Optimization of Motor bike frame for single wheeled vehicle.

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Abstract- ***The application of software to the optimization of metallic frame for single wheel motor bike is described by using Bidirectional Evolutionary Structural Optimization (BESO) and Evolutionary Structural Optimization (ESO) methods. The work involves maximizing the performance, in terms of lateral stiffness. The frame is designed and optimized by using a parametric approach for achieving low weight to stiffness ratio in order to meet functional behaviour. The modeling of frame is done in CATIA V5 and weight optimization of frame is carried out by using SolidThinking Inspire. Different iterations are performed to get best optimized result.***

Keywords—BESO; ESO; Optimization

I. INTRODUCTION

RYNO motors has designed and manufactured one wheeled motor bike as shown in fig.1. The present work is considered on the same line. This is single wheeled single rider electrical motor bike. The single wheeled motor Bike frame has requirements for low weight/stiffness ratio and the Finite Element Method makes the design more Efficient.

Fig. 1. Benchmark and working concept

Motor bike chassis is a vital part of a vehicle. The frame provides support to the body and various components of the automobile. In addition, it should be stiff enough to absorb the shock, twist, vibration and other stresses. To improve handling characteristics, it should have sufficient bending stiffness along with strength. Thus, maximum stress, maximum equilateral stress and deflection are key criteria for the design of the frame. The primary concept of frame has been shown in fig.2.

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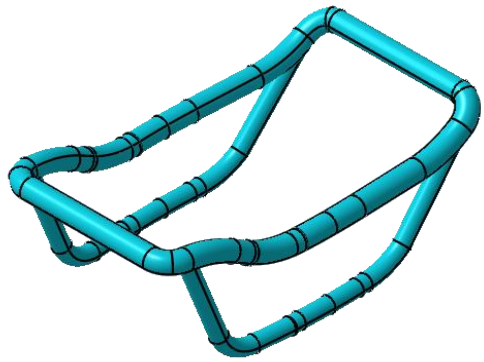


Fig. 2. Inintial frame concept

Bike frame has been designed using constraints like maximum shear stress, equilateral stresses and deflection of chassis, then the chassis is modeled in CATIA and analysis of frame structure is done using SolidThinking Inspire which is based on structural optimization. Currently optimization [1] has become a precious tool for designers and engineers due to availability high performance computing systems frames and components are becoming stronger, lighter and economic as industries have adopted optimization of parts for their better performance.

Programmers [2] straight away began introducing latest optimization methods like nonlinear programming, unconstrained optimization, and multi-objective optimization. A fresh addition to the family of numerical optimization methods is that of evolutionary computation.

II. SOLIDTHINKING INSPIRE

SolidThinking Inspire helps design engineers, product designers, and architects to generate and explore structurally efficient concepts rapidly and effortlessly. Inspire is based on the Industry leading Altair OptiStruct technology to produce design concepts. The software is easy to be trained and works with existing CAD tools to assist design structural parts right the first time, dropping costs, development time, material consumption, and product weight.

Benefits:

- Design Faster

It generates concepts which meet structural performance requirements at the beginning of the design cycle. This results in important time savings over the traditional way of design, validate, redesign to accomplish structural requirements.

- Design Smarter

Inspire makes it easy to perform "what-if" scenarios where connections, package space, shape controls and load conditions can be customized. Reviewing the resulting concepts often reveals important solutions.

- Design Lighter

Inspire makes efficient use of material, only placing it where required to satisfy structural performance requirements. Reduced design weight leads to material cost savings, performance improvements and reduced shipping costs.

III. MATERIAL

The material used for motor bike frame for the structural optimization is Austenitic Stainless Steel of grade AISI 304.

- Material Composition:

The percentage of other substances in AISI 304 stainless steel is as C 0.008% max, Mn 2.0%, Si 0.75%, P 0.045%, S 0.03%, Cr 18-20%, Ni 10.5% and N 0.1%

- Mechanical Properties:

The mechanical properties of AISI 304 are Tensile strength 520MPa, Compression Strength 210 MPa, Proof stress 0.2% 210 MPa, Elongation 45%.

- Physical Properties:

The physical properties of AISI 304 are density 8.00g/cm^3, Melting point 1400-1450^{0}C Modulus of Elasticity 193 GPa.

IV. CAD MODELLING

The motor bike frame dimensions are taken from prototype developed. These prototypes are made for the clearance analysis of the frame with tire and other moving components. The CAD modeling is further done with help CATIA V5 software as shown in fig.3. The step file is generated and input is given to the software.

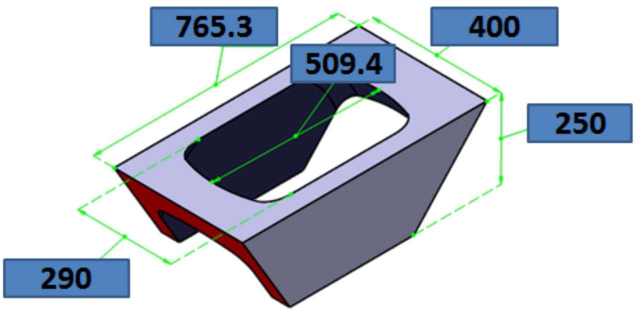


Fig. 3. CAD modelling

V. BOUNDARY CONDITIONS

The boundary conditions are applied to the CAD model according to the rider positions obtained through prototype and forces acting on the frame structure are calculated with reference of 60kg of human weight as practiced by ARAI. Upper structure weight of component along with weight of frame itself is calculated as 60Kg. Thus total weight on frame is acting 120 Kg. The force F_1 is the force acting along the line of steering at an angle of 20 deg to Z-axis. By, considering factor of safety as 1.5 and along –Z direction force acting F_1 will be 120*1.5*9.8. So F_1 =1764 N has been applied at the end of steering bearing at an angle of 20 deg to Z. The F_2 is acting due to self weight of motor bike frame and it is calculated as the weight on front side of frame is 10 Kg i.e. as 100N in –Z direction. Both F_1 and F_2 are point loads acting along single line on the frame, as shown in fig.4.

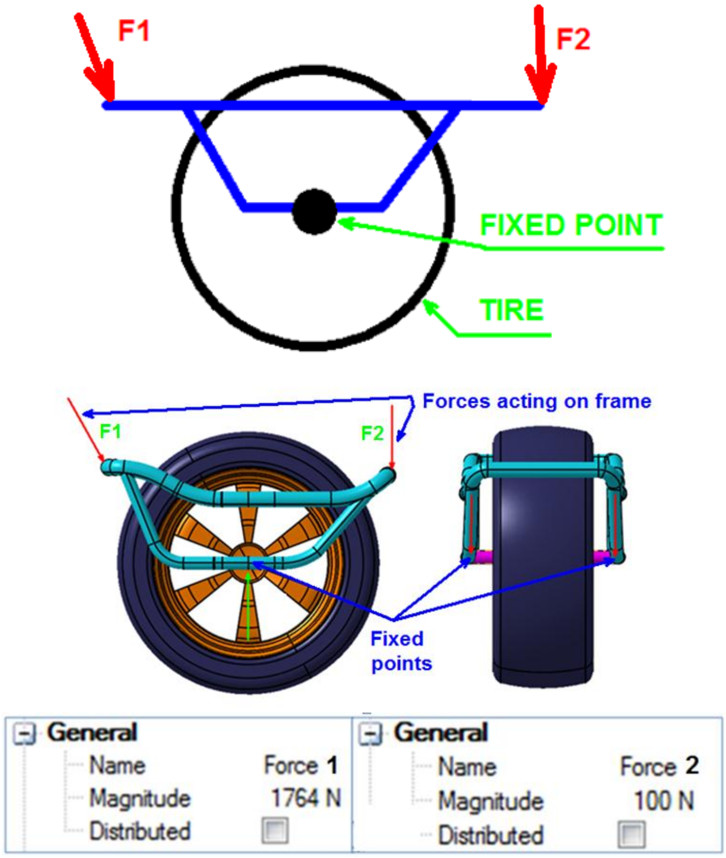


Fig. 4. FBD and Forces acting on the frame

The forces are applied according to the free body diagram as shown in fig. 4 and 5. The forces on frame coming from upper frame and rider are point loads in –z while the points of reaction at the axle are to be considered as fixed points.

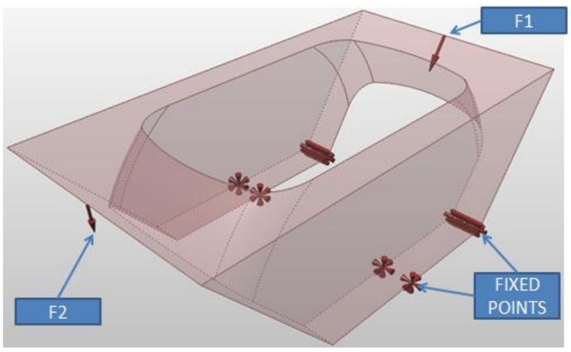


Fig. 5. Boundry conditions for the frame

VI. RUN PARAMETERS

The structural optimization is constrained with some factors like material thickness, thickness variation and gravity forces, as shown in fig.6. In these parameters we can control the thickness of the structural model; we can give input for percent of material to be kept in the optimized structure. The application of gravity is also considered to be major factor in structural optimization.

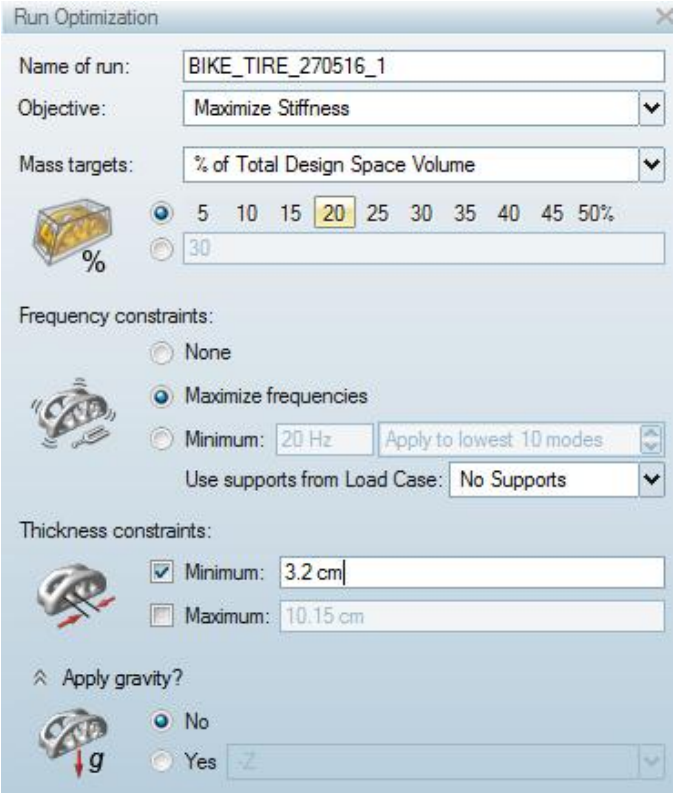


Fig. 6. Run parameters

VII. RESULTS AFTER STRUCTURAL OPTIMIZATION

After application of run parameters and the boundary conditions the software has given the results as below. The thickness is controlled according to the required minimum limit of manufacturing. The concept iterations are listed below and output of software is represented to fig.7 to fig.11.

1. Reduction to 5% of material

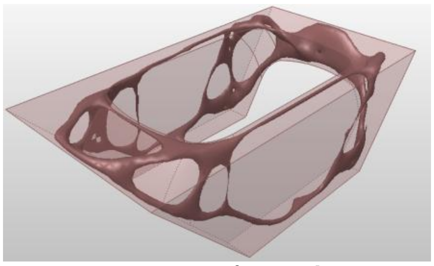


Fig. 7. 5% of material

2. Reduction to 10% of material

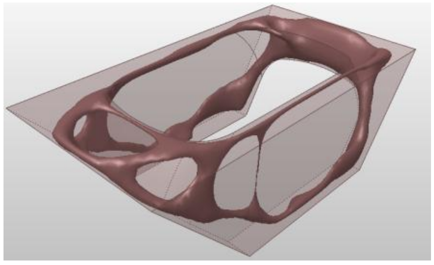


Fig. 8. 10% of material

3. Reduction to 15% of material

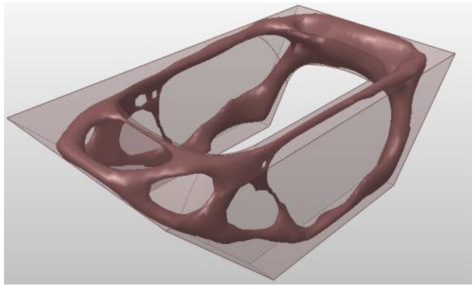


Fig. 9. 15% of material

4. Reduction to 20% of material

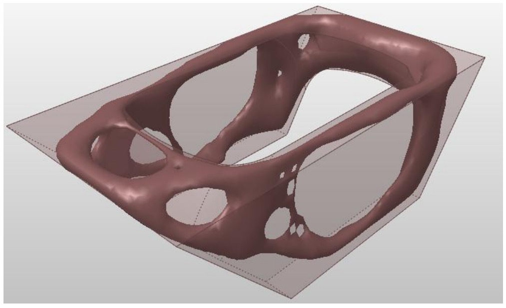


Fig. 10. 20% of material

5. Reduction to 30% of material

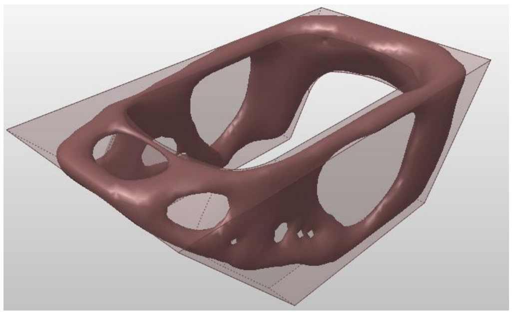
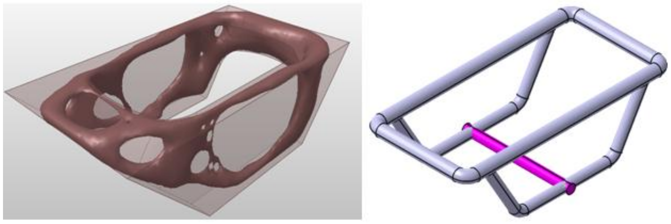


Fig. 11. 30% of material

VIII. RESULT COMPARISON

The results of iterations are fine tuned for further testing of frame in CAE for strength and stiffness of the frame to carry weight of the bike and rider. The iterations no 1, 2 and 3 have material filling problem as per results from software. Iteration 4 and 5 has sufficient material to fill the body with required stiffness of the frame. Both iterations have the ability to withstand the forces on the frame. With the benefit of having lower weight in the concept of 20% reduction in material is selected as shown in Fig. 12a and the fine tuned model is shown in fig.12b. The final cad model concept will be used for the CAE study for stiffness.



12a 12b

Fig. 12. Result Obtained and fine tuned CAD model

IX. CONCLUSION

Bidirectional Evolutionary Structural Optimization (BESO) and Evolutionary Structural Optimization (ESO) methods are the faster way to perform structural conceptualization and optimization than the traditional methods of structural optimizations. This gives better results with good accuracy and cheaper for economy along with stiffness and the strength of the motor bike for overall functional requirements. The frame is fine tuned and CAE testing is under progress.

Acknowledgment

I expressed my thanks to my guide *Prof. D. S.* Choudhari, for his encouragement and guidence. I wish to express my thanks to Prof. N. J. Jamadar, Dr. K. K. Dhande (HOD) and Dr. R.K.Jain (Principal, Dr, DYPIET, Pune) for their motivation and providing necessary facilities.

References

[1] Mark J. Jakiela, Colin Chapman, James Duda, Adenike Adewuya,Kazuhiro Saitou, "Continuum structural topology design with genetic algorithms," ELSEVIER Comput. Methods Appl. Mech. Engrg. 186 (2000) 339-356

[2] Emad Elbeltagia, Tarek Hegazy, Donald Grierson, "Comparison among five evolutionary-based optimization algorithms", ELSEVIER Advanced Engineering Informatics 19 (2005) 43–53

[3] Nikolaos D. Lagaros, Manolis Papadrakakis, George Kokossalakis, "Structural optimization using evolutionary algorithms," ELSEVIER Computers and Structures 80 (2002) 571–589.

[4] SolidThinking Inspire brochure updated 2016.

[5] Kalyanmoy Deb "Multi-Objective Optimization Using Evolutionary Algorithms" KanGAL Report Number 2011003.