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Design And Optimization Of Sheet Metal Control Arm For Independent Suspension System

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ABSTRACT:

Suspension system of an automobile plays an important role in ensuring the stability of the automobile. Although it has been achieved to a considerable extent, another major aspect of suspension system is passenger car is luxury. A lot of research is going on in this direction, which led to the development of independent suspension system.

Control arm plays a major role in independent suspension system. It is generally made of forged steel which has considerable disadvantages such as weight, cost etc. The project involves the development of sheet metal control arm, which has many advantages over forged metal. The component has been modeled using the curves extracted from workspace available in PRO-E. This model is translated into STEP file, which is than retrieved in 'Unigraphics' for analysis.

The model is subjected to different load conditions and thus analyzed using Structures P.E solver. The stress and stiffness of the model is studied from the results obtained from analysis to verify the success of the design

I. INTRODUCTION:

I.1 CONTROL ARM:

Control arm is the major part of the independent suspension system. It forms connection between the wheel hub and the automobile chassis .
The main functions of control arm are:

- To form a rigid connection between the chassis and wheel hub, to which wheel is attached.
- It allows the wheel, the required degrees of freedom for proper steering and suspension abilities.
- It supports the spring and dampers, which form the major components for shock absorbing.
- To do these functions properly the control arm needs to sufficiently strong. Depending upon the position of the control arm, there are mainly two types of control arms

- Upper and lower control arm. The springs are and shock absorbers are supported between these arms, which prevents lateral movement of springs. Conventionally the control arms are manufactured by the process of forging the medium carbon steels, which are sufficiently strong as shown in figure.1.
- This forged component is bulky and heavier accounting for an increase in vehicle weight. Moreover, the process of forging the control arm is a costlier process as it involves use of complex dies .it also needs a proper care in heating process so as not to effect the strength of the component.

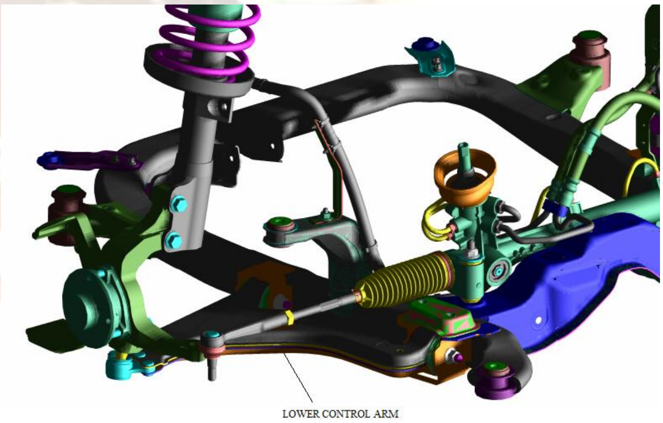

Figure.1: A Suspension System with Ball Joint and Control

I.2 FORGING OPERATION:

Forging is the operation where the metal is heated and then a force is applied to manipulate the metal in such way that the required final shape is obtained. This is the oldest of the metal working processes.

I.2.1 Forging types:

- Smith forging: this is the traditional forging operation done openly or in open dies by the village black smith or modern shop floor by manual hammering or by power hammers.
- Drop forging: This operation done in closed impression dies by means of the drop hammer .Here the force shaping the component is applied in a series of blows.
- Press forging: Similar to drop forging, the press forging is also done in closed impression dies with the exception that the forces is continuous squeezing type applied by the hydraulic presses.

Machine forging: Unlike the drop or press forging where the material drawn out, in machine forging, the material is upset to get the desired shape. The control arms are mostly manufactured by drop forging process.

Advantages:

- Uniformity of qualities for parts subjected to high stress and loads.
- Close tolerances
- Speed of production

Disadvantages:

- High tool cost
- High tool maintenance
- No core holes
- Limitations in size and shape

I.2.2 Sheet Metal Operation:

The sheet metal operation basically involves the process of press working consists of shearing and then plastically working the metal to the desired finished shape and the size through a few quick strokes under heavy loads .

I.2.3 Press Tool Operations:

- Shearing shearing, blanking, piercing,trimming, shaving.
- Tension stretch forming
- Compression coining, sizing, ironing, hobbing
- Tension and compression drawing, spinning, bending, forming and embossing

Advantages:

- It is one the cheapest and fastest way of complete manufacture of a component.

Disadvantages:

- Sheet metal operations are generally performed on the sheets of thickness less than 5mm.

II. DESIGN OF CONTROL ARM

II.1 DESIGN CONSIDERATIONS:

- Space
- Strength
- Weight
- Manufacturing feasibility
- Cost

II.2 DESIGN PROCEDURE:

The design is mainly based on the consideration like decrease of weight and cost etc. The existing forged component is heavy and its manufacturing is complex. So in order to make more reliable it is replaced by sheet metal component which is light and involves more simple operations. The workspace for the design is extracted from the existing forged model. The design and modeling is done using CAD software,"PRO-E". To obtains the workspace the curves are extracted from the extreme edges of the workspace model and copied to a new file. Modeling is done using surfaces. Design with surfaces is simpler and complex shapes can be modeled using operations like merging, trim etc. After the creation of the model using surfaces the surface is thicken to 3.5mm using solid protrusion.

The rod and washer are designed as per required dimensions. A standard ball joint of suitable dimension is modeled. The thickness of the sheet metal component is 3.5mm. Practically the ball joint and the rod are attached to the sheet metal component using wields. Sheet metal component can be manufactured by making two bends along with form operation and one roll operation. The design is improvised based on the analysis results and a final model is developed.

Figure.2: Existing Forged Model

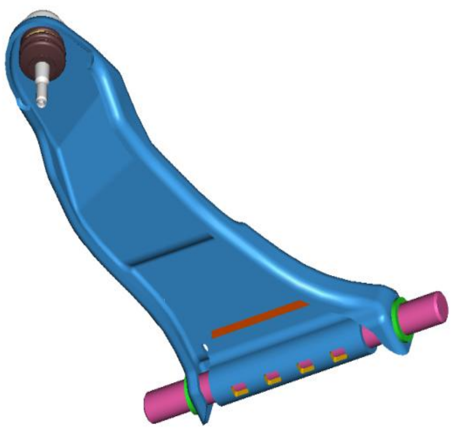

Figure.3: Sheet Metal Control Arm

II.3 MANUFACTURING PROCESS:

1. A flat blank is created from the design.
2. The blank is then subjected to vertical draw.

Figure4: Vertical Draw

1. Flange inside operation is performed; it is done in 2 to 3 stage.
2. The sheet is rolled on to the back rod using rolling punches. It is also performed in 2 to 3 stages.
3. Finally, holes are pierced in the component

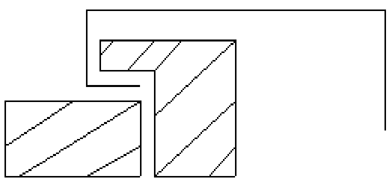

Figure5: Flange Inside

III.ANALYSIS

The final model is exported by "step translator" to a step file. The created step file is imported into Unigraphics' software and converted to Unigraphics part file. Environment : Structures P.E./Linear Statics Plus

Analysis : Structural
Linearity : Linearity:
Time dependency : Steady-state
Solver : Structures P.E.

III.1.MESHING:

The model is meshed with tetrahedral 10 elements. The element is defined by ten nodes having three degrees of freedom at each node, translation in the nodal x, y, and z direction. The element also has plasticity creep, swelling, stress stiffening, large deflections and large strain capabilities.

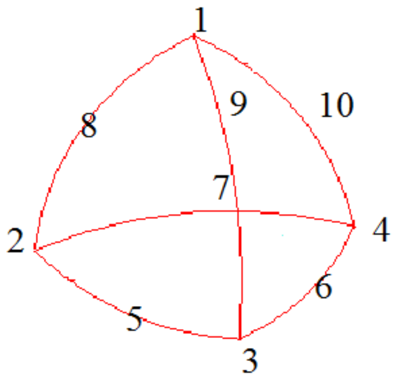

Figure.6: Tetrahedral Element

Figure7: Meshed Component

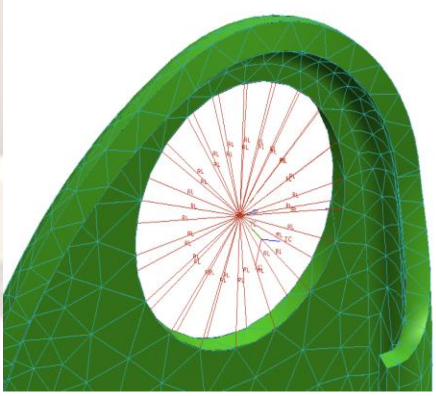

Figure 8: Rigid Links In Hole

At the ball joint hole a central node is created and rigid links are created connecting between the central node and nodes created on the hole during meshing of the component. This is to make nearest to practicality .The point loads are applied at that central node.

Number of elements created = **28276**
Number of nodes created =**53272**
The analysis is carried for three different load conditions.

III.2.LOADS AND BOUNDARY CONDITIONS:
The Model has been analyzed for the following load cases.

III.2.1. Incidental Load case:
These loads act on the vehicle when it is subjected to high and sudden decelerating forces.

Loads:

Load (N)	
f_X	f_Y
0910	350

All the loads were applied at the point D.

Boundary Conditions:
z translation fixed for point D.
x, y, z translations fixed for point E1.
y, z translations fixed for point E2.

III.2.2Maximum Load case:
These load conditions are observed during regular operations of the vehicle.
Loads:

Load (N)	
f_X	f_Y
7880	5860

All the loads were applied at the point D.
Boundary Conditions:
z translation fixed for point D.
x, y, z translation and rotations fixed for point E1.
x, y, z translation and rotations fixed for point E2.

III.2.3Stiffness calculations:
Loads:

Load (N)	
f_X	f_Y
1000	1000

All the loads were applied at the point D.

Boundary Conditions:
z translation fixed for point D.
x,y,z translations fixed for point E1.
y,z translations fixed for point E2.

III.3MATERIAL PROPERTIES:
Modulus of Elasticity =210000 MPa
Poisson's ratio = 0.3
Steel (safe stress = 540 MPa)
It is finally solved using structures P.E solver .The results obtained are retrieved through post processor section.

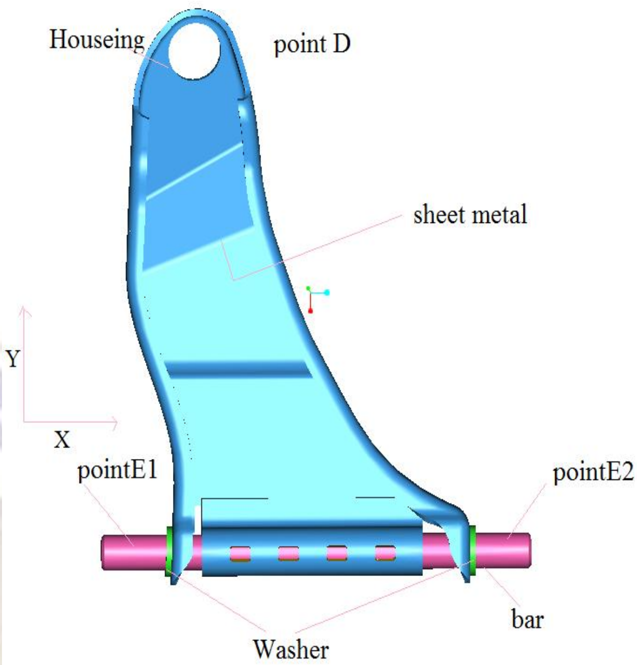

Figure 9: Points Where Loads and Boundary Conditions To Be Applied

IV.RESULTS AND DISCUSSIONS

IV.1. INCIDENTAL LOAD CASE:
The maximum stress observed during this case is 513 MPa
The yield strength of the material is 540 MPa
It is observed that, the stress obtained is less than the yield strength of material .So the control arm withstands the incidental loads.

IV.2. MAXIMUM LOAD CASE:
The maximum stress observed during this case is 466 MPaThe yield strength of the material is 540 MPa
It is observed that, the stress obtained is less than the yield strength of material .So
the control arm withstands the maximum loads.

IV.3. STIFFNESS LOAD CASE:
Stiffness calculations:
Stiffness=force/maximum deflection
K_X **=1000/.1439=5263N/mm**
K_Y **=1000/.02643=37835N/mm**

Direction	Objective Stiffness N/mm	Obtained Stiffness N/mm
K_X	3000	5263
K_Y	24000	37835

From the stiffness calculations it is observed that, the control arm satisfies the stiffness requirements in X and Y-directions.

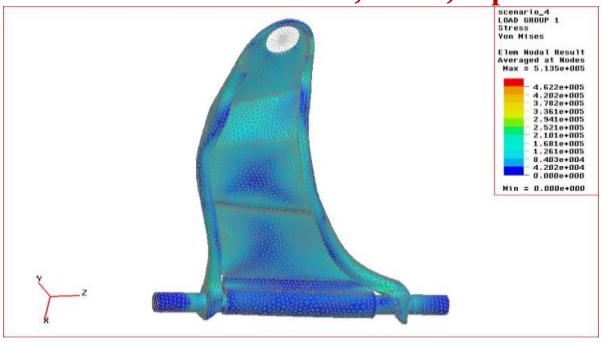

Figure10: Incident Load Case

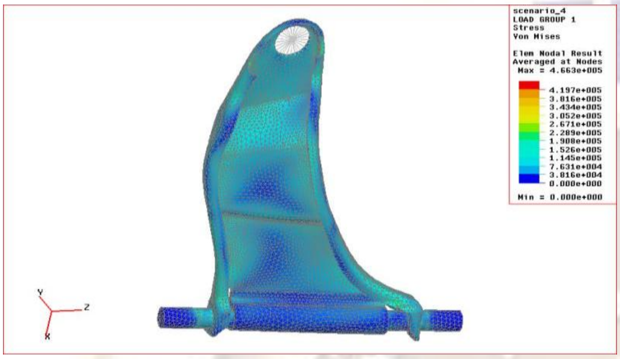

Figure11: Maximum Load Condition

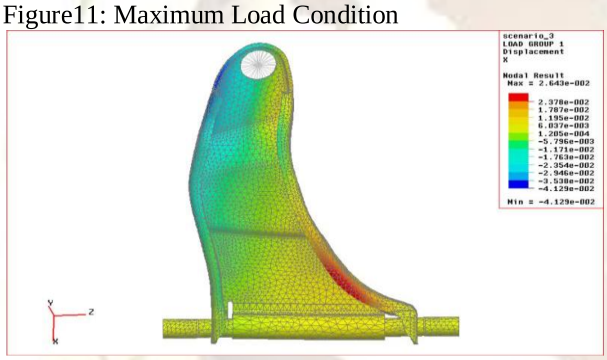

Figure12: Displacement (-X) In Y Direction

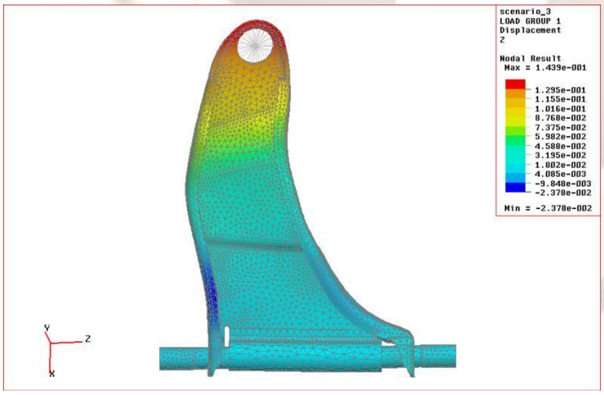

Figure13: Displacement (Z) In X Direction

V.CONCLUSIONS

From the design and analysis data, it is observed that

- The weight of the component is decreased by 25% i.e. the weight of the forged model is 4.32 kg and the weight of the sheet metal model is 3.23kg.
- Ease of manufacturing. The sheet metal operations are simple and cheap when compared to the forged operations.
- Ball joints of different standards can be used by varying the size of the hole by changing the piercing tool.
- The cost of component is reduced to a considerable extent as the raw material used for sheet metal component is very cheap than that used for forged component.
- The results obtained from analysis infer that the sheet metal component satisfies all the design considerations. The stresses obtained for different load conditions are within the limits. Stiffness is observed to be satisfactory.

Hence, sheet metal control arm is more beneficial than forged control arm.

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