Comparative CAE Study for Driveline Elements & CNG Cylinder Mounting Arrangements with Pro/Mechanica & Nastran

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***Abstract*—Sevral software are available for Computer Aided Engineering. Nastran is one of the popular software in the era of CAE, because of the accuracy of the results with the actual one, but because of the time taken for the analysis, cost of the software, also skills required for software handling, it is popular amongst the big scale industry only.**

Pro/Engineer is one of the most used software in industry for modeling purpose. Pro/Mechanica is a module from PTC (Parametric Technology Corporation) for the CAE with Structural & Thermal analysis. Mechanica uses P element, where as Nastran uses H element theory.

So, to check both these theories, some components are selected for the analysis, in which same loading & constraint conditions are maintained. After carrying out this exercise, it can be concluded that, almost in all the models Mechanica results falls with in +-7 % of the Nastran results. So, when modeling is in Pro/Engineer, and wants to analyze any part quickly, it is highly recommended to go for the Pro/Mechanica, so that design lead time can be reduced, to some extent.

***Keywords*—CAE, Pro/Mechanica, Nastran, P-element theory, H-element theory**

I. INTRODUCTION

Nowadays Computer Aided Engineering (CAE) is used for virtual prototyping and analysis. Sufficient confidence level is made by using CAE software for the product performance, prior to prototype testing. While this is a welcome step and has resulted in substantial reduction in development time, further improvement is still possible by ensuring that, the initial design chosen is closer to the optimal design. This will potentially result in less iteration using costly CAE resources and can further reduce the development time.

P-Elements Versus H-Elements

Pro/MECHANICA Structure uses adaptive p-element technology whereas traditional finite element codes use non-adaptive h-element technology. With h-elements a linear or quadratic equation is usually used to describe the element's deformation shape function. This has several consequences

1. These elements cannot follow accurately curved geometry, and one can get a faceting effect in the FE model which is not present in the true geometry.
2. In areas of high stress gradient it is difficult for such elements to give an accurate result, because they are incapable of giving sufficient internal stress variation to follow the true stress contour.
3. Lots of small elements are required. The solution to these problems with traditional codes is to decrease element size and increase element density in troublesome areas. The problem with this approach is that it relies either on an experienced analyst predicting the location of stress concentrations and hence where increased element density will be required before the analysis, or for very small elements to be used everywhere (significantly increasing run times).

Case Study

To compare p-element & h-element theories, same component is analyzed with both theories that is by Pro/Mechanica & MSC Nastran, with all loadings & constraints remaining the same. Selected components are Centre Mounting Bracket, Spring Hanger Bracket, Rear Axle and CNG Cylinder Mounting Arrangements.

In the present study main interest is the comparison of the both the theories, so not much emphasize is given for the loads calculations. But whatever the loadings & constraints conditions are taken, all the things are made same in both the cases, and then the results are compared.

Centre Mounting Bracket

This is the bracket used for mounting the propeller shaft, with cab or cross member. General loading is the vertically downward force. According to SAE AE-7, four types of forces are acting on the bracket, and they are,

1. Self weight of propeller shaft
2. Forces due to unbalance
3. Secondary couple
4. Forces due to length compensation

For the case taken in to account load is coming 2900 N, vertically downward, and upper plate is made fixed, that is displacement & rotation in all direction are made zero. Load is only applied to the lower part of bearing, according to Stribeck's theory.

After applying constraints, loading, material is applied, then meshing is done, which states that, there is no error in model.

After successful meshing, mesh file can be saved, for further use. Then analysis is run.

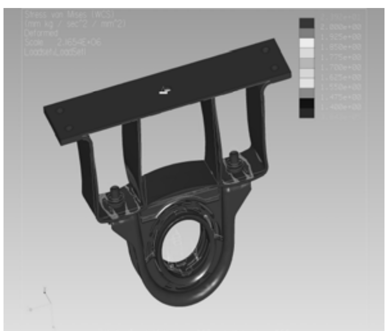

Fig.1. Mechanica Stress Plot, with max stress coming 239.2 N/mm^2

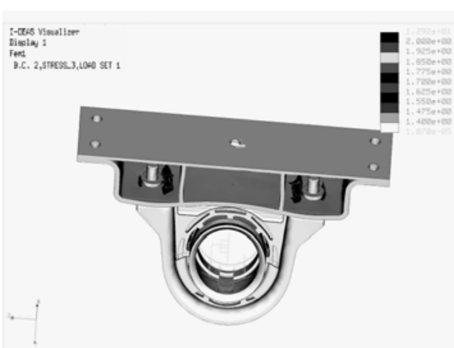

Fig. 2: Nastran Stress Plot, with max stress coming 251.6 N/mm^2

Centre Mounting Bracket with Cross Member Mounting

Same bracket is then mounted with cross member, without changing the angle, which can affect the loading conditions.

Cross Member Centre Mounting Bracket with Optimization

From manufacturing point of view, all plate members are made of 5 mm thickness.

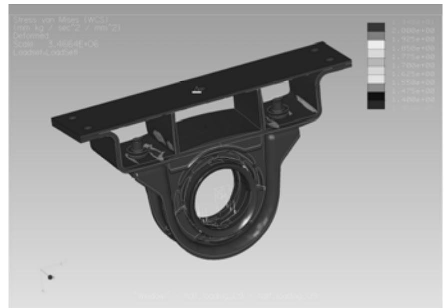

Fig. 3: Mechanica Stress Plot, with max stress coming 134.8 N/mm^2

Fig. 4: Nastran Stress Plot, with max stress coming 129.2 N/mm^2

Spring Hanger Bracket

In Rear Wheel Drive type vehicles, there is addition of the Spring Hanger Bracket, to incorporate the differential in the system. Load acting on the bracket is the weight of the Rear Axle, with 3g effect.

When rear axle weight is compared with the 3g effect, its too less, so it can be neglected. But as the main concern of the paper is to compare the Nastran & Pro/Mechanica results, such details are not discussed, while throughout in the paper.

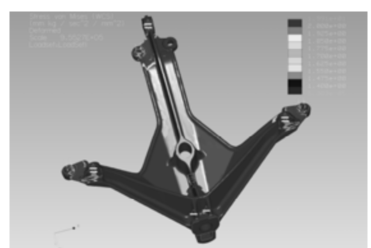

Fig. 5: Mechanica Stress Plot, with max stress coming 199.1 N/mm^2

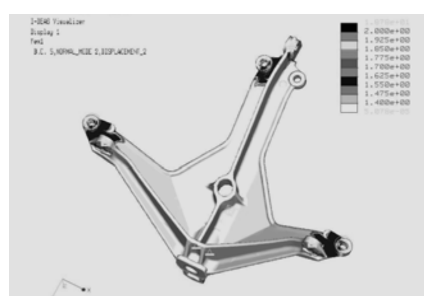

Fig. 6: Nastran Stress Plot, with max stress coming 187.8 N/mm^2

Rear Axle

Axle selected for the analysis is of front wheel drive vehicle. In which loads are taken as, brakeing 1g, bending 1.5g, cornering 0.4g, and torsional load of 116 kgm. After loading & constraining of the model, is allowed for the RUN.

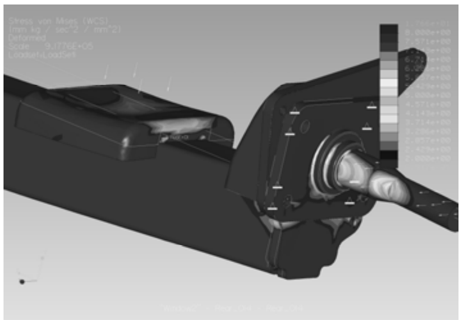

Fig. 7: Mechanica Stress Plot, with max stress coming 176.6 N/mm^2

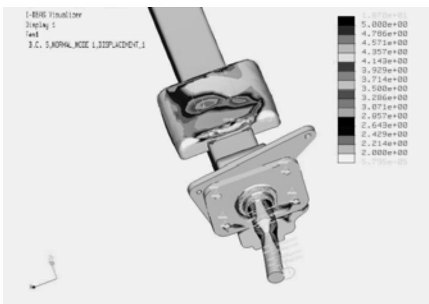

Fig. 8: Nastran Stress Plot, with max stress coming 187.4 N/mm^2

CNG Mounting Arrangement

Basically there are three types of the cylinder mounting arrangements. Out of which two are analyzed. Those are above floor & Below Floor. In above floor arrangement two cylinders of 78 & 85 kg are used, and in below floor one cylinder of 35 kg is analyzed. According to SAE 2512 FOS should be taken as 20, so as to include the dynamic conditions in design.

Above Floor Arrangement

Load on single bracket is 1/3 of the total load of the cylinders.

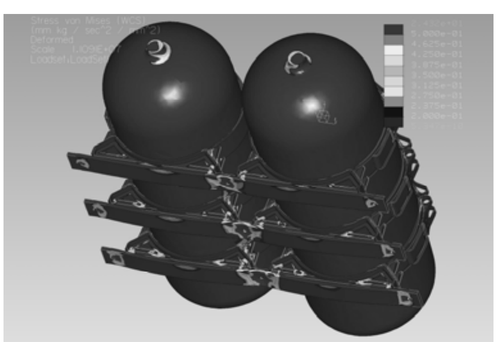

Fig. 9: Mechanica Stress Plot, with max stress coming 243.2 N/mm^2

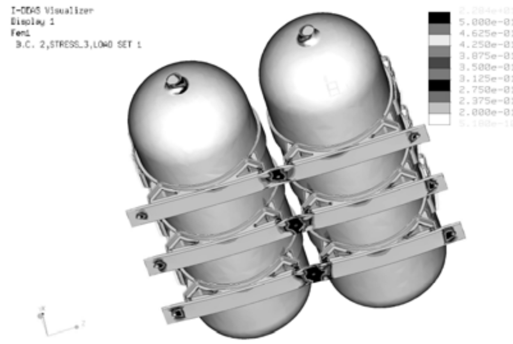

Fig. 10: Nastran Stress Plot, with max stress coming 228.4 N/mm^2

Below Floor Arrangement

Load in this case is also made same, as all other conditions are remaining the same.

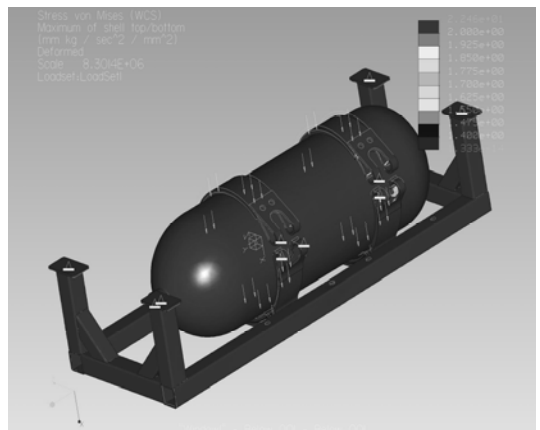

Fig. 11: Mechanica Stress Plot, with max stress coming 210.6 N/mm^2

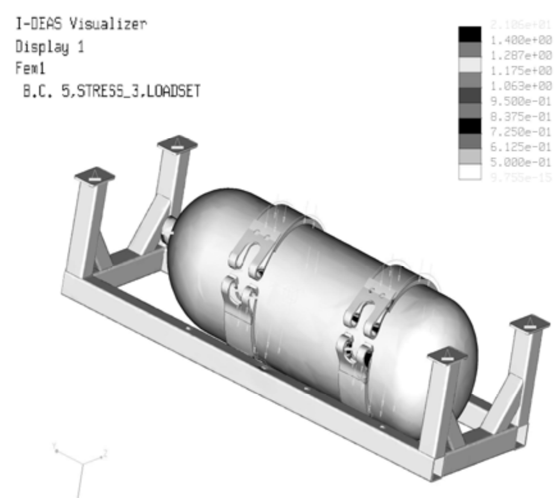

Fig. 12: Nastran Stress Plot, with max stress coming 224.6 N/mm^2

Comparison with Nastran

Nastran is one of the most popular software in the CAE field, so, all these results are compared with this software. This can be concluded in the following table.

TABLE 1: MECHANICA COMPARISON WITH NASTRAN

Model No.	***Stress Level N/mm²***		***% Diff.***
	Pro/M	***Nastran***	
1.	239.2	251.6	-5.18
2.	152.7	159	-4.13
3.	134.8	129.2	4.15
4.	199.1	187.8	5.68
5.	176.6	187.4	-5.91
6.	243.2	228.4	6.09
7.	210.6	224.6	-6.65

II. CONCLUSIONS

From all above results, we can conclude the following things.

1. Almost all MECHANICA analysis results are coming within +- 7% of the Nastran results, so we can predict the Nastran results without actually carrying out the analysis.
2. Redesigning is very easier from analysis point of view if you are working with the MECHANICA.
3. Time taken for the analysis in Nastran for Centre Mounting bracket was on an average 8 hr, while working in Nastran, but for MECHANICA it was just 45 min., also in all other models it was having the same ratio.
4. As we are doing modeling in Pro/ENGINEER, and analysis in MECHANICA, there is no need of transferring the data from one software to other, and hence there is no data loss because of such transaction, which is happening in other modes of analysis.
5. Analysis can be carried out by the moderately trained person, as we are using the P-element it can be taken in to account by the MECHACNIA solver. Hence, there is no need of the experienced person from the analysis area, so as to decide the meshing size, meshing density for particular area.
6. And finally the cost point of view, which is a more important. Pro/MECHANICA cost is nearly 1/10th of the Nastran.

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