

## Creep Sagging Analysis for a Main Steam Line

### BACKGROUND

Power and process piping systems operating at high temperatures (in the creep range) may undergo large permanent deformations as they age (*Fig. 1*). This sagging may lead to failure of pipe supports, pressure boundary attachments, branch connections, and, ultimately, the piping system. A major fossil plant hired MIS to find the cause of continuous sagging of a main steam



Figure 1. Sagging ( Left)  
vs. Straight Pipe

line and develop corrective action to mitigate further sagging.

### DISCUSSION

MIS performed a detailed literature search, and found that for a thin-walled vessel, the creep bending deflection of a pressurized pipe can be orders of magnitude larger than of unpressurized pipe. This had been shown to result from an increase in effective stresses due to internal pressure.

Since main steam lines are classified as thick-walled pressure vessels, the existing closed form solutions for creep bending in thin-walled vessels were not applicable. Therefore, MIS developed a closed form mathematical model for creep bending in thick-walled pressure vessels. Simplification of this method required calculation of a factor (“Finnie” factor), that is a function of material property, stress conditions, time, and temperature of operation and application to elastic deformations to estimate the system’s permanent creep deformation.

MIS applied this method to a sagging main steam line. Material testing was performed to identify its creep properties. Metallurgical evaluation of the sagged area was performed to assess the condition of the pipe. Testing of constant spring pipe support was conducted to

measure their actual load before the piping analysis. The profile of the horizontal section of the line was surveyed so that the calculated deformations could be compared to the actual deflections. Elastic stress analysis was performed to obtain the moment distribution of the line in the sagged area. Finally, creep deflections were estimated using material properties obtained from the literature. The comparison (*Fig. 2*) showed that creep bending was the major contributor to the line sagging. A corrective scheme was designed and implemented to eliminate further sagging.

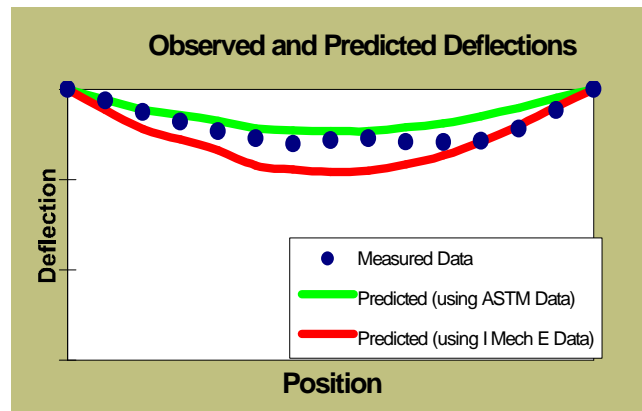


Figure 2: Predicted vs. observed sagging

### CONCLUSION

This study showed that creep bending can be a major contributor to the sagging of pressurized, high-temperature lines. MIS developed a simple yet powerful model to predict the creep bending of thick-walled pressure vessels. Application of this method to predict the sagging of a main steam line correlated well with the measured deflection, hence confirming the method’s applicability. This study also showed that meeting the ASME/ANSI B31.1 (Code) stresses does not address this creep sagging problem and, therefore, may not ensure the long-term integrity of piping systems