

SHAPE OPTIMIZATION OF KNUCKLE JOINT FOR DIFFERENT MATERIAL USING CAE TOOLS

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ABSTRACT : Knuckle joint is one of important component of vehicle which is connected to steering, suspension and brake to chassis of vehicle. It undergoes different loading under different conditions. The shape optimization has received a lot of attention in recent years, particularly in relation to a no. of application in engineering, where the name of optimal design for structure is more common. In the design optimization of the knuckle joint, a weight should be minimized. In this project we have done static analysis of steering knuckle. In this paper we have done shape optimization of knuckle joint of different material resource using, CATIA V5 R20 and ANSYS WORKBENCH 14.0 making objective function as reducing weight without affecting its strength, frequency and stiffness. Reducing the weight of vehicle component plays vital role in increasing efficiency of vehicle and reducing fuel consumption. Shape optimization technique is used for performing optimization cause measurable reduction in weight (20% target reduction) of knuckle joint.

KEYWORDS - *Knuckle Joint, Shape Optimization, CATIA V5 R20, ANSYS Workbench 14.0, FEA, CAE.*

INTRODUCTION: In the design optimization of knuckle joint, a weight should be minimized. The mass or weight reduction is becoming important issue in automobile industry. The weight reduction will give substantial impact to fuel efficiency, effort to reduce emissions and hence, save environment. The weight can be reduced through different types of technological method, such as advances in different types of materials, design and analysis methods and using different types of optimization technique etc. Knuckle joint is subjected to time varying load during its service life and leading to fatigue failure. So, its design is an important effect on the product development cycle. The technique of optimization of weight reduction of knuckle joint should be such that the strength, stiffness and life cycle performance of the knuckle joint are satisfied.

S. N. Datey et al. [1] focused on finite element analysis of universal joint. Analysis of rigid flange coupling was carried out which is similar to universal joint. In this analysis ANSYS software was used to find different torques and load condition and it was verified by manual calculations.

R. S. Dharpure et al. [2] studied failure of the knuckle pin in a railway coupling due to shearing. It was found that a proper elastic material can be used instead of steel for pin of knuckle joint for deformability of 5mm.

Pantazopoulos et al. [3] studied the failure of a knuckle joint of a universal coupling system. It was mentioned that torsional overload of the knuckle joint is the major cause of failure.

K. Chaurasia et al. [4] studied non parametric shape optimization of knuckle joint for different materials using finite element analysis. It was found that with the help of shape optimization

light weight rigid design for knuckle joint could be developed resulting in reducing the mass of knuckle joint.

S.Vijayarangan, N. Rajamanickam et al. [5] carried out structural analysis of steering knuckle made of alternate material Al-10 wt.% Tic and compared it with that of aluminium alloy and SG iron steering knuckles for its performance and results encourage using particulate reinforced metal matrix composites for critical component steering knuckle with a weight saving about 55%.

Fuganti, Cupito [6], describes the development of a suspension steering knuckle through the application of thixoforming technology of an aluminium alloy and described the methodology which was used for material/technology choice and component optimization. A component weight saving of about 30% was obtained, compared to the solution made of cast iron.

Kulkarni and Tambe [7] focuses on optimization of steering knuckle targeting reducing weight as objective function, while not compromising with required strength, frequency and stiffness.

Nipun Kumar, Gian bhushan, Pankaj chandna [8] studied the analysis of knuckle joint of various materials using CAE tools. Knuckle joint of various materials like aluminum, stainless steel, structural steel, magnesium and gray cast iron has been studied and it was found that knuckle joint made of aluminum has highest factor of safety for 50 KN loading condition.

Purushottam Dumbre et al. [9] achieved mass or weight reduction of steering knuckle of 5% respectively that of existing, subjected to various loads at different conditions using FEA Software.

Wan Mansor Wan Muhammad et al. [10] achieved mass or weight reduction of steering knuckle of 8.4% that of existing, subjected to various loads at different conditions using FEA Software.

I. CAD MODELLING

Finite element analysis first step is to create CAD model. A knuckle joint having diameter 35mm subjected to tensile force has been taken into consideration. Fig 1 shows the drawing and dimension of knuckle joint for the present study. CAD model of knuckle joint in CATIA V5 R20 is prepared according to these dimensions. Fig 2 shows the assembled CATIA model of knuckle joint.

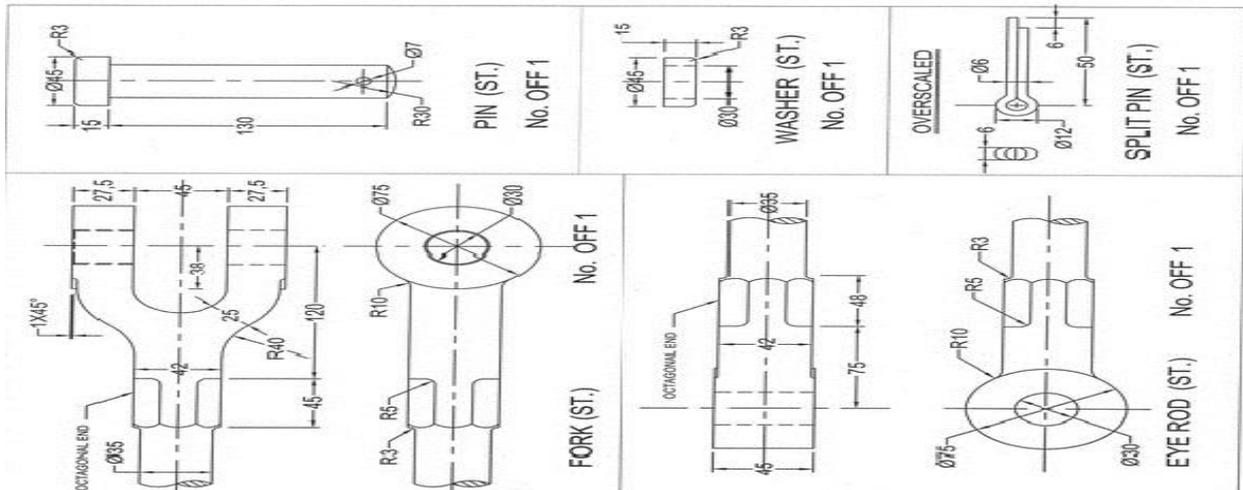


Fig. 1. Knuckle joint with dimensions

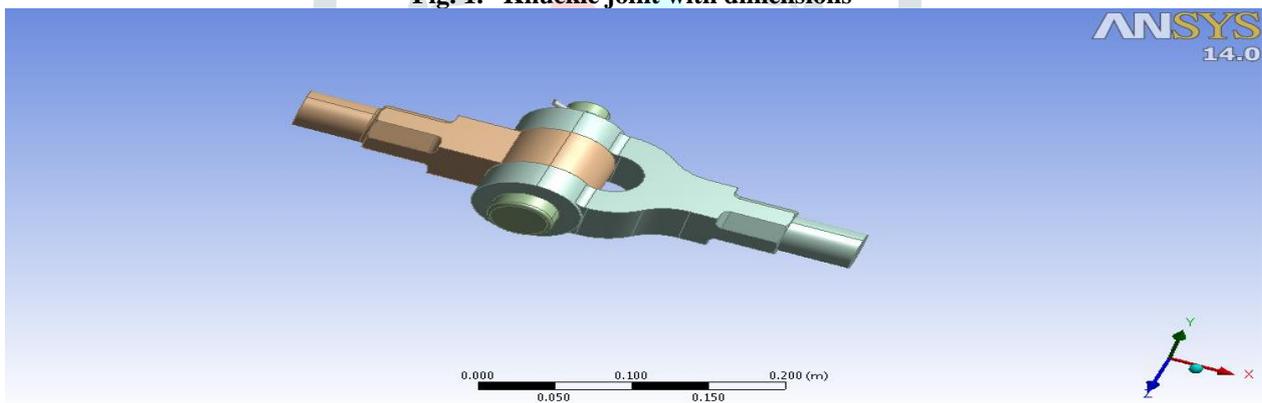


Fig. 2. CATIA V5 R20 assembled model of original knuckle joint

II. STRUCTURAL ANALYSIS USING ANSYS

Finite element analysis is an indispensable technology used in modelling and simulation of advanced engineering problems such as manufacturing transportation, housing and building design. Knuckle joint having diameter 35mm is taken into consideration. After converting assembled CATIA model into IGS format it is then imported into ANSYS 14.0. Fig 3. shows the meshed model of original knuckle joint in ANSYS having 19250 nodes and 10016 elements.

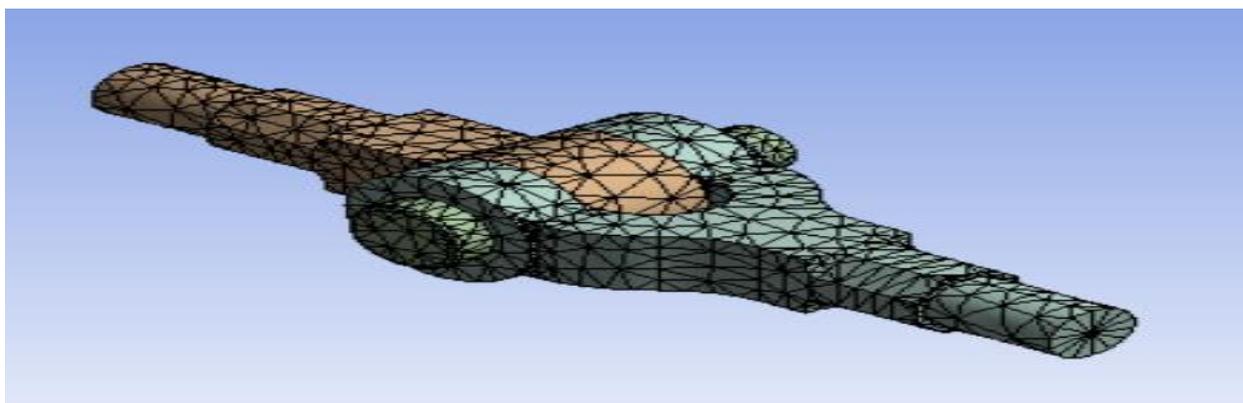


Fig.3. ANSYS 14 Meshed Model of knuckle joint

III. MATERIALS USED

The material must be selected such that it must have sufficient hardenability and strength for the size involved. In the present work Aluminum alloy, Structural steel, Gray cast iron, Magnesium alloy, Stainless steel and Copper alloy have been taken as material for knuckle joint for shape optimization in Ansys workbench 14.0. Table 1. shows the mechanical properties of Aluminum alloy, Structural steel, Gray cast iron, Magnesium alloy, Stainless steel and Copper alloy taken into consideration for shape optimization. Table 2. shows the mass reduction of knuckle joint made of Aluminum alloy, Structural steel, Gray cast iron, Magnesium alloy, Stainless steel and Copper alloy.

TABLE 1. Mechanical properties for Knuckle joint of Aluminum alloy, Structural steel, Gray cast iron, Magnesium alloy, Stainless steel and Copper alloy.

Mechanical property	Aluminum alloy	Structural steel	Gray cast iron	Magnesium alloy	Stainless steel	Copper alloy
ρ (kg/m ³)	2770	7850	7200	1800	7750	8300
E(Pa)	7.1 E+10	2.0E+11	1.1E+11	4.5E+10	1.93E+11	1.1E+11
NU(Poisson ratio)	0.33	0.3	0.28	0.35	0.31	0.34
Tensile yield strength (MPa)	280	250	190	193	207	280

IV. RESULTS AND DISCUSSION

The Figures 4, 5, 6, 7, 8 and 9 show the results of shape optimization of knuckle joint made of Aluminum alloy, Structural steel, Gray cast iron, Magnesium alloy, Stainless steel and Copper alloy have been obtained under the load of 100 KN through linear static analysis. The original mass of knuckle joint made of Aluminum alloy is 2.7487 kg, Structural steel is 7.7896 kg, Gray cast iron is 7.1446 kg, Magnesium alloy is 1.7862 kg, Stainless steel is 7.6904 kg and Copper alloy is 8.2362 kg before optimization. After optimization, the optimized mass knuckle joint made of Aluminum alloy is 2.3803 kg, Structural steel is 6.7475 kg, Gray cast iron is 6.189 kg, Magnesium alloy is 1.5461 kg, Stainless steel is 6.6606 kg and Copper alloy is 7.1315 kg. The mass reduction of knuckle joint target is achieved for Aluminum alloy is 13.40%, Structural steel is 13.41%, Gray cast iron is 13.36%, Magnesium alloy is 13.44%, Stainless steel is 13.39% and Copper alloy is 13.41% respectively.

TABLE 2. Mass reduction of knuckle joint made of Aluminum alloy, Structural steel, Gray cast iron, Magnesium alloy, Stainless steel and Copper alloy.

Material	Original mass (in Kg)	Optimized mass (in Kg)	% error
Aluminum alloy	2.7487	2.3803	13.40
Structural steel	7.7896	6.7475	13.41
Gray cast iron	7.1446	6.189	13.36
Magnesium alloy	1.7862	1.5461	13.44
Stainless steel	7.6904	6.6606	13.39
Copper alloy	8.2362	7.1315	13.41

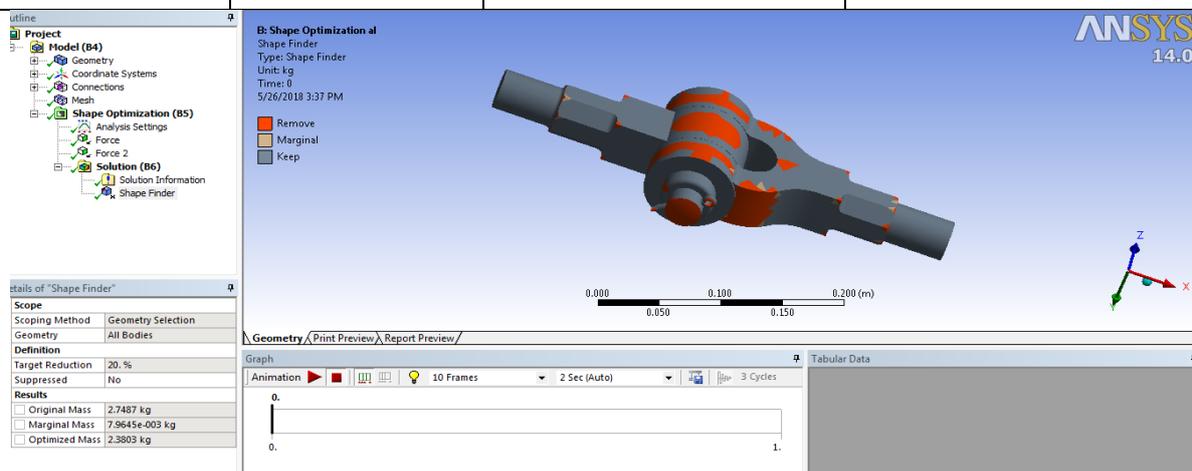


Fig. 4. Weight optimization of Knuckle joint made of Aluminum alloy stress at 100 KN

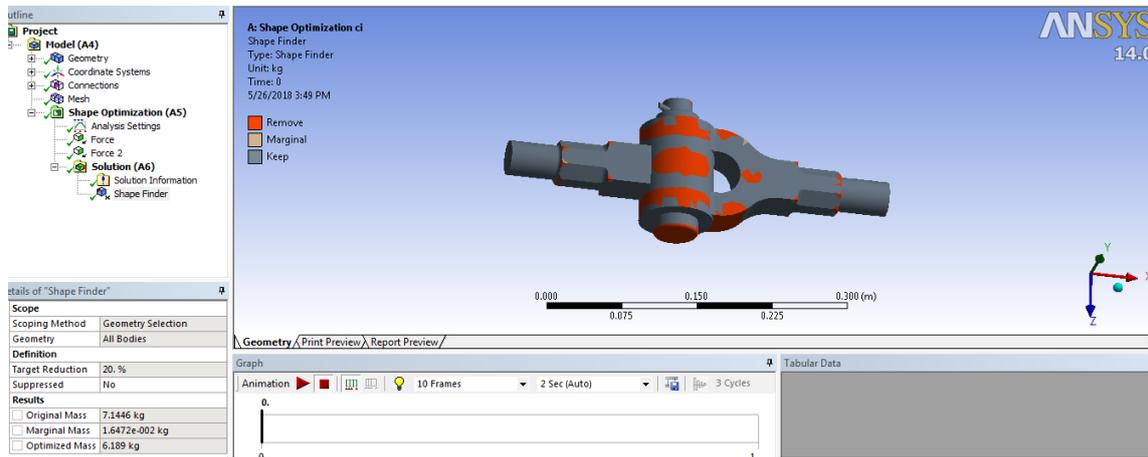


Fig. 5. Weight optimization of Knuckle joint made of cast iron stress at 100 KN

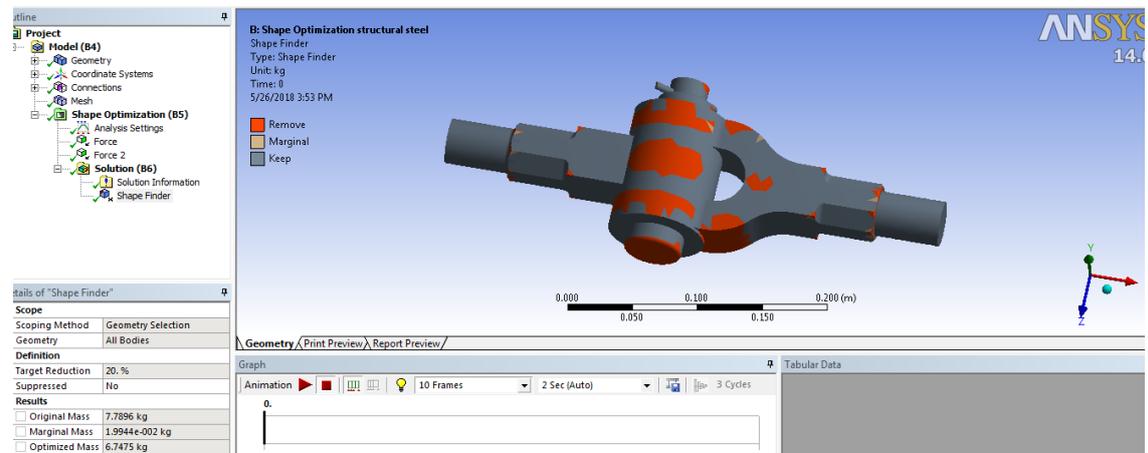


Fig. 6. Weight optimization of Knuckle joint made of structure steel stress at 100 KN

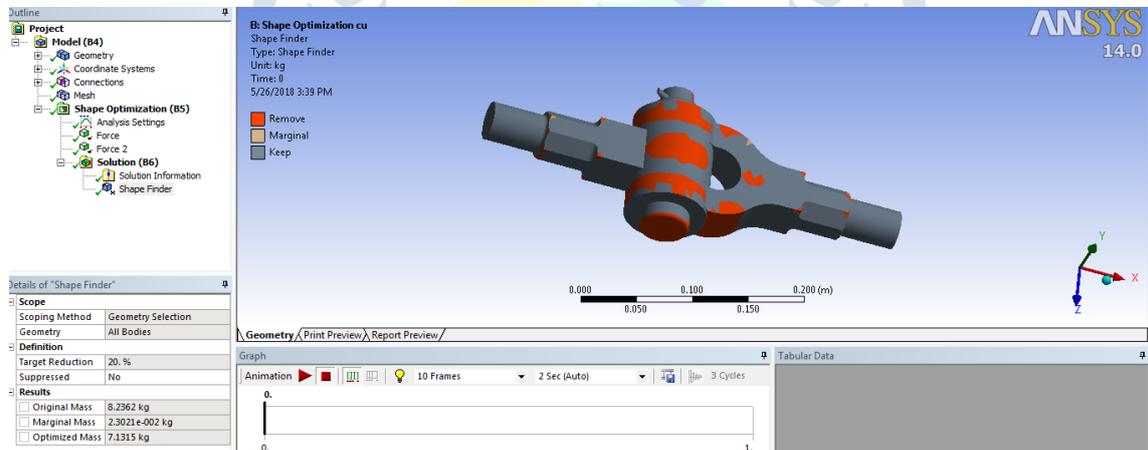


Fig. 7 Weight optimization of Knuckle joint made of copper alloy at 100 KN

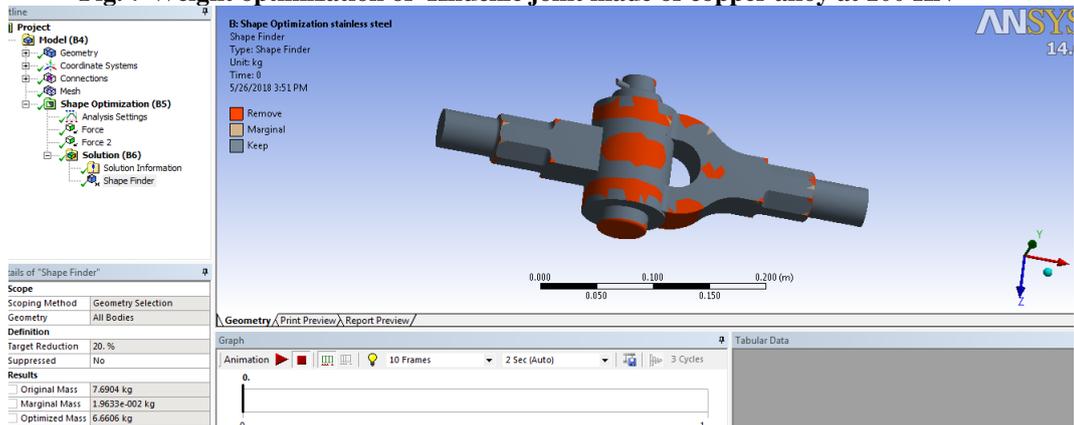


Fig. 8. Weight optimization of Knuckle joint made of stainless steel at 100 KN

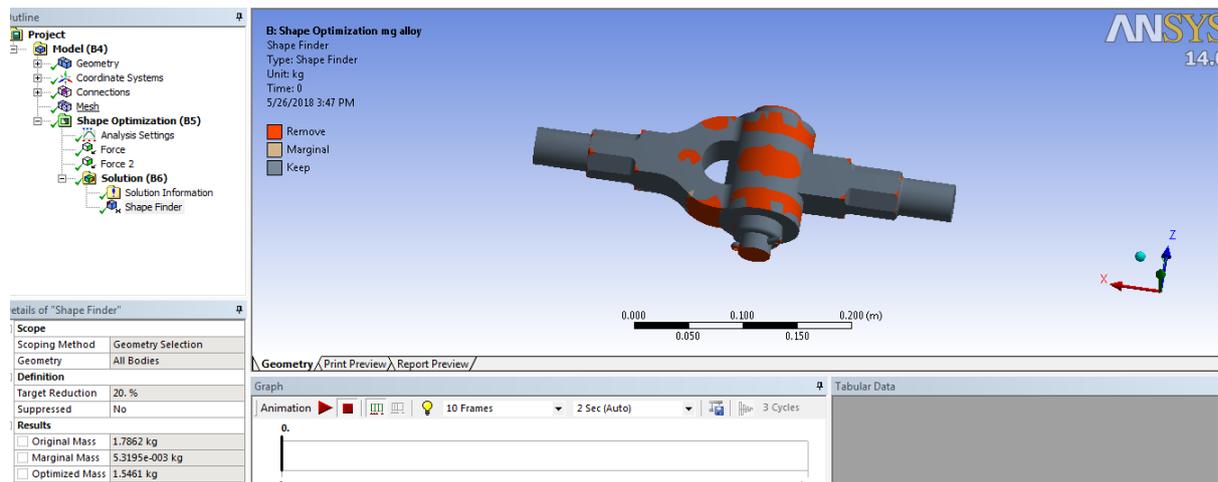


Fig.9 Weight optimization of Knuckle joint made of magnesium alloy at 100 KN

CONCLUSION

It has been found that knuckle joint made of Magnesium alloy having largest mass reduction from 1.7862 kg to 1.5461 kg and having largest % error in mass i.e. 13.44%. So we can prefer Magnesium alloy for the development of knuckle joint.

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