# Quarter Model Analysis of Wagon-R car's Rear Suspension using ADAMS

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## Abstract

*An ADAMS is multi-body dynamic simulation software, for doing analysis in ADAMS first 3-d modelling is done in Pro-e and importing the model to ADAMS. For quarter model analysis of suspension system material and joints have to be applied to the imported parts and then wheel movements are given. The results are obtained in the form of time history plot for force and displacement of the spring. Simulation results are same as obtained by analytical procedure.*

*Here in this paper we represent the procedure for quarter model analysis of wagon-R car's rear suspension system using ADAMS and some interesting results. In ADAMS we have perform force and deformation analysis for quarter model of Wagon-R car's Rear suspension.*

## 1. Introduction

Suspension system is a very essential part of the automobile vehicle. Suspension system basically has two main components. Spring and shock absorber, both have their own function. Spring gives vertical motion to the wheel and provides allowance to work for shock absorber. Shock absorber as name suggests absorb the shock that may be transmitted to the body if not provided.

The suspension system must provide proper steering control and ride quality. Performing these functions is extremely important to maintain vehicle safety and customer satisfaction.[1] The suspension system significantly affects ride and handling of the vehicle that is 'vibrational' behavior including ride comfort, directional stability, steering characteristics and road holding. The factors which primarily affect the choice of suspension type at the front or rear of the vehicle are the engine location and whether the front wheels are driven /undriven and /or steered/un steered. [2] So it is important to analysis the suspension system.

There are two approaches to modeling shock absorbers: analytical (or physical) modeling based on physical and geometrical data, and parametric modeling based on experimental data. An exhaustive review of physical models to date is presented by Duym, et. al [3].

Suspension system analysis is done with the help of Automatic Dynamic Analysis of Mechanical Systems (ADAMS). For analysis we have imported part from Pro-e. And that assembled using appropriate joints.

## 2. Analysis procedure in ADAMS

Some physical parameters in the equation of motion can be calculated directly while other parameters must be identified from experiments [4]. One of these parameters is force exert on the spring while deflection for that analysis of the mechanism in ADAMS we have to follow some standard procedure. Step to follow for the analysis is as shown in fig 1. The detailed procedure is as below

For analysis of the suspension system as shown in Fig 2 first we have to import the model from pro-e (in this tool we have created solid models of suspension system). We have import solid parts of the suspension system in Para solid format (.x_t).

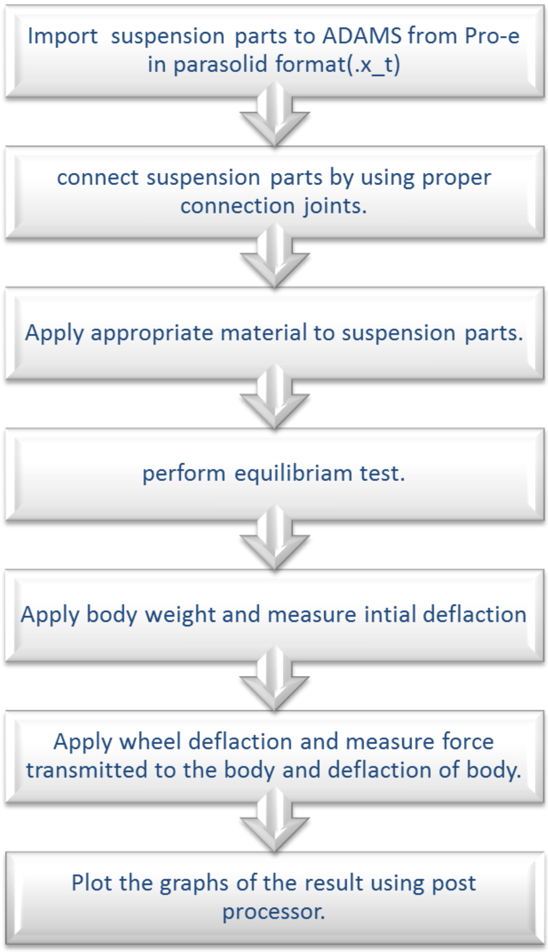


Fig 1 Steps for the analysis in ADAMS

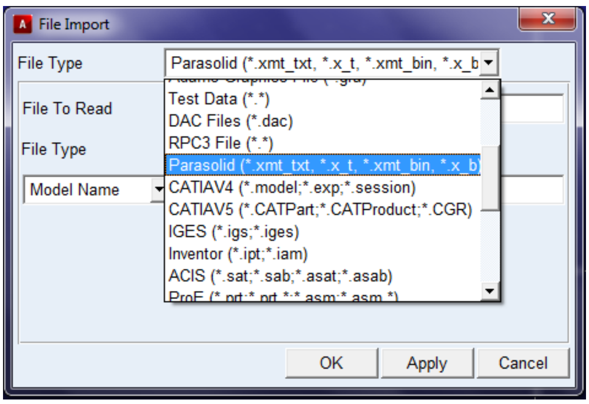


Fig. 2 importing part in Para solid model

After importing the solid models connect the suspension parts by using appropriate joints in the ADAMS as shown figure 3.

In the third step materials have to be applied to the solid parts so that all the parts behave like applied material the material applied to the suspension parts are as below. As shown in figure 4 first we have to select the part and then a window pop up having information about the part in that select mass properties. In that select geometry and material type and in that select material as shown in figure 4

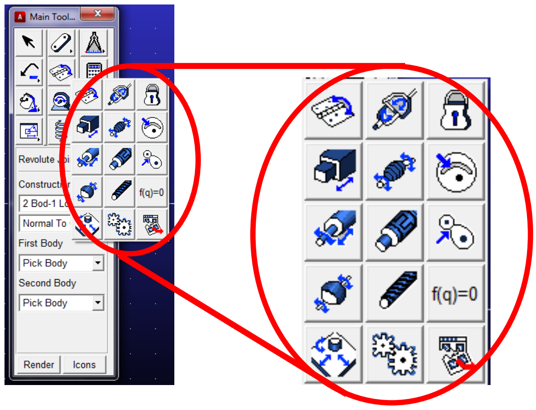


Figure 3

| Material | Density (Kg/mm$^{3}$) | Young's modulus (N/mm$^{2}$) | Position's ratio |
|---|---|---|---|
| Automobile steel | 7.801 x $10^{-6}$ | 2.07 x $10^{5}$ | 0.29 |

Table 1

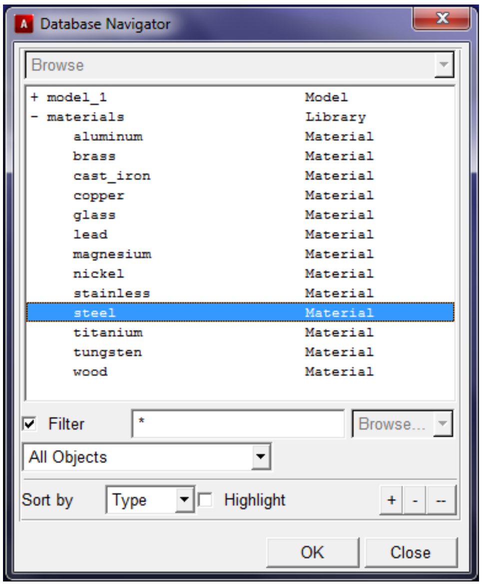


Fig.4 Material selection in ADAMS

After connection of the suspension parts and applying material to the suspension system we have to perform an equilibrium test to for the connected parts. This equilibrium test checks that all parts which are connected to each other is having some DOF or not, and if DOF is there then

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mechanism is in working condition or it collapse when motion is given to the mechanism.

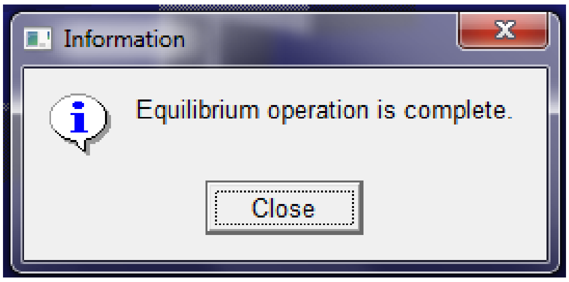


Fig. 5 Equilibrium completions in ADAMS

If equilibrium test is successful then one window will pop up as shown in fig 6.5 and then only we can go for further analysis. For further analysis part weight and body weight is an important criteria. So we apply part and body weight first before proceeding to the further force deformation analysis. Also measure an initial deflection for the suspension system due to body weight.

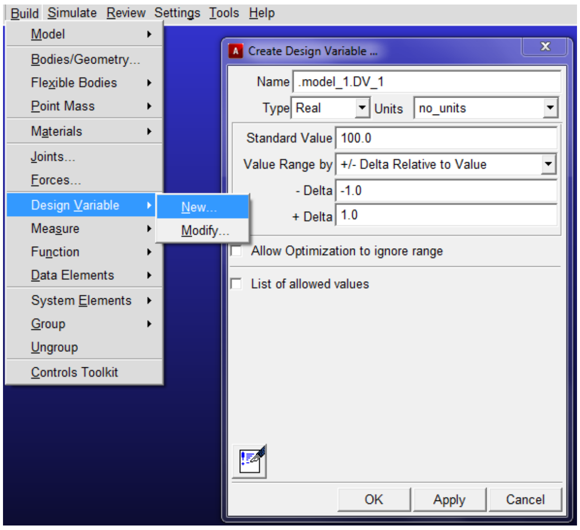


Fig. 6 Bump heights as a Design Variable in ADAMS

Now for giving a wheel a deflection first a design variable has to be made in ADAMS. This design variable will work as an input data of wheel deflection and gives movement to whole suspension mechanism.

To build a Design variable go to the design variable in build tool and then select new, one pop up window open in that fill necessary data as shown in figure 6

Now before applying a wheel deflection we have to point a marker at which point we want to measure force and deflection. We want to measure a force at a spring end because spring is in connection with the car body and also we want a deformation of the body due to the wheel deflection.

| Deflection (in mm) | Description |
|---|---|
| 50 | rambling strip, (small continuous bumps), height diff. while transferring from one to another road surface |
| 100 | Normal bumps |
| 150 | Heighted bumps (speed breaker) |

Table 2 Analysis deflection detail and description

For comparison of the suspensions deflection of both suspension systems should be same, for that deflection of the wheel should be same. So we have decided to perform the analysis for following bump height. Bump heights are having some identical reasons to be chosen.

## 3. DOF in for various link connection of wagon-R car's suspension in ADAMS

Analysis of quarter model of existing suspension system is done using a same procedure mentioned above. Existing suspension's component is first imported and then assembled in ADAMS using appropriate joints.

| **Links connected with kinematic joints** | **Type of joints** | **DOF** |
|---|---|---|
| Car body- ground | Transitional | 1 |
| Car body- body support | Fixed | 0 |
| Body support- lower support arm | Revolute joint | 1 |
| Lower support arm – lower support connect | Fixed | 0 |
| Lower support connect- wheel rod | Revolute | 1 |

Table 3 Joint type and DOF for existing suspension system

For quarter model analysis only quarter part of the suspension system is analyzed. As the body is not in stable position without four wheels body must be connect with transitional joint for first analysis and ground for further analysis. Connection detail of existing suspension is given in table 3.

## 4. Assembled quarter model of Wagon-R car's rear suspension in ADAMS

For the quarter car analysis of existing suspension system is assembled using joints mentioned in the table 3 Assembled model is first check for the initial deflection and force and deflection analysis has been performed.

In Adams Model of spring and shock absorber cannot be imported; it is having an inbuilt function to create spring and shock absorber. So in this quarter model of existing suspension system as shown in the figure 7 springs and shock absorber are not like model in Pro-e.

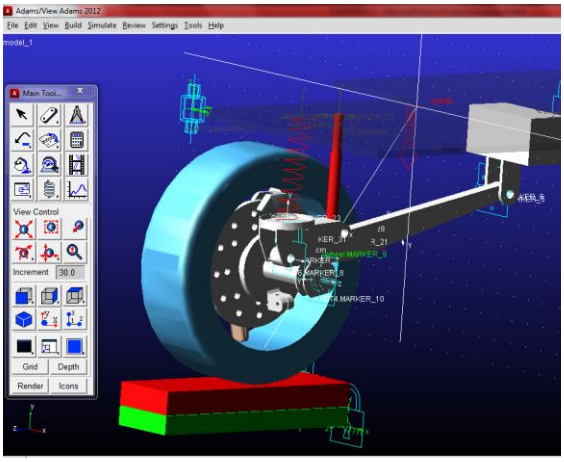

Figure 7 existing suspension models in ADAMS

## 5. Analysis Results of Quarter model suspension system.

In ADAMS Force and deformation analysis has been done and for both the cases we have graphs in the form of time. Analysis is also done for various heights of 50, 100and 150 deflections. Analysis result here presented by bump height variations. And then self-comparison is done. Means comparison of force and deflection is presented for different bump height.

### 5.1. Result of kerb weight on quarter model of existing suspension

Due to kerb (self) weight of the car spring of the suspension is initially compressed at some extent. This when we find analytically we found it was 70 mm and here it is also about 72 mm. as shown in figure 8. Both answers are nearly similar. In a full load condition out 104 mm initial compression is done. As we seen in figure 9 deflection calculated by the software is also near to the answer of analytical calculation.

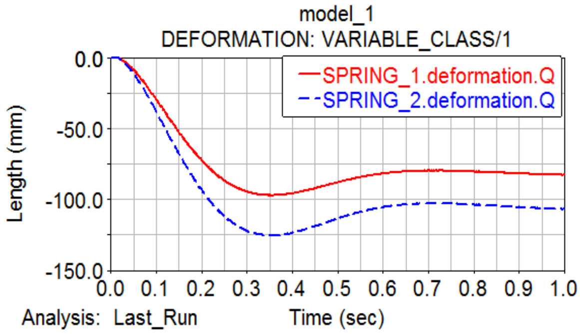


Fig. 8 Initial deflection of spring and damper of existing suspension system

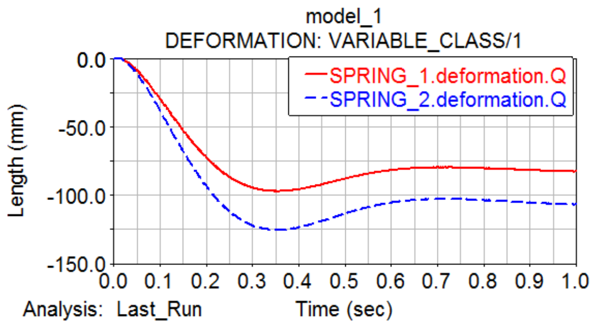


Fig. 9 Deflection of spring and damper in full load condition of existing suspension system.

### 5.2. Results for analysis done for various bump heights

- **For 50 mm deflection**

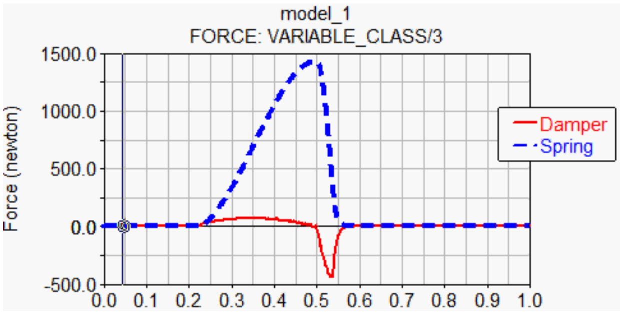


Fig. 10 Force V/s Time graph of spring and damper for 50 mm deflection

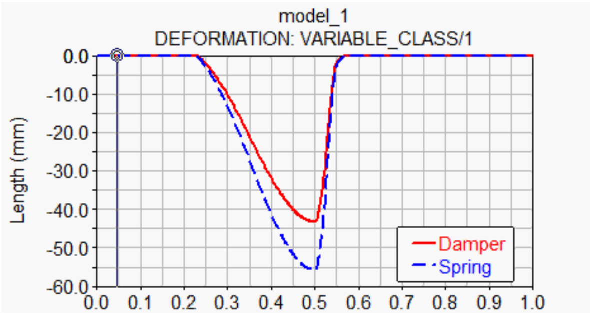


Fig. 11 Deflection V/s Time graph of spring and damper for 50 mm deflection

- **For 100 mm deflection**

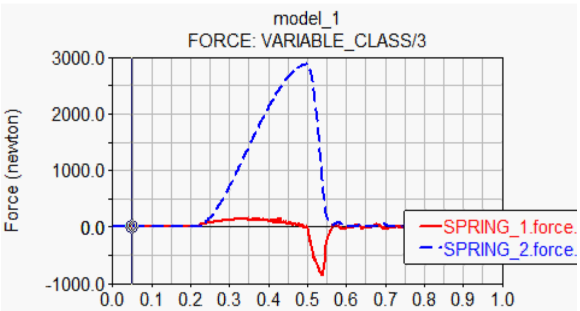


Fig. 12 Force V/s Time graph of spring and damper for 100 mm deflection

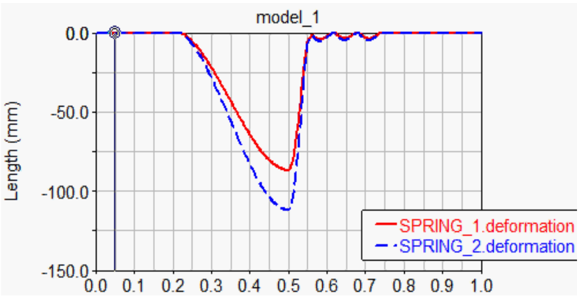


Fig. 13 Deflection V/s Time graph of spring and damper for 100 mm deflection

- **For 150 mm deflection**

In existing suspension system after analysis we come to know that suspension system is not capable of taking such a high amount of deflection by itself. The system collapses at 0.39 sec.

It means the system is barely capable of taking a deformation of 115 mm. and above that comparison of damper is not possible and system fails.

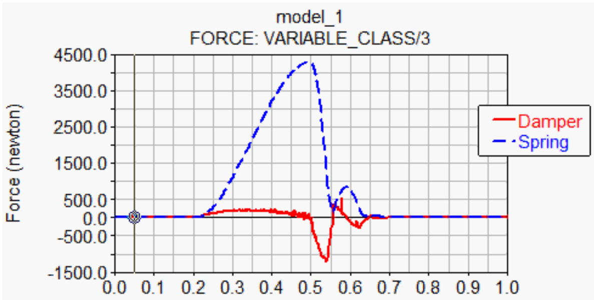


Fig 14 Force V/s Time graph of spring and damper for 150 mm deflection

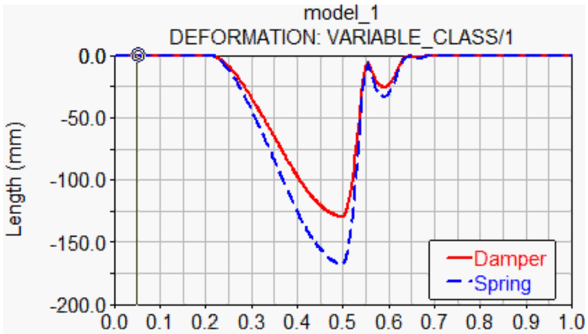


Fig. 15 Deflection V/s Time graph of spring and damper for 100 mm deflection

### 5.3. Self-comparison result of existing suspension

Force required to compress existing suspension system that we compare for different deflection of spring.

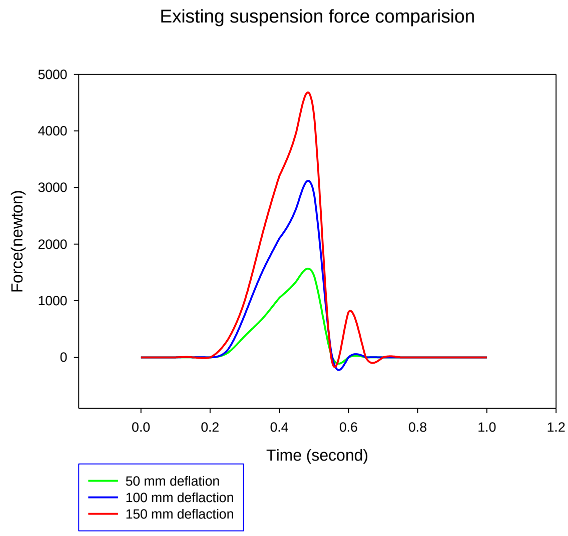


Fig 16 self-comparison of force of existing suspension system

## 6. Conclusions

As we have seen a results of quarter model of wagon-R car's rear suspension system. From these results we can say that the system is not capable of taking load more than 2700N.Means system is only capable of taking load of 1100kg at spring's full deflection. Means car is only design for 3.5 persons. If the car is having more person than discomforting is sure. And excessive load decreases stability and ride handling.

## 7. References

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[4] W. Schiehlen, B.Hu, "Spectral Simulation and Shock Absorber Identification", International Journal of Non-Linear Mechanics 38, 2003, pp. 161-171