing is 196N.
Considering factor of safety (F.S.) 2 then
F= 196*2 =392N.

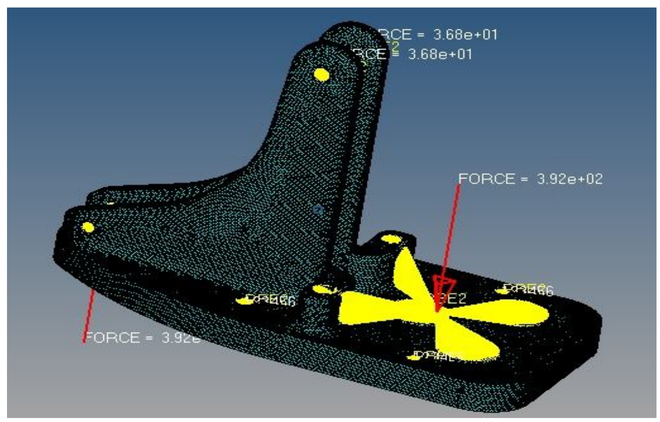

Figure 2. Housing at pre-processing (meshing, loading & boundary Condition).

Table 1. Material properties and specification of Housing

Parameter	*Description*	value
E	Young's Modulus (Mpa)	69000
NU	Poisson's Ratio	0.33
RHO	Density (kg/m3)	2700
M	Wt. of housing assembly before optimisation	4.62

V. RESULTS AND DISCUSSION

a) Static analysis

Static analysis was performed in Opti struct solver. From figure3, it is observed that the maximum disp.lacement is 0.002mm for housing. Stress developed is 6.07 N/mm2 which is lower than the Yield strength. Hence, design is safe & values of maximum stresses are acceptable as compared to yield strength so design constraints for Optimised housing is to maintain disp.lacement value lower than 0.002 mm.

Table 2. Analyzed results for fix materials

Description	value	node
Max disp.lacement (mm)	0.002	14704
Von Mises stress (N/mm2)	6.07	163209

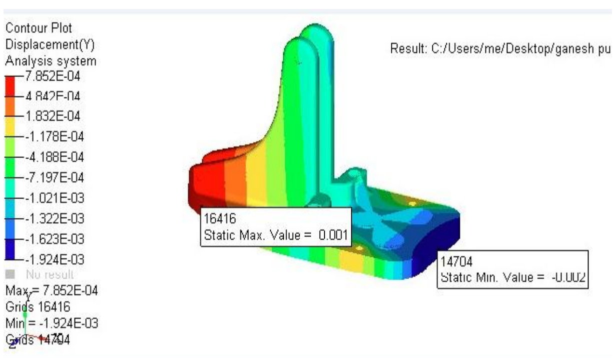

Figure 3. Max. Disp.lacement of housing

b) Topology optimisation

Topology Optimisation technique gives an optimum material distribution within given design space. The design space defined using solid element having design property. Firstly topology variables are created. Design response was volume Fraction, weighted compliances, displacement. Optimisation design constraints were volfrac for that upper bound 0.30 and Displacement constraint was upper bound 0.002mm for housing. Finally design objective was Minimum weight compliance.

Run optimisation by using Opti struct Solver. Finally viewed result in hyper view.

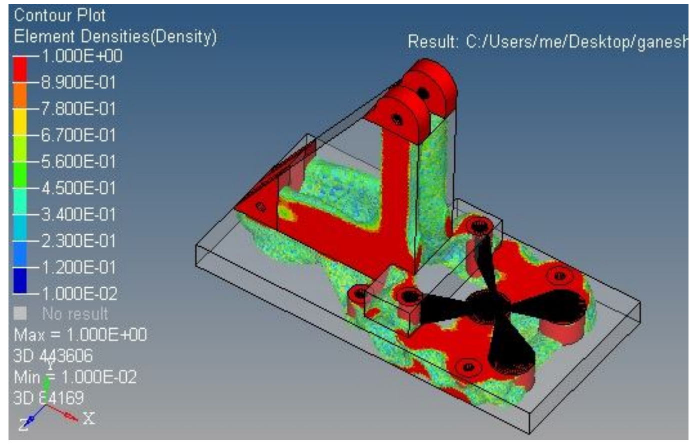

Figure 4. Hyper view element densities of housing

Figure 4 shows element density for housing in Hyperview. Opti struct shows material distribution pattern throughout housing geometry and removed material from that region in successive iterations based upon set of objectives and constraints. This material removal is given by varying density of each element from 0 to 1. After numbers of iterations, when solution converges then density pattern of component a region with lower density indicate that it can be removed without hampering safety of component. So by removing the material from these design space of component, objective of reducing a cost of component will be fulfilled with all design constraints. A conceptual design can be imported in a CAD system using by OSSmooth post tool in Hypermesh. This IGES model imported in solid works makes changes as per manufacturing aspect.

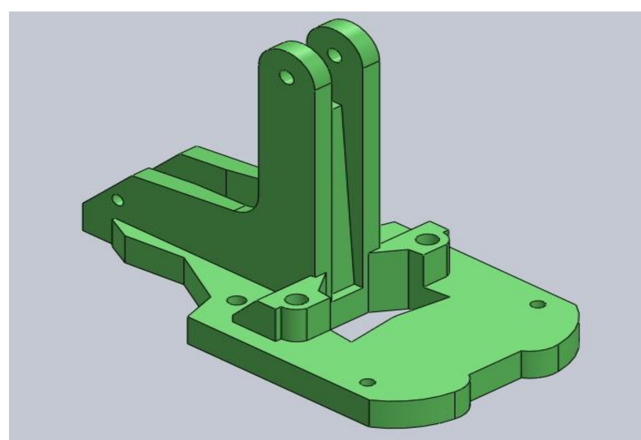

Figure 5. Shows CAD model of fix housing.

Again analysis is conducted on newly optimised housing model. All meshing, boundary and loading condition are set up. Cross checked that displacement and stress of optimised model do not exceed value than Initial model. Figure 6 Shows displacement result of optimised housing. Displacement of optimised housing is 0.002mm (<0.002mm of existing model). Then checked the magnitude of displacement and stress of optimised model is equal to initial model.

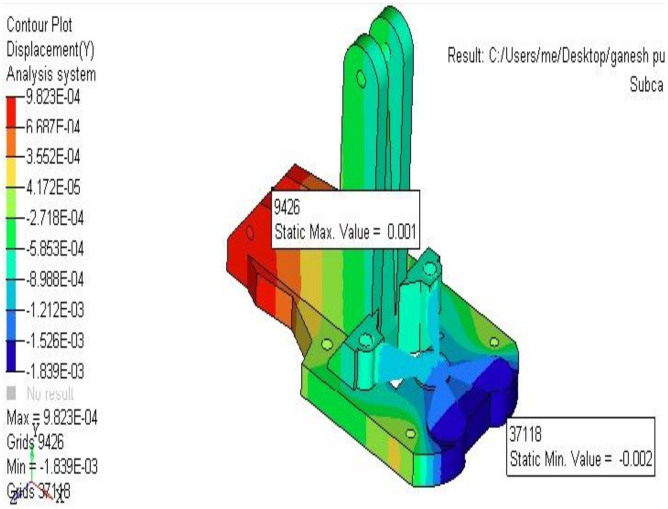

Figure 6. Disp.. of optimised housing 0.002mm

Table 3. Analyzed results for housing

Parameter	*before optimised*	*after optimised*
Max. Disp.lacement(mm)	*0.002*	*0.002*
Max. Stress (N/mm2)	*6.07*	*6.63*

Table 4.Total a cost and a cost saving

Design parameter	fix jaw after optimised
Total a cost saving/unit	Total a cost saving/unit =750-(4.5*55)= 502.5
Total a cost saved/year	502.5 * 40= 20,100/-

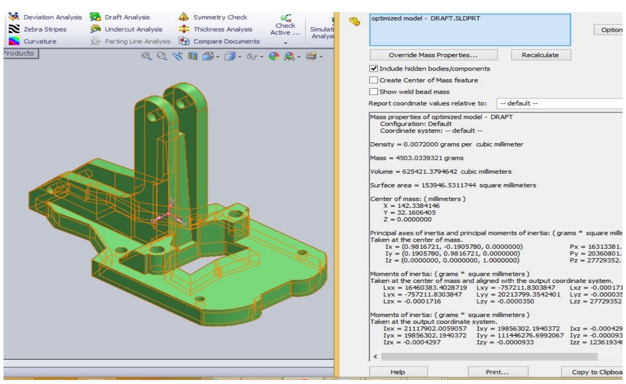

Figure 6. Development of prototype of 3d printer

Figure 7. Development of prototype of 3d printer

Figure 8. Development of prototype of 3d printer

Here for developing prototype we created optimised housing in FDM 3d printer as shown in figure 8 & 9. 3D CAD model of the housing is sent to a FDM 3D printer for fabricating the plastic geometry of housing before metal casting because we can make required changes in optimised model by actual prototype of result, so here we have taken important suggestion from company. The CAD model (STL file) is first processed offline in a computer containing an open source slicing software Cura, which generates the G-code file containing the part cross-sections and crosshatching motion of the 3D printer. This file is copied into an SD card, which is inserted in the card reader attached to the printer. The printer has a spool of plastic wire, which is pushed by an extruder into a heated nozzle. Semisolid plastic comes out of the nozzle and gets deposited on a platform. A controller moves the nozzle head in horizontal (X) direction, and the platform in horizontal (Y) direction. After the completion of a layer, the nozzle is moved in vertical (Z) direction. The layer thickness is 0.1 mm and the printing speed is 60 mm/s. Parts of size up to 300 x 220 x 200 mm can be fabricated. A mechanically stable design coupled with high quality liner motion guide provides good dimensional accuracy. The PLA bio-plastic wire is made from renewable natural resources and is biodegradable, but is strong enough to be used as pattern for the no-bake process. The housing took about 3hours to fabricate.

VI. CONCLUSION

In this work, structural Design & a cost optimisation of housing for Laddu making machine is carried out by topology optimisation. From the analyzed results, it is concluded that.

- The values obtained for the maximum disp.lacement and von-mises stress of optimised model are equal to current model.
- Topology optimisation generates an optimised material distribution for a set of loads and constraints within a given design space. By optimisation, manufacturing a cost of component is fulfilled with all design constraints.
- A cost optimisation of housing is reduced to 3 times of lowa cost than existing model. So that company saves 20,100/- per year.
- Finally we reduced a cost of housing by 502.5/- per piece.
- By this work, we can minimise load on resources & help company to increase profit by low manufacturing a cost

VII. ACKNOWLEDGMENT

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