CHAPTER 6

DYNAMIC FEM ANALYSIS

From the meshed model got in chapter 5 for static analysis, with the same established constraints, the dynamic analysis was developed in Algor^{TM} software.

6.1 Objectives of dynamic FEM analysis

The main purpose of dynamic analysis is to find out how the steering system behaves under a dynamic force equivalent to driver's weight, it means 981 N. Such force is located all over the surface of the seat. To set weight-shifting conditions under steering action, the operative force of 323 N calculated in chapter 4, page 88 was located in the right half of seat. Force elements (bolts and springs) are a particular topic in this simulation; the analysis will give the deflections and forces that each element experiment during the event.

Also stress distribution in each element of rear axle is a concern in this chapter to get an evaluation parameter for the design.

6.2 Model Set up

This analysis follows the same constraints and force loads set up in chapter 5 as shown in figure 6.1

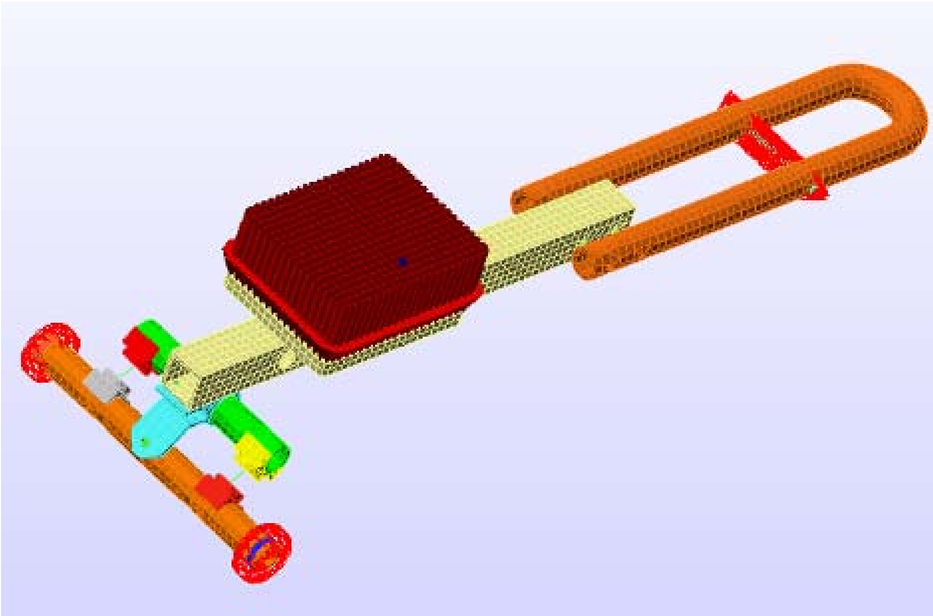


Figure 6.1 Overview of constraints and force set up as given in chapter 5, page 114.

6.3 Dynamic analysis

A good approach to set the test for our model would be a 5 E7 cycle-duration test under a sinoidal load ( ), as the maximum design life cycle to which an element was designed is such value –in case of aluminum 6061 parts-. However, hardware requirements for such a test are beyond the computer resources available for the execution of it. Even for 10E6 cycles, corresponding to steel number of cycles before failure, test becomes unachievable.

Principal parameters set up for the analysis are shown in figure 6.2 in MES with non linear materials model analysis type. The time the event last is 0.042 s and the capture rate –it means the number of iterations per second- was set up to 100 Hertz, setting the event to have 43 time steps.

Test consisted in a 25 Hz inverse force equivalent to driver’s weight under a sinoidal signal.

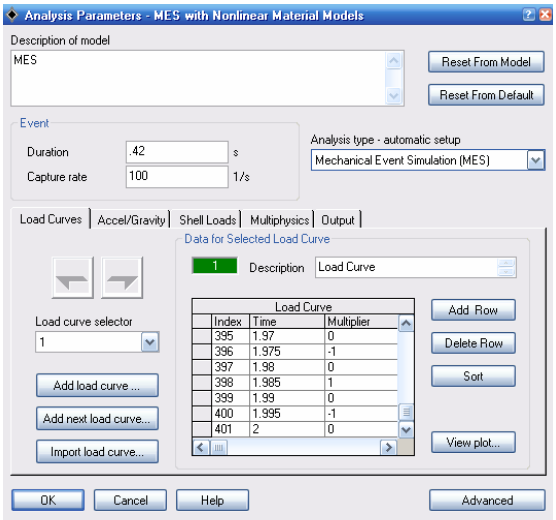


Figure 6.2 Analysis parameters for MES with non linear material models for first and second tests.

Analysis last 4 minutes 30 seconds and screen for the first time step is shown in figure 6.3. View of first time step is shown in figure 6.4

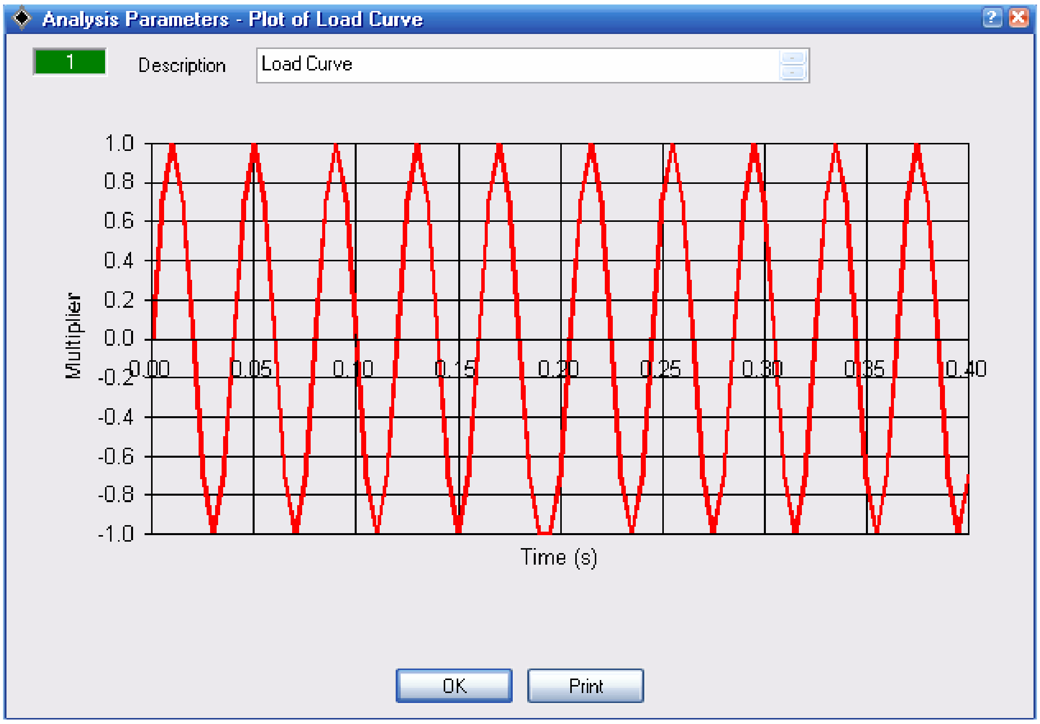


Figure 6.3 Force sinodial signal for dynamic event.

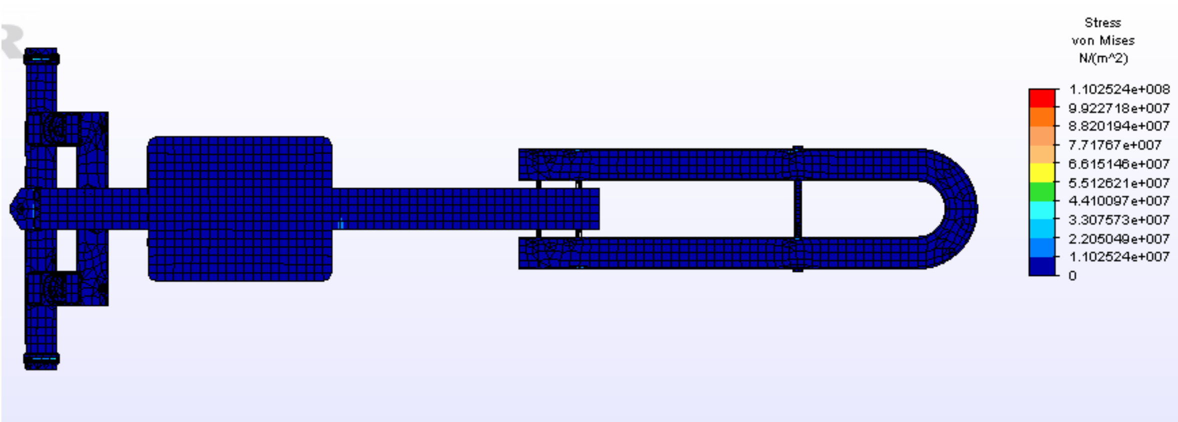


Figure 6.4 General overview, first time step.

6.4 Spring Force elements

Fig. 6.5 showing the axial force that springs, bolts and steering pin undergo during the event.

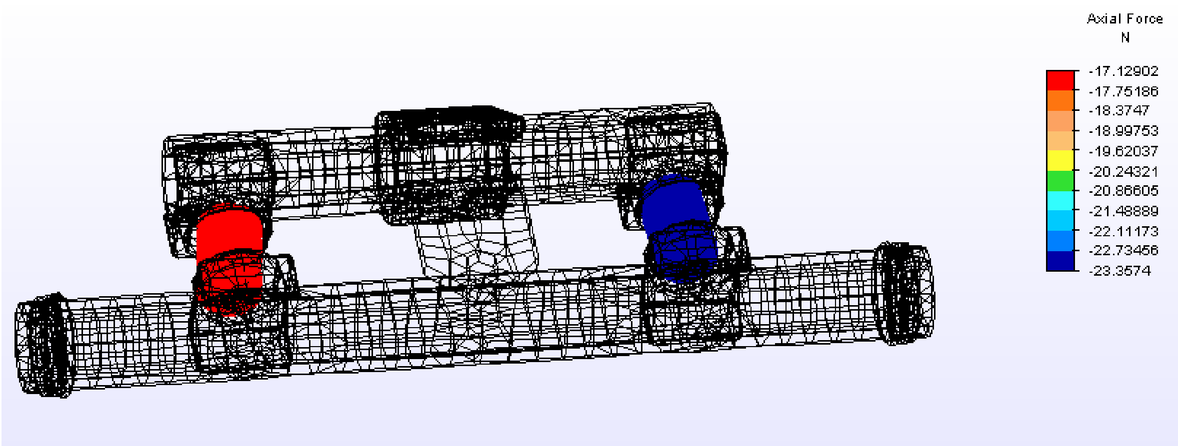
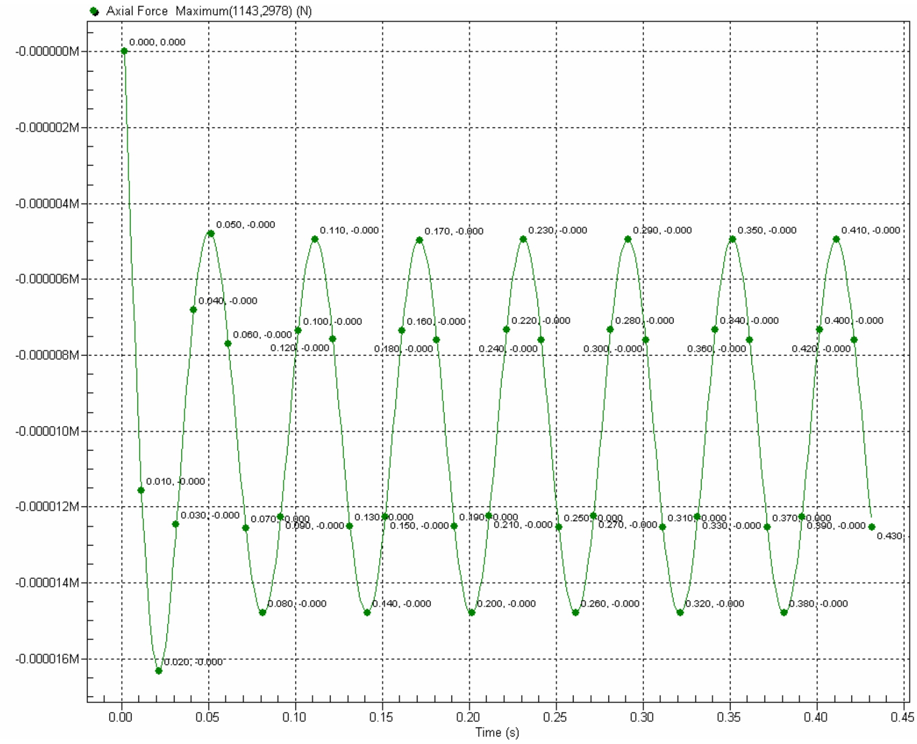
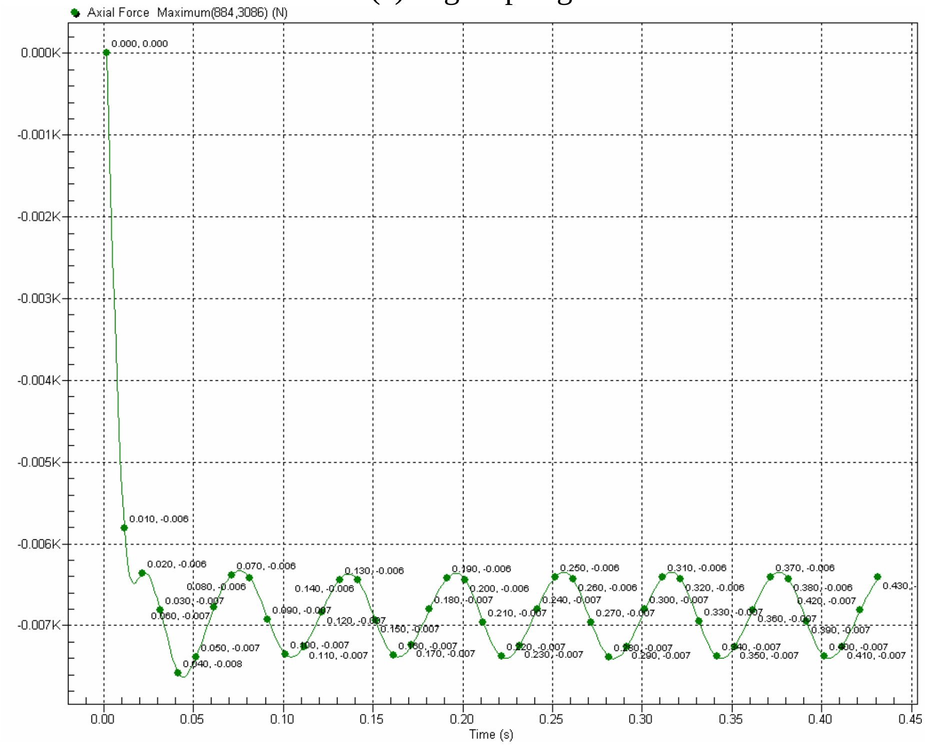


Figure 6.5 First time step sequence for force elements.

The following plots of force in springs versus time were got from the test.



(a) Right spring



(b) Left spring

Figure 6.6 Forces in springs during dynamic event.

It is seen that maximum value for spring force took place in time 0.025 s, with an approximate value of 16 N for right spring and 7.5 N for each spring.

6.5 Steering kingpin

Fig. 6.7 shows the truss element representing the steering kingpin. Such element was constructed with the joint browser feature as a pin joint (fig.6.8)

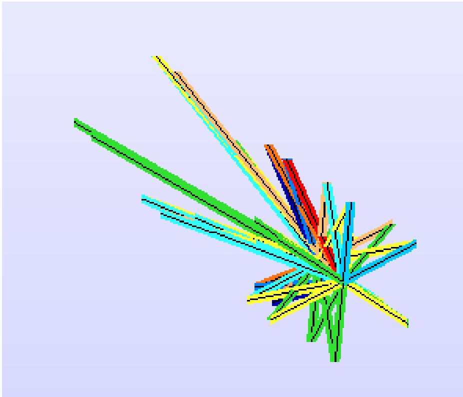


Figure 6.7 Steering pin truss element.

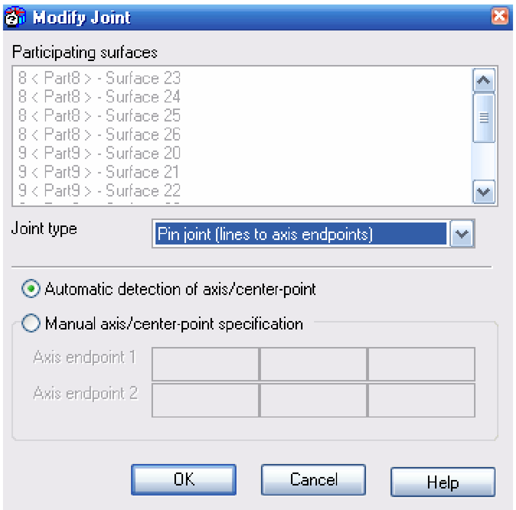


Figure 6.8 Joint browser window

Figure 6.9 plots axial force and figure 6.10 plots axial stress in the steering pin.

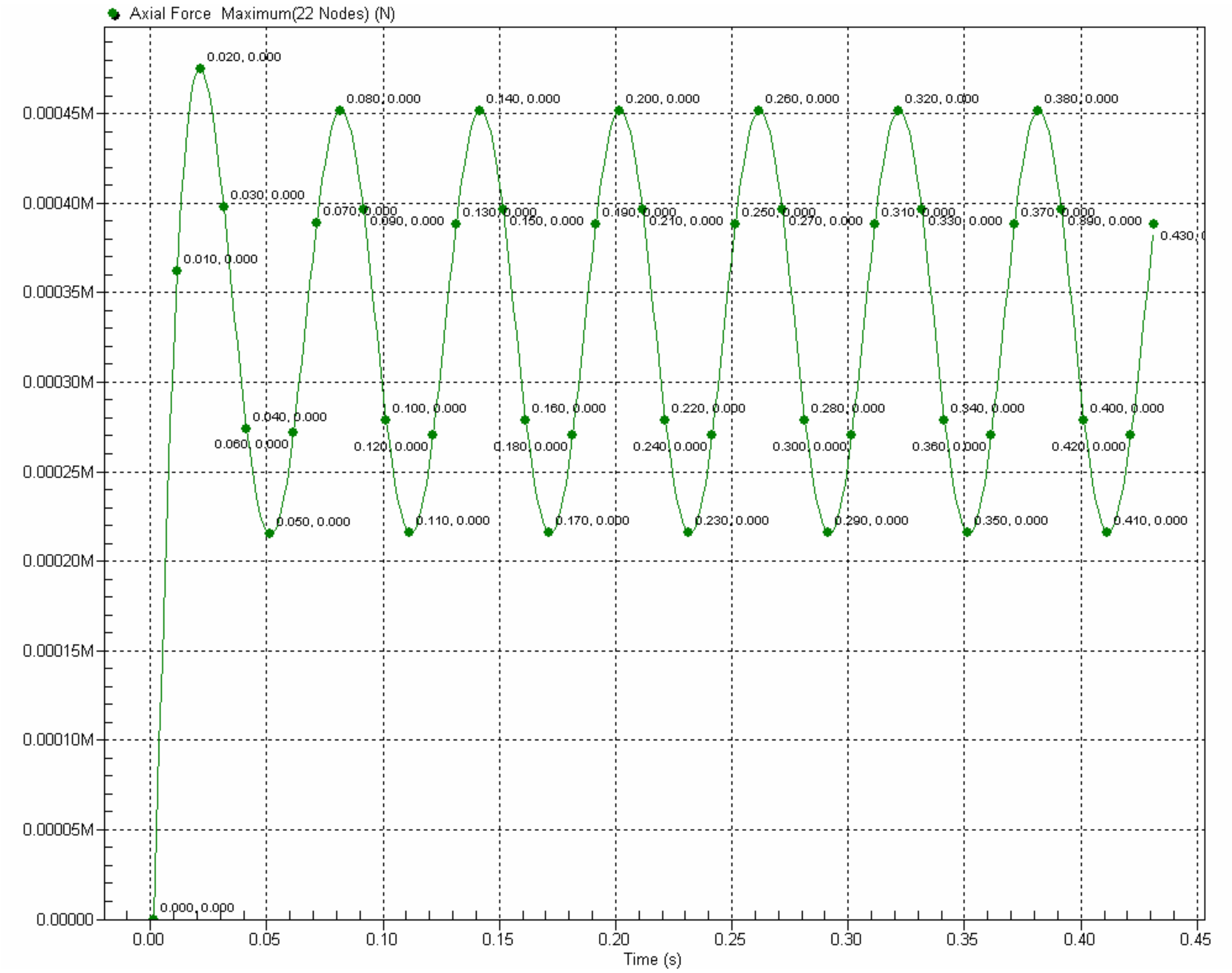


Figure 6.9 Axial force in each line element of truss

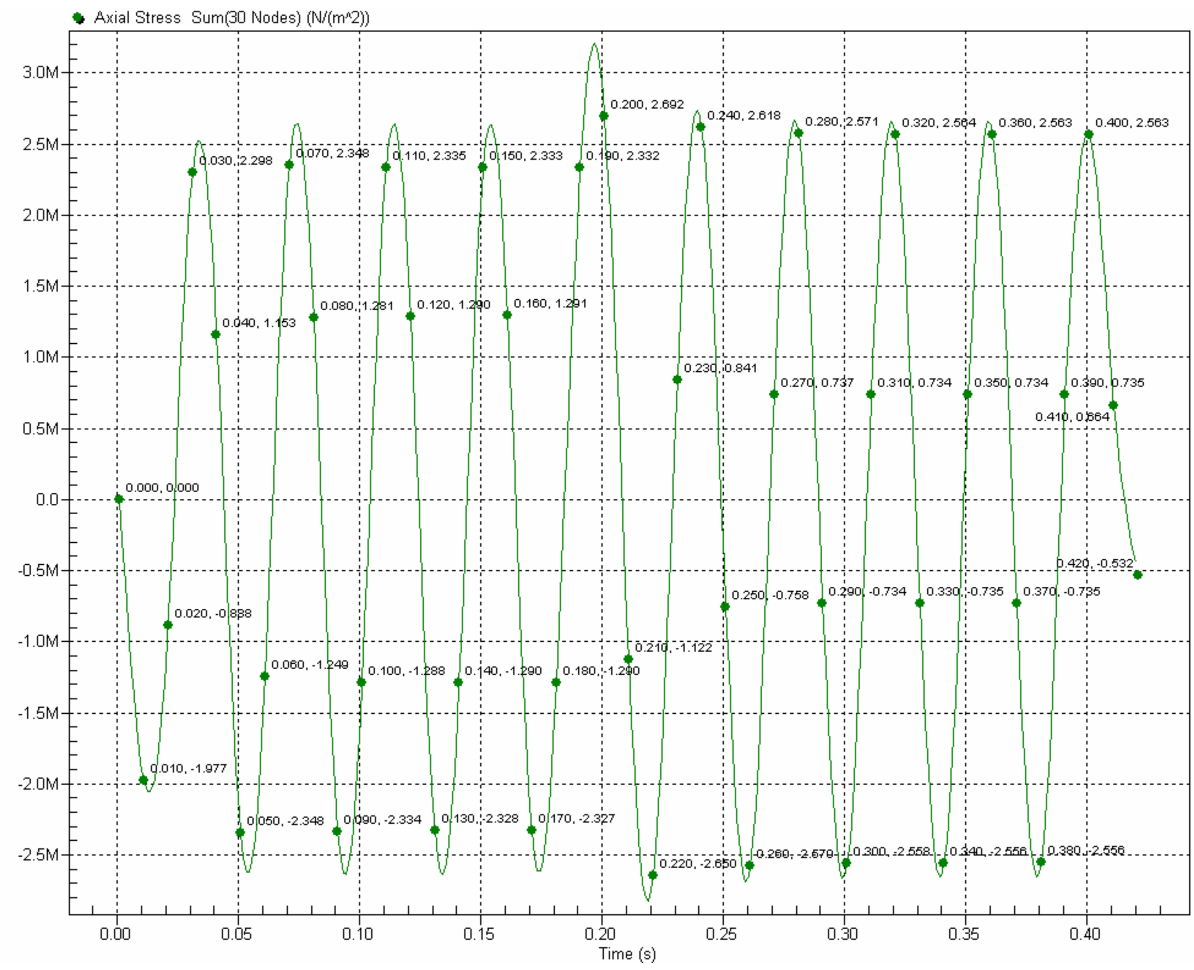


Figure 6.10 Axial stress in steering pin.

Axial force presented a maximum value of 480 N while axial stress was 3.2 E6 Pa. Stress did not exceed the design stress value for steel.

6.6 Matrix

As shown in figure 6.11, stress distribution in steering matrix is regular and almost symmetrical. However, there's an area of special concern in the rib. Plot of stress for matrix is given in figure 6.12. Maximum stress in such point is 4.7E7 Pa, under the allowable stress limit of 6.29E7Pa.

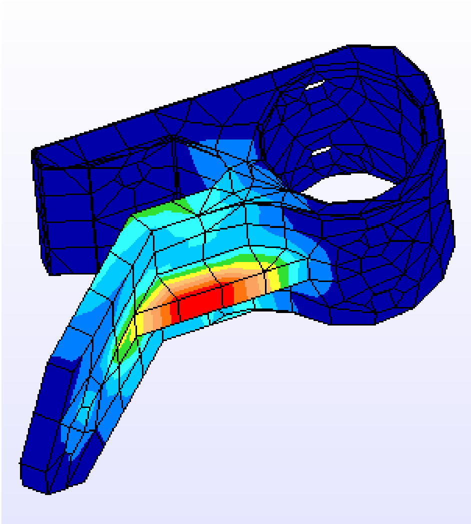


Figure 6.11 Steering matrix stress distribution.

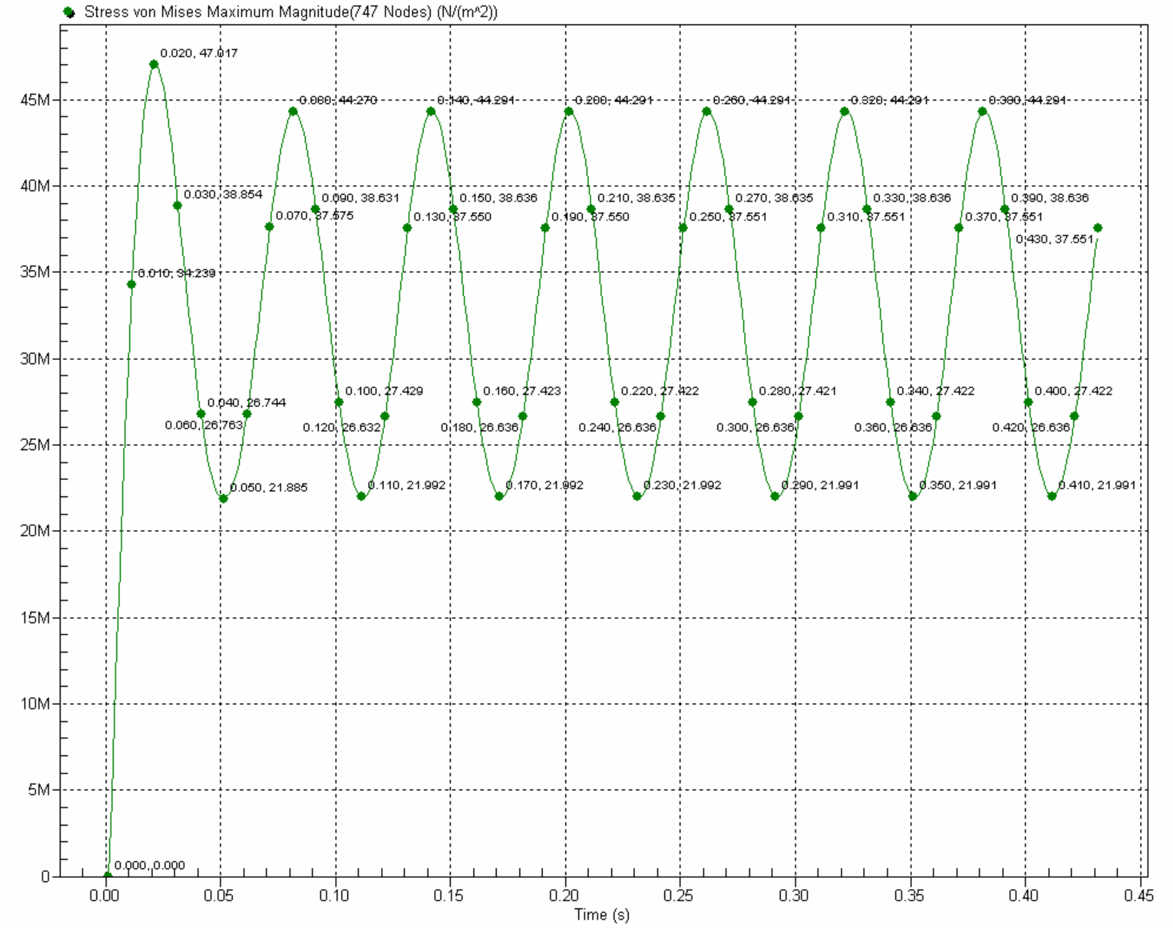


Figure 6.12 Aluminum 6061 Steering matrix stress plot

6.7 Rear axle

As shown in fig. 6.14, main point of concern regarding stress concentration is the hole where steering kingpin will be located. Through time, as can be seen in figure 6.13, stress distribution remains practically the same. Plot of stress concentration versus time is shown in chart 6.13.

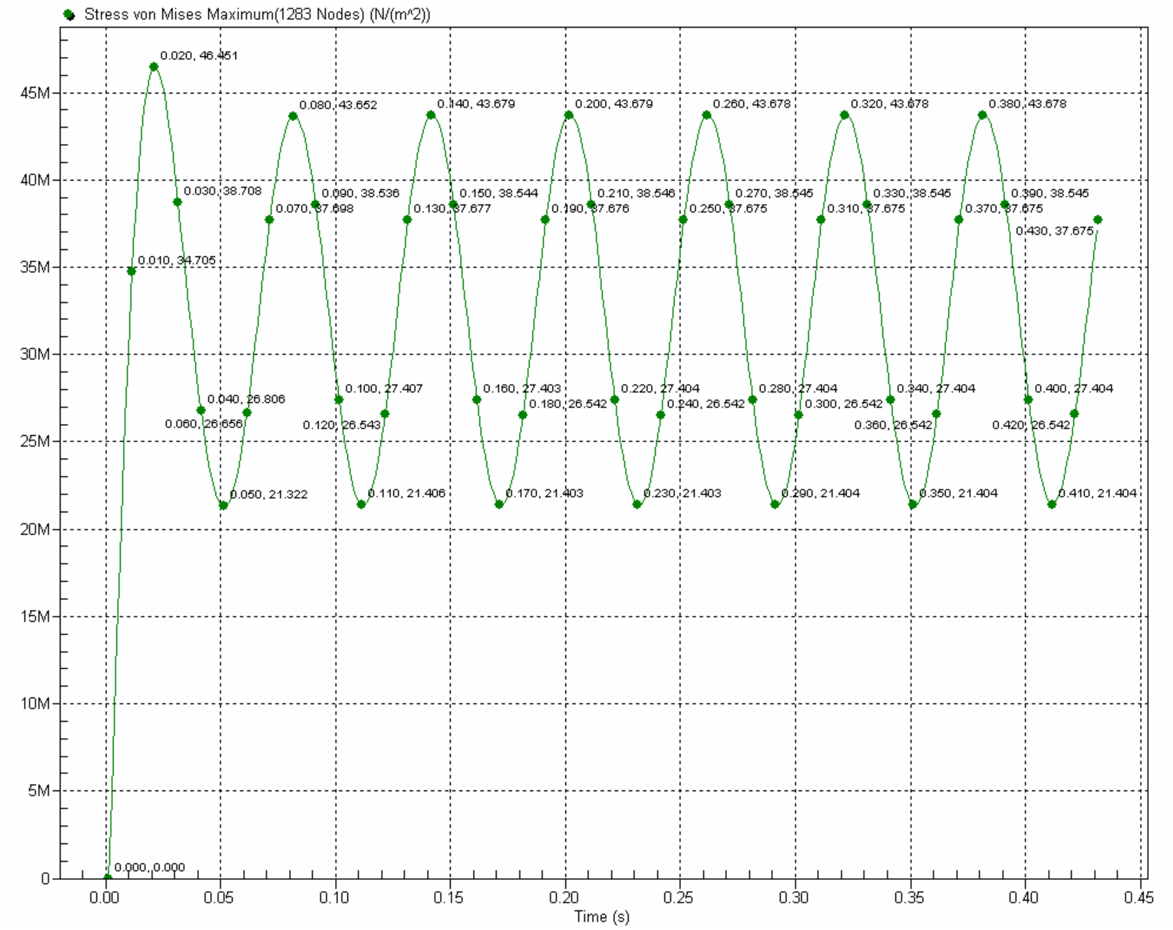


Figure 6.13 Stress concentration in rear axle

Maximum stress experienced by rear axle is 4.7E7 Pa, under the design stress limit of 6.29 E7 Pa.

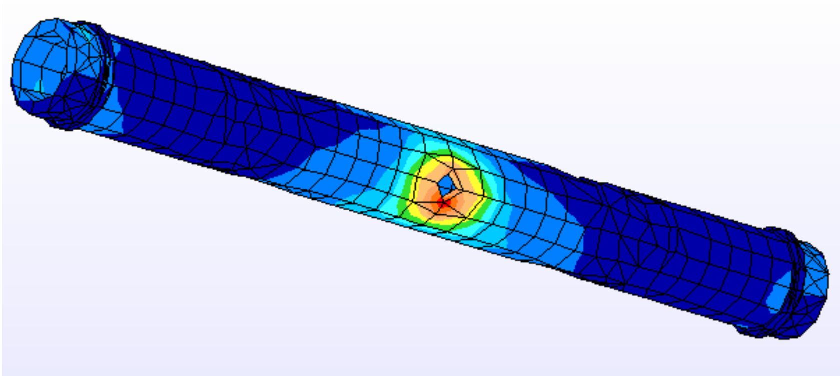


Figure 6.14 Stress distribution for rear axle.

6.8 Spring support

Main point of concern is stress concentration in the rounded edges in contact with each conduit (figure 6.15). Plot of stress for these elements is given in figure 6.16.

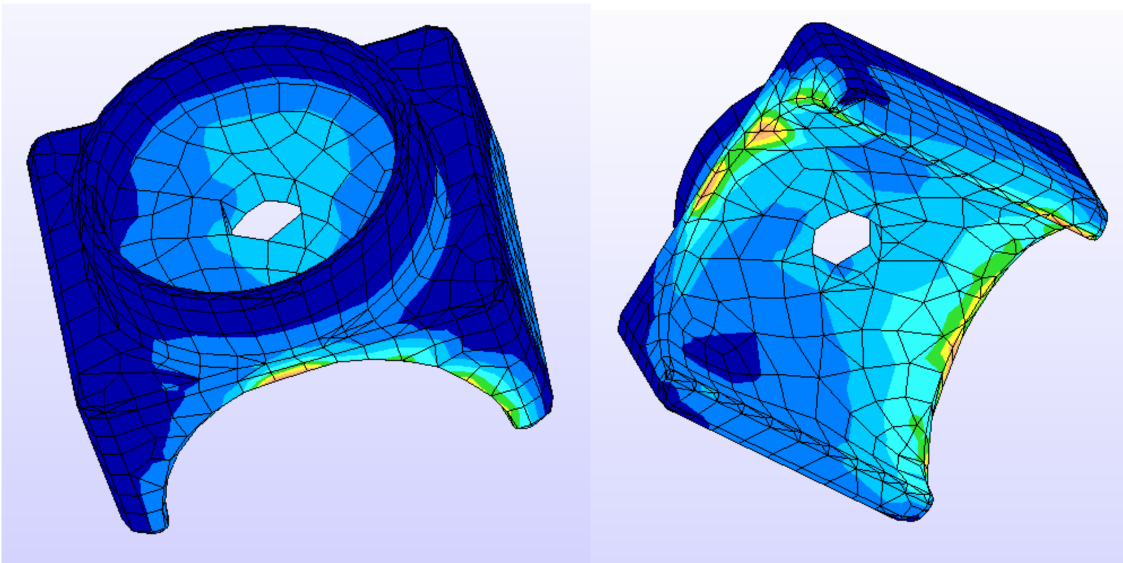


Figure 6.15 Spring support

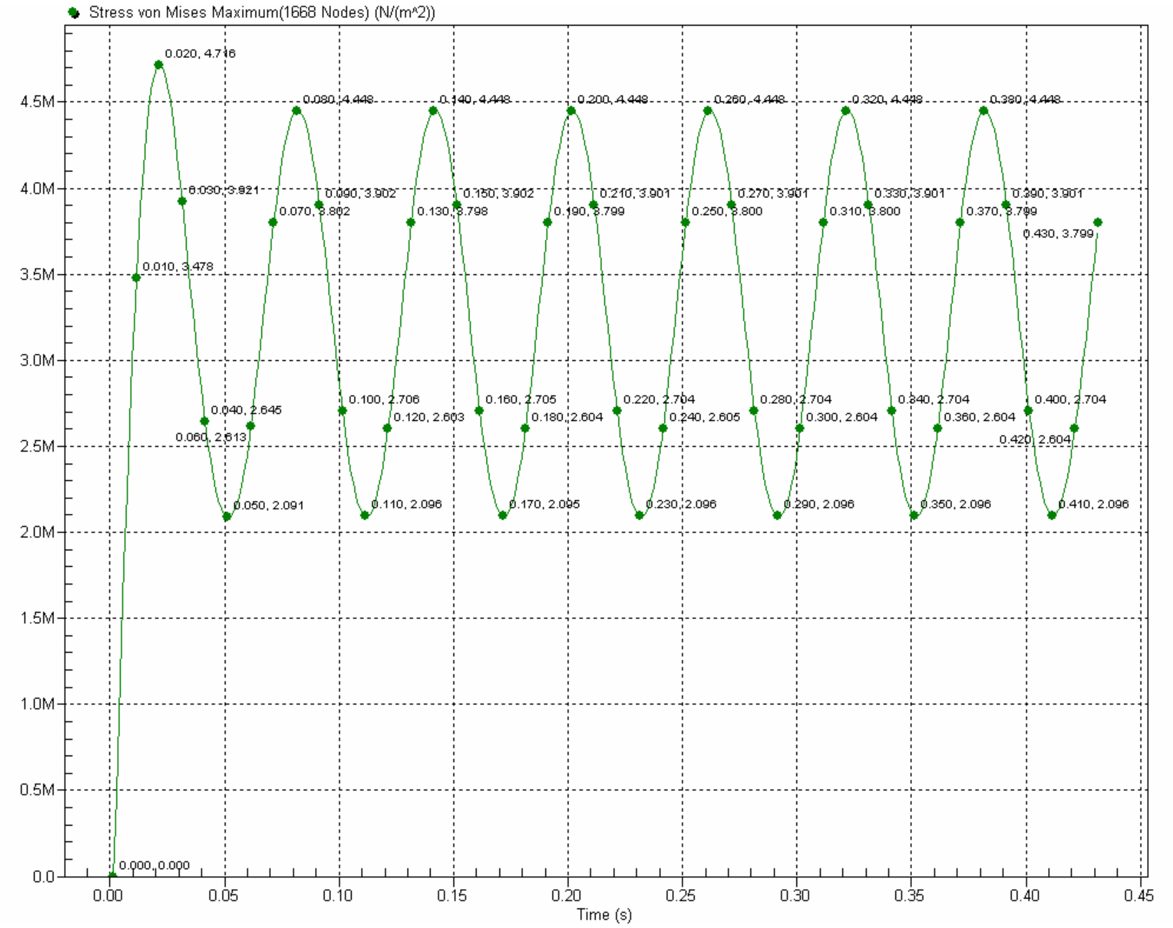


Figure 6.16 Stress plot for spring support.

Maximum stress comes to a value of 4.7E6 Pa, value under the design stress limit for aluminum 6061.

6.9 Matrix conduit

Figure 6.17 shows how the matrix conduit behaves during the test. Stress plot is given in figure 6.18.

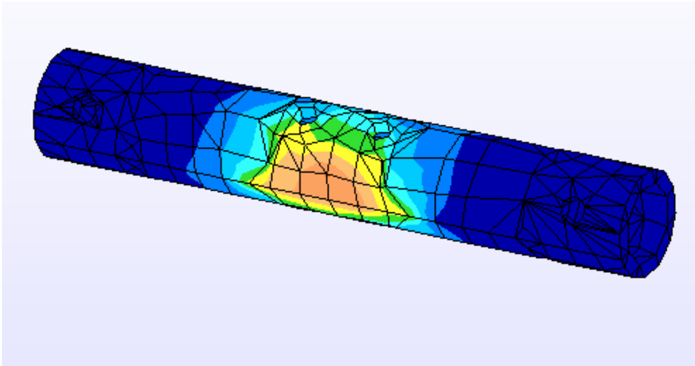


Figure 6.17 Matrix conduit first critical region

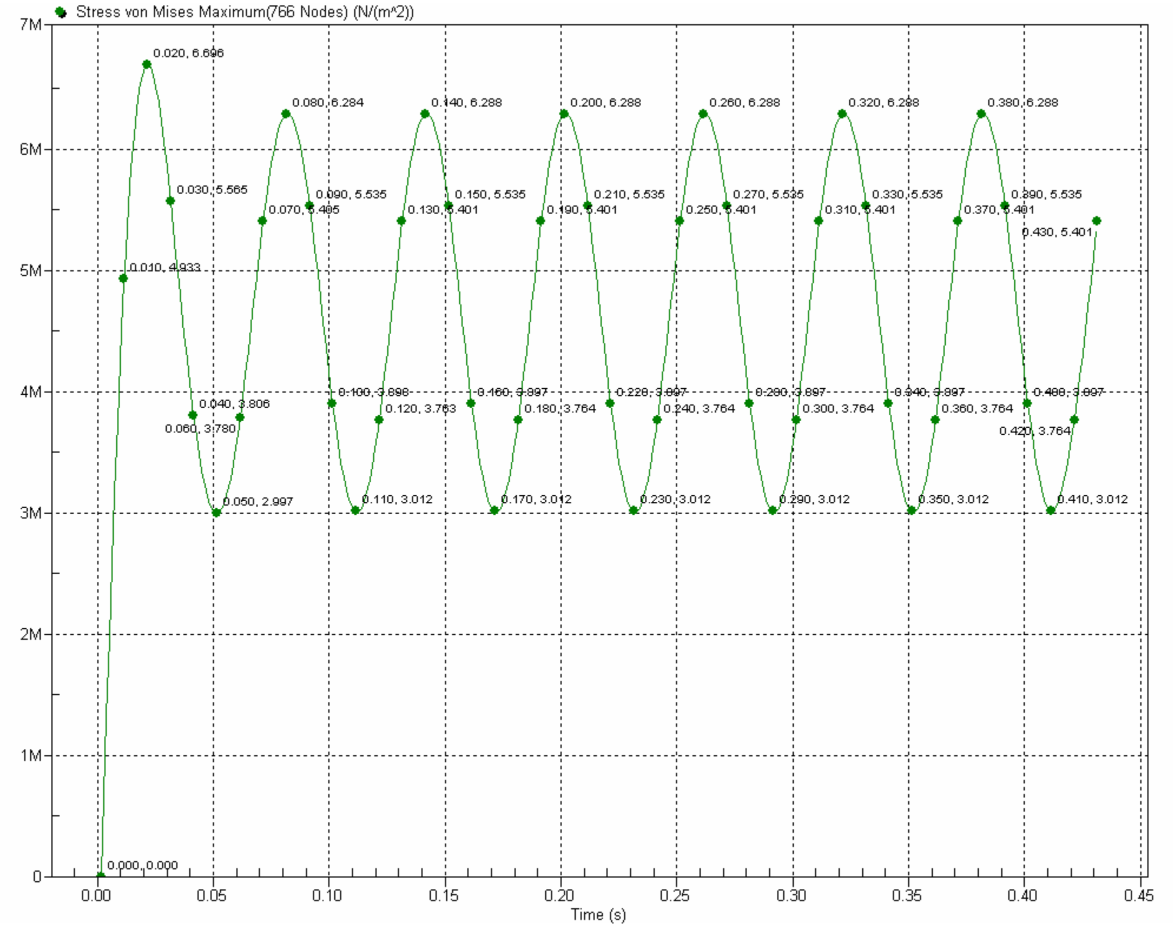


Figure 6.18 Stress distribution in matrix conduit

Maximum stress shows a value of 6.7 E6 Pa, under the design limit for aluminum.

6.10 Other bolts

Stress plot is shown in figure 6.19 and axial force in chart 6.20

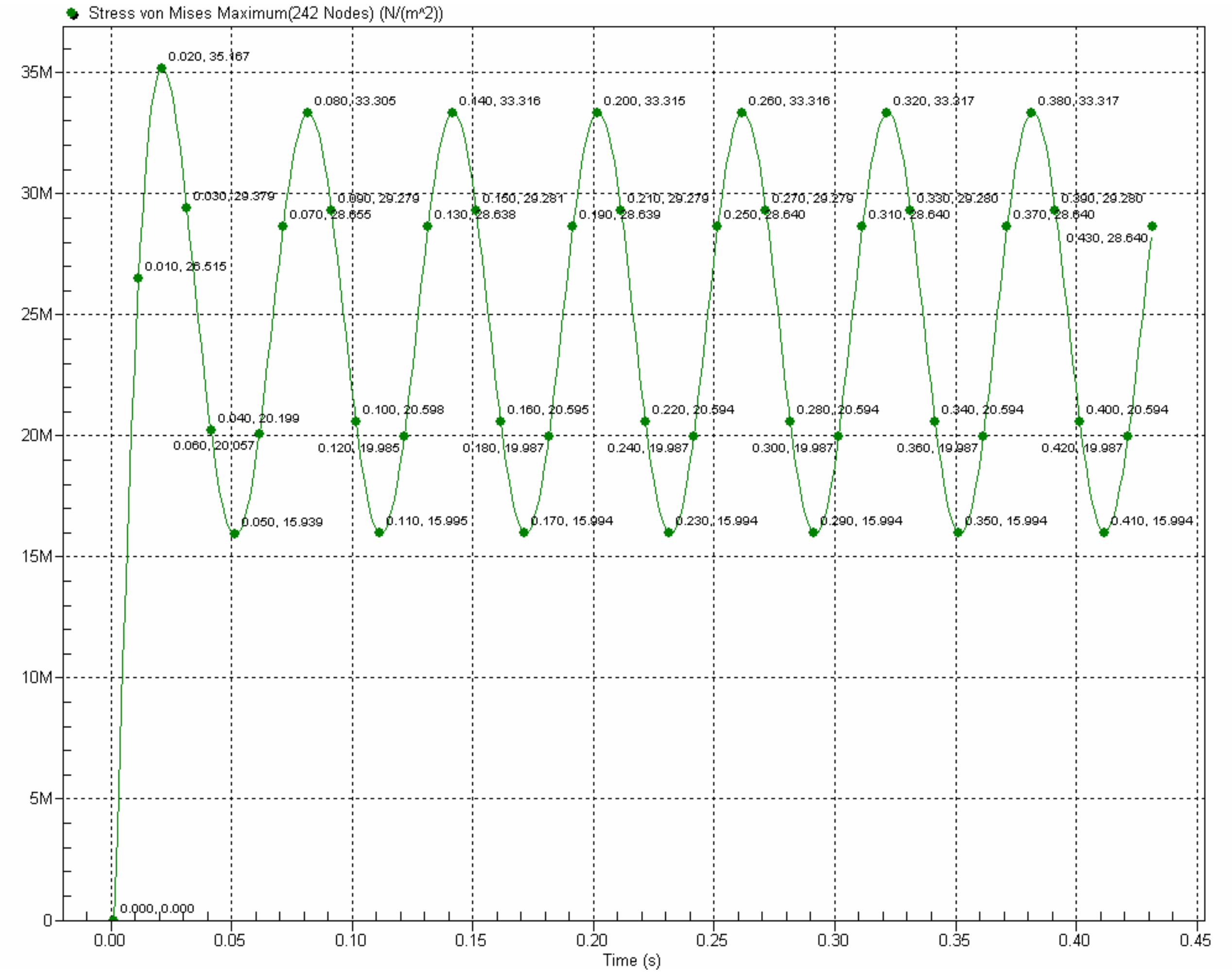


Figure 6.19 Stress plot for bolts

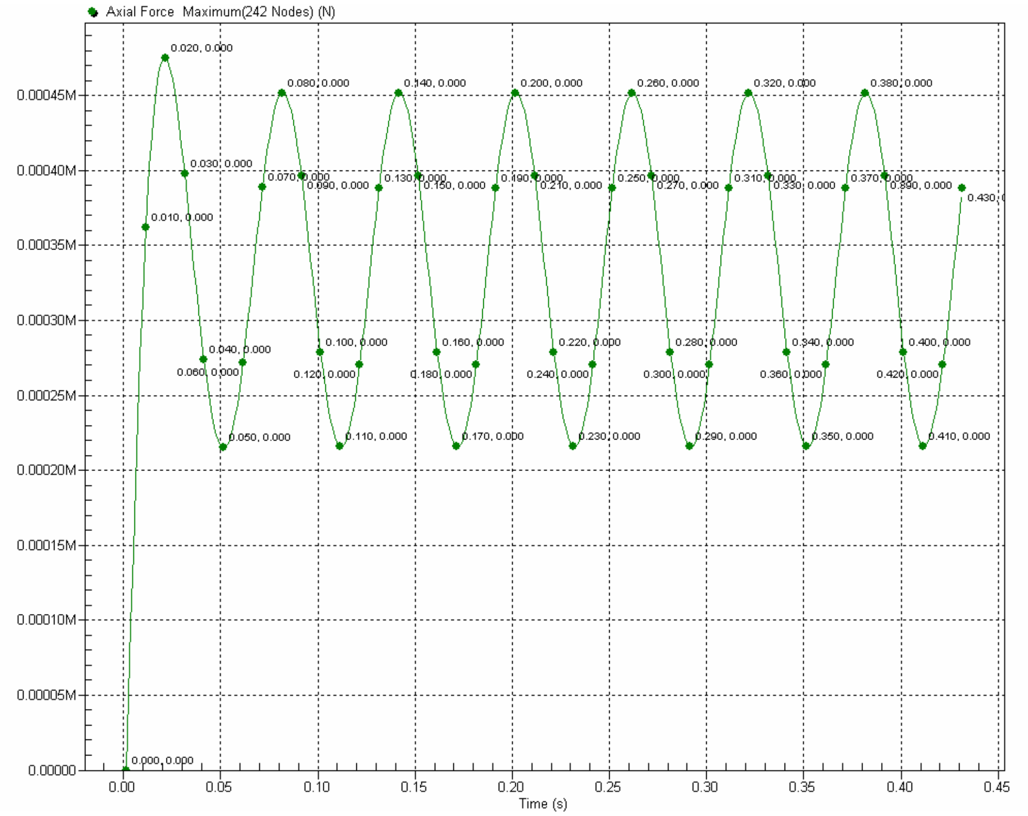


Figure 6.20 Axial force for bolts

Maximum stress experienced by bolts is 3.5 E7 Pa and maximum axial force is 450 N.

Stress is under the design limit for AISI 304 steel.

6.11 Strain in general assembly

Most important strain values are given in the bearings allocative regions and in the steering rib in the matrix, shown in figure 6.21.

The matrix maximum strain is 1.1E-4 . In the bearing inner race maximum strain is 1.8E-3.

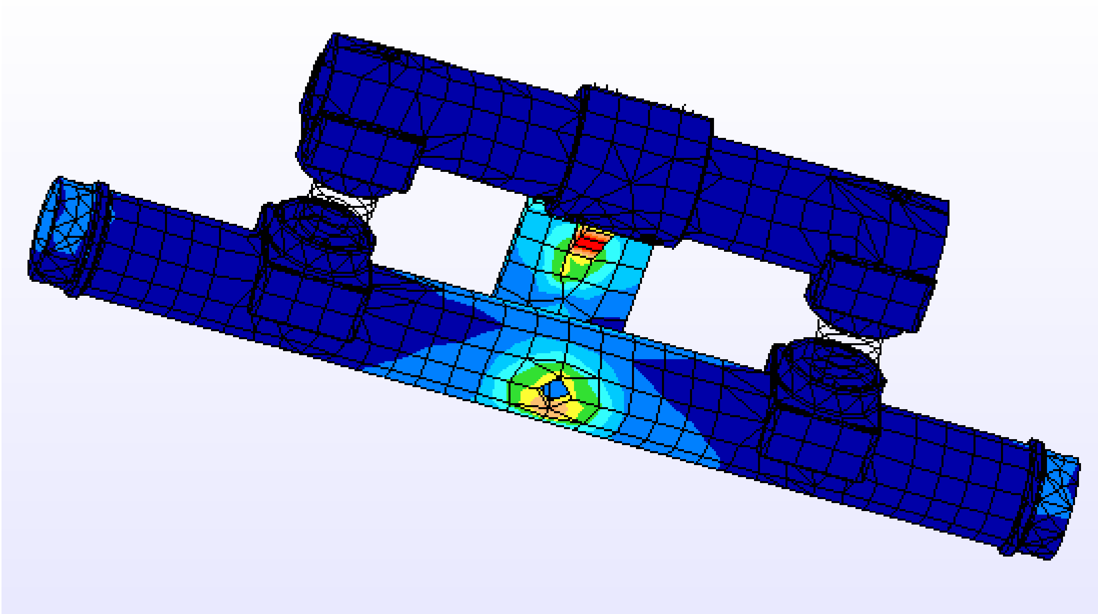


Figure 6.21 Strain in general assembly

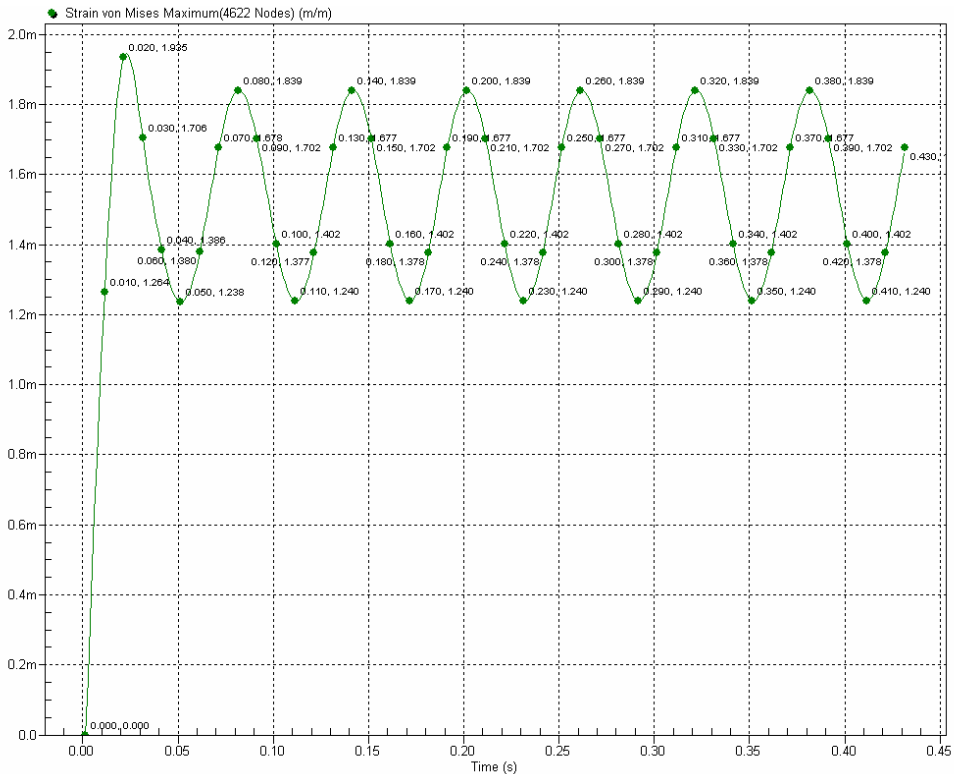


Figure 6.22 Strain in general assembly: aluminum 6061 matrix.

6.12 Principal stress values for bolts

As referred in chapter 4, bolts presented the following maximum, intermediate and minimum maximum stresses.

6.12.1 Short bolts

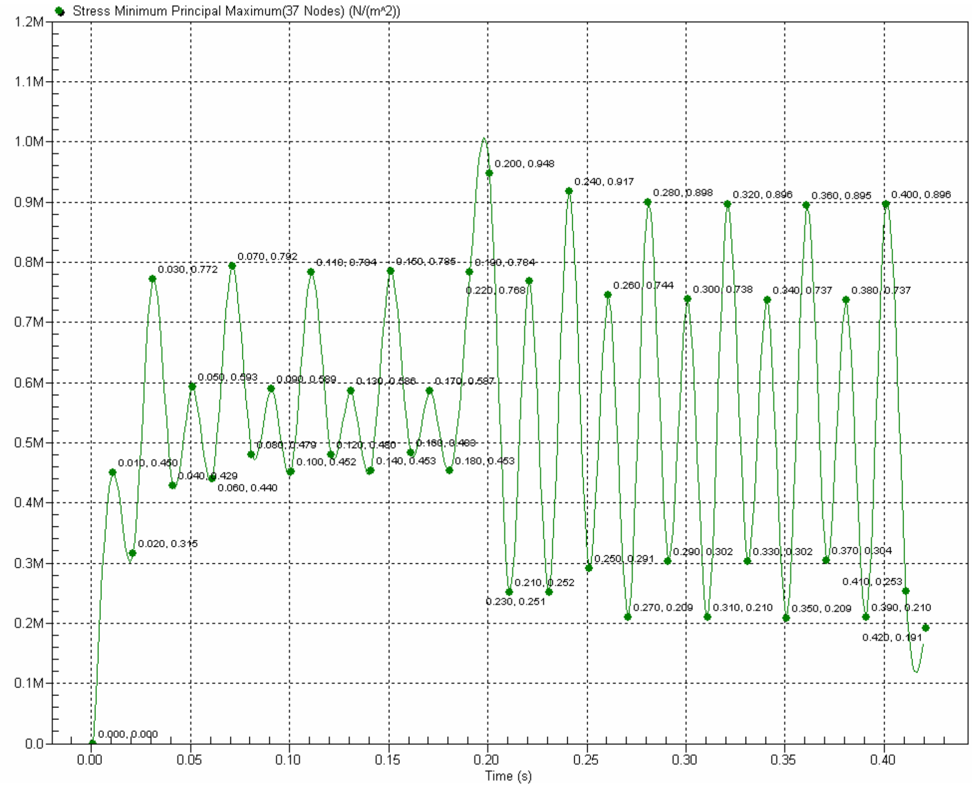


Figure 6.23 Minimum principal stress in short bolts.

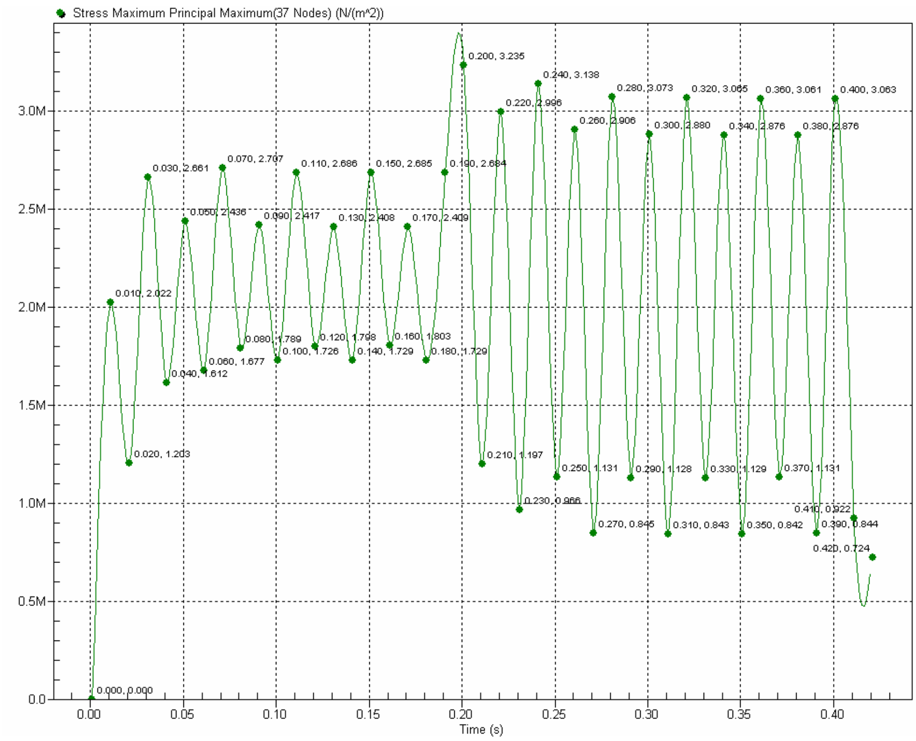


Figure 6.24 Minimum principal stress in short bolt.

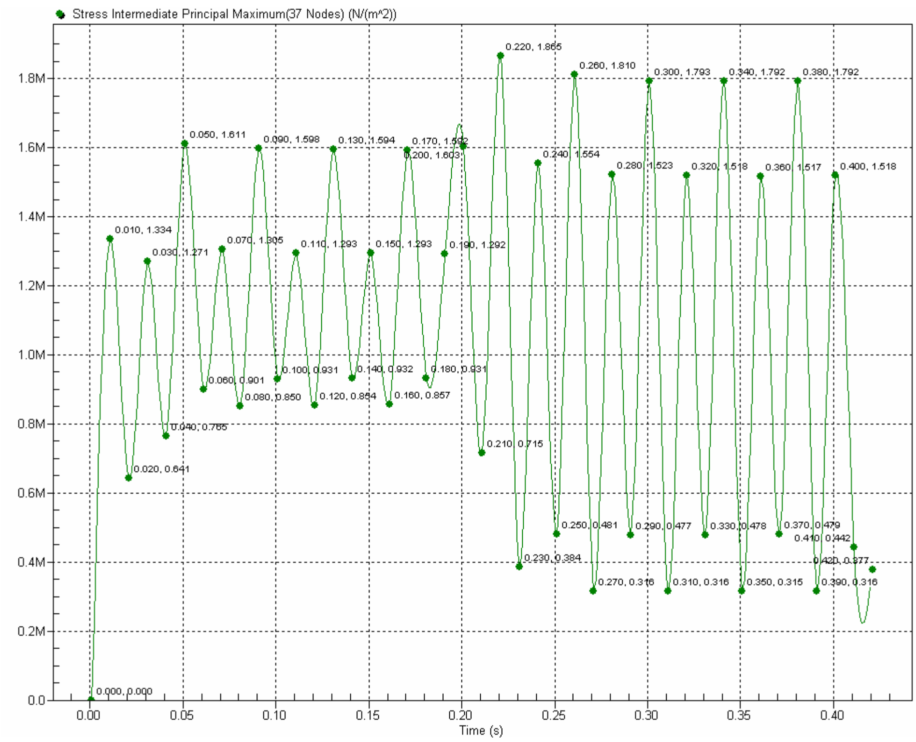


Figure 6.25 Intermediate principal stress in short bolts.

6.12.2 Long bolts

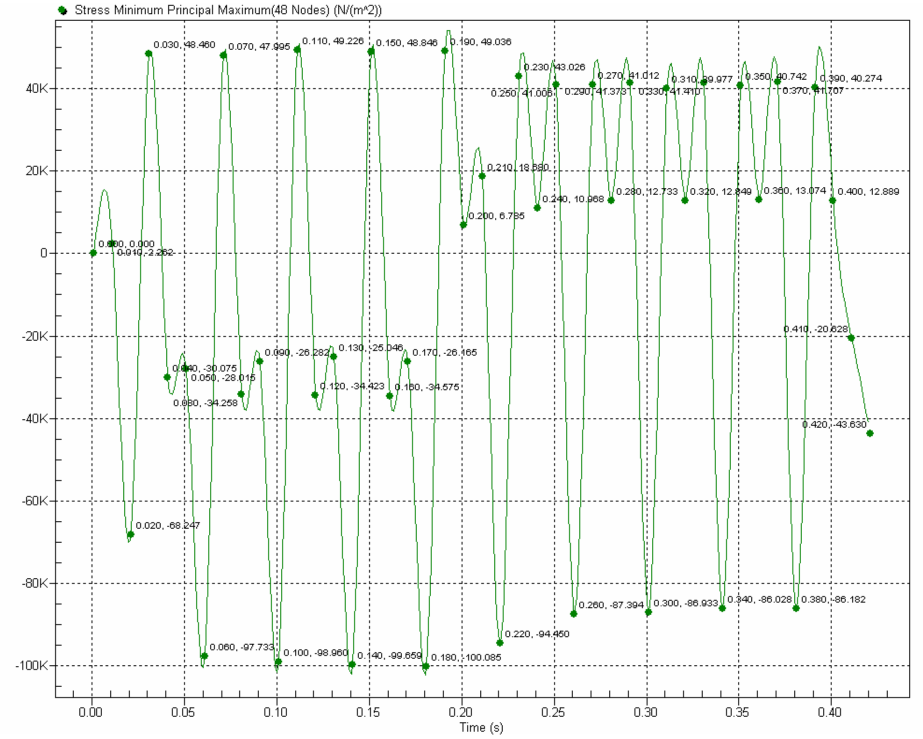


Figure 6.26 Minimum principal stress in long bolts.

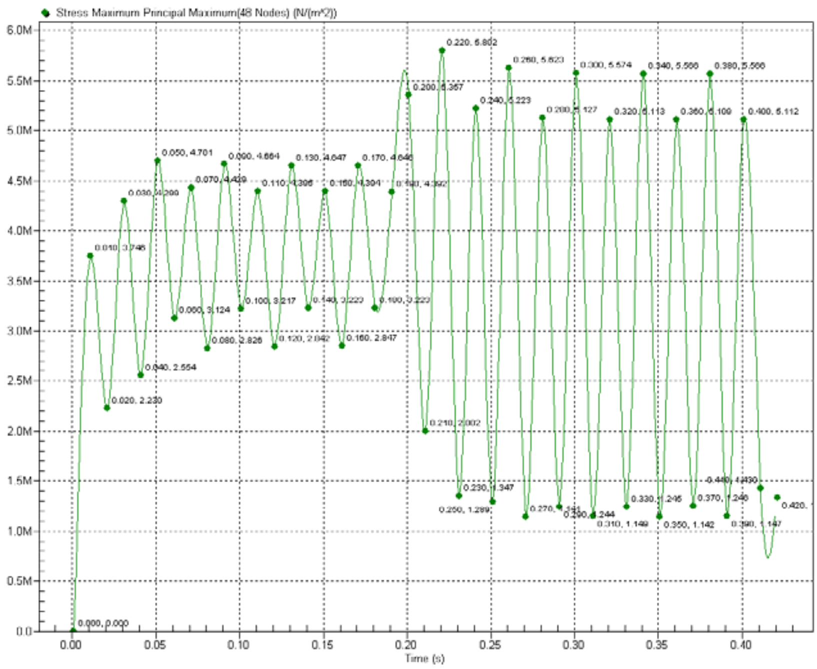


Figure 6.27 Maximum principal stress in long bolts.

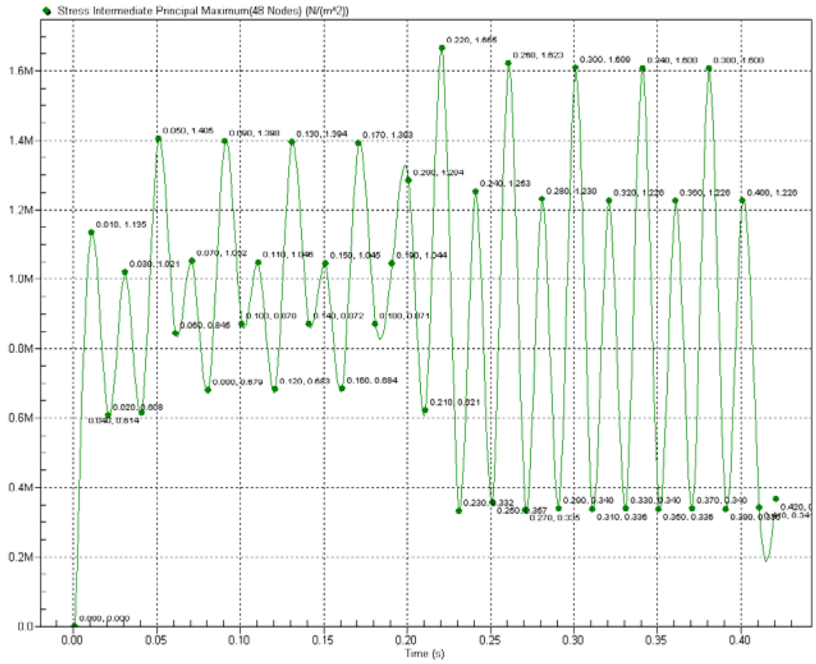


Figure 6.28 Intermediate principal stress in long bolts.

6.12.3 Spring support bolts

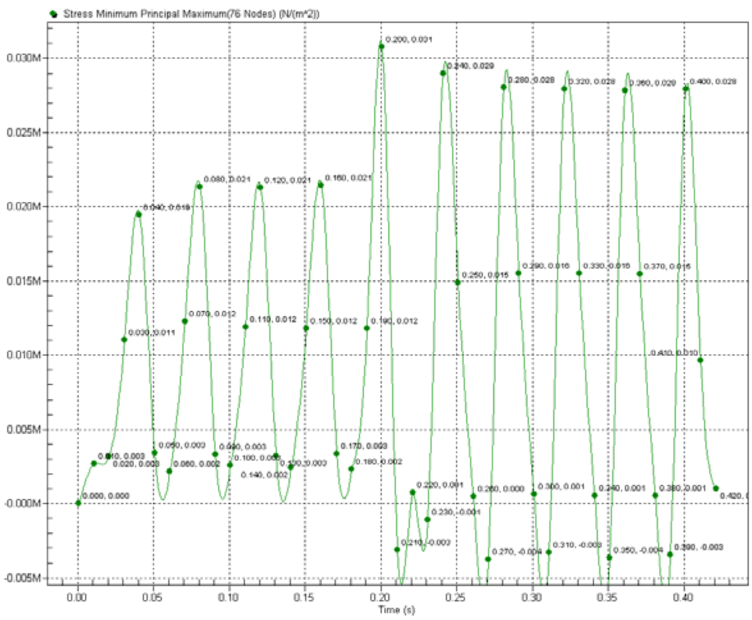


Figure 6.29 Minimum principal stress in spring support bolts.

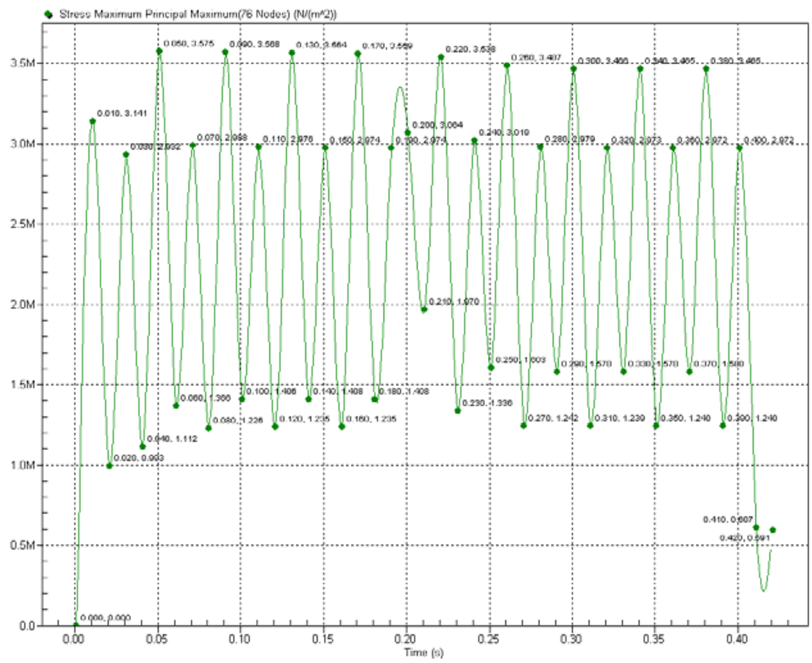


Figure 6.30 Maximum principal stress in spring support bolts.

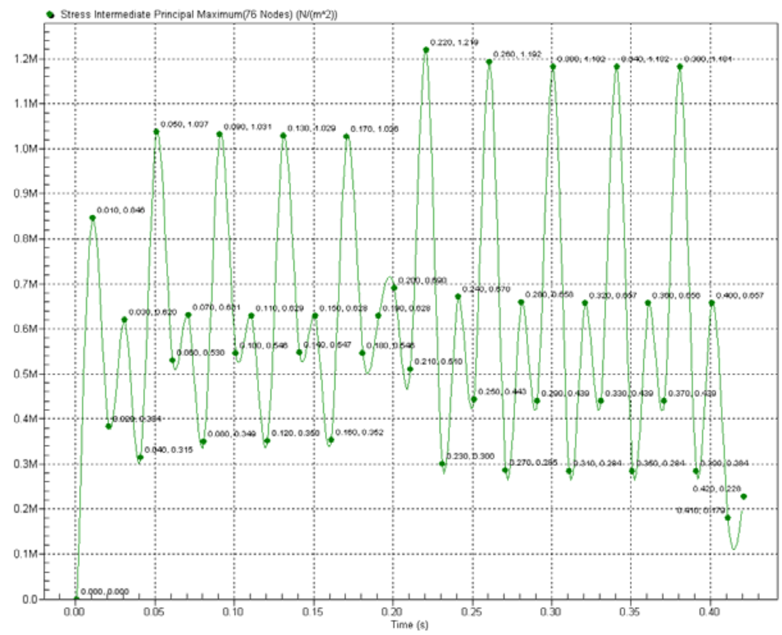


Figure 6.31 Intermediate principal stress in spring support bolts.

6.12.4 Steering kingpin

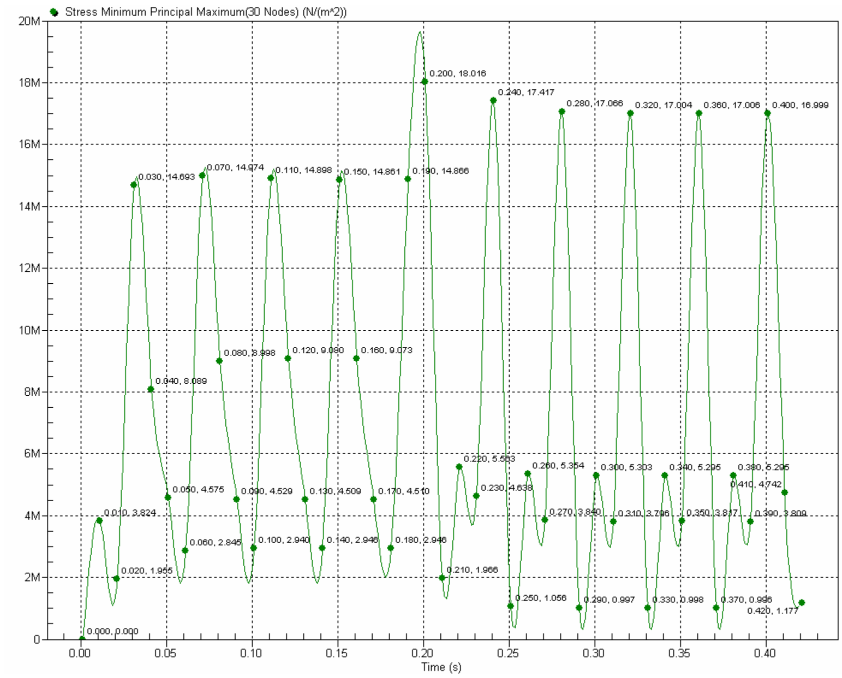


Figure 6.32 Minimum principal stress in steering kingpin.

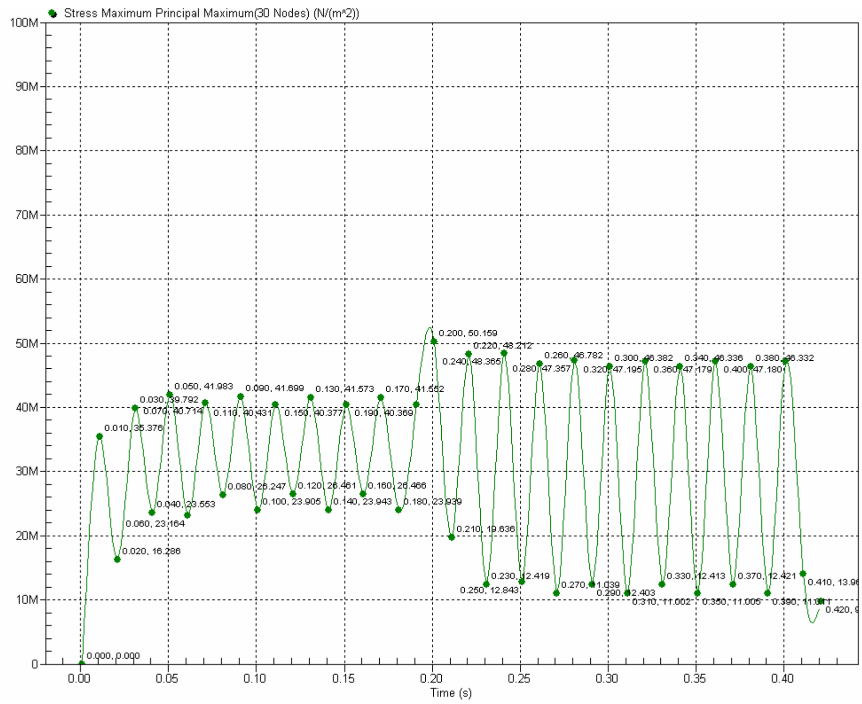


Figure 6.33 Maximum principal stress in steering kingpin.

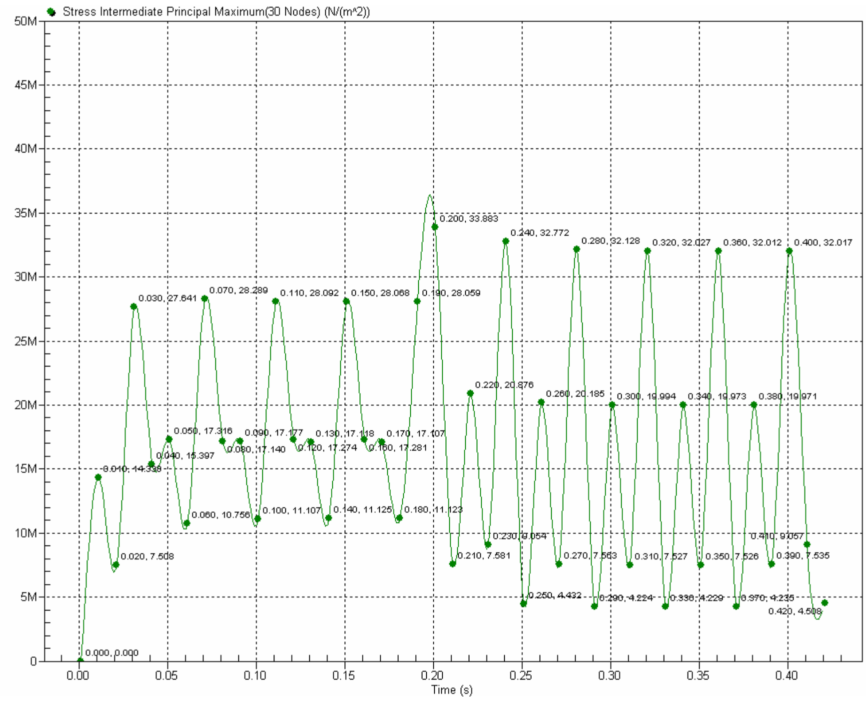


Figure 6.34 Intermediate principal stress in steering kingpin.