Structural Integrity of Modified Railroad Bearing Adapters for Onboard Monitoring Applications

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Abstract

The purpose of this project is to study the structural integrity of railroad bearing adapters (Figure 1) modified for onboard monitoring applications. Freight railcars rely heavily on weigh bridges and stations to determine cargo load. As a consequence, most load measurement are limited to certain physical railroad locations. This limitation opened the door for an optimized sensor, that could potentially deliver significant insight on bearing condition monitoring as well as load information. Bearing adapter modifications (e.g. cut-outs) were necessary to house the sensor and, thus, it is imperative to determine the reliability of the modified railroad bearing adapter, which will be used for onboard health monitoring applications.

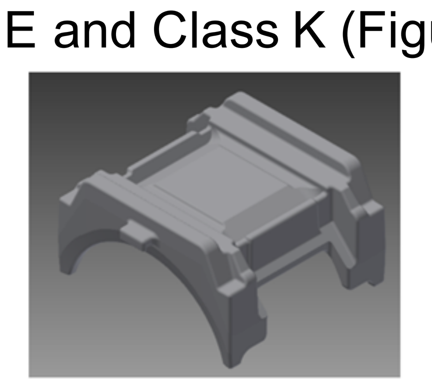
Figure 1. Axle Configuration and AdapterPlus™ SteeringPad

Introduction

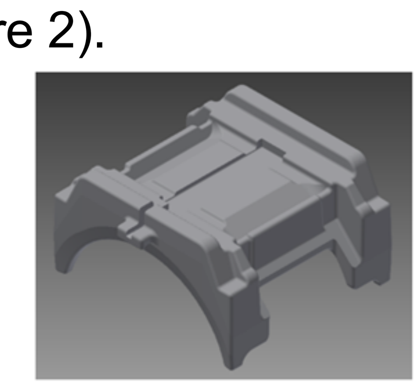
One of the keys to improving rail safety and reliability is improvements in monitoring technology that enhance ability of railroad companies to remove cars from service prior to catastrophic failure. Previous projects done by the University of Texas-Pan American Railroad Research Group (UTPA-RRG) have found a reliable way of measuring static and dynamic loads on bearings: a sensor placed inside the modified adapter of the bearing assembly. The sensor, made from A242 tooling steel, is embedded in a bearing adapter under a thermoplastic elastomer patented as the AdapterPlus Pad. Modifications (cutouts) on the bearing adapter were necessary to house the sensor, therefore it is important to determine the structural integrity of the railroad bearing adapter. This preliminary study shows the use of Finite Element Analysis using the ALGOR commercial software on modified bearing adapters with one of the expected operational boundary conditions and loads. In the future, results of a few cases will then validated with some physical experiments in the lab.

CAD & Finite Element Modeling

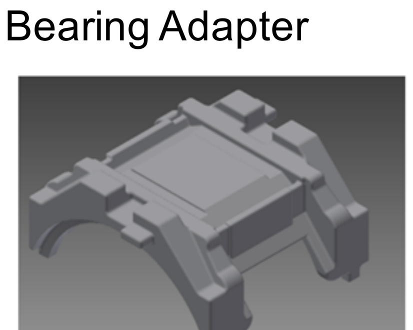
FE and CAD models were created on two adapters: Class E and Class K (Figure 2).



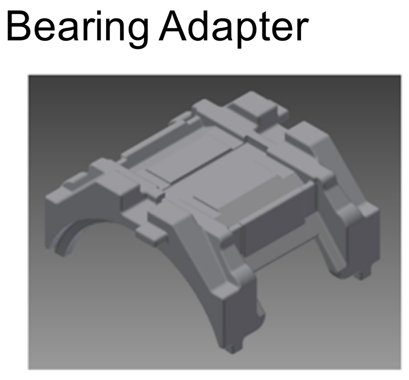
(a) Original Class E Bearing Adapter



(b)Machined Class E Bearing Adapter



(c)Original Class K Bearing Adapter



(d)Machined Class K Bearing Adapter

Figure 2: CAD models for original & modified Class E & Class K Bearing Adapters

The material properties being used for these initial analyses were those of Ductile Iron 60-40-18. An FE model was constructed in Autodesk Inventor, imported into Autodesk Simulation, and discretized into elements with a mesh size of 0.015 in and 0.017 in. A combination of bricks, wedges, pyramids and tetrahedral elements were used to successfully mesh the model. The initial conditions studied for this sample model were that the raceways of the bearing adapter were supported by the bearing cup. In the boundary conditions of the FE model, the side of the bearing adapter was constrained from moving in the x-direction in order to simulate the constraints imposed by the side frame. Additionally, the raceways were supported by a pin constraint to simulate the support the bearing cup provides (Figure 3). A pressure equivalent to the full load on the projected surface was applied at the top.

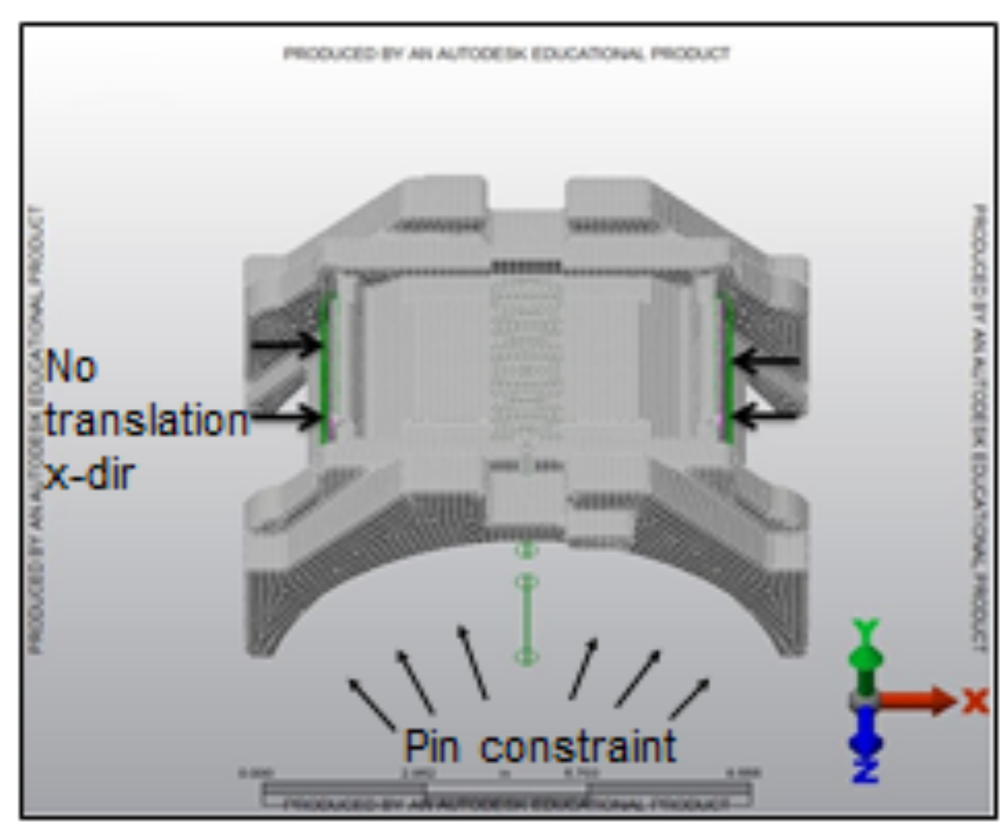


Figure 3. Initial Boundary Condition on CAD Model

Preliminary Results

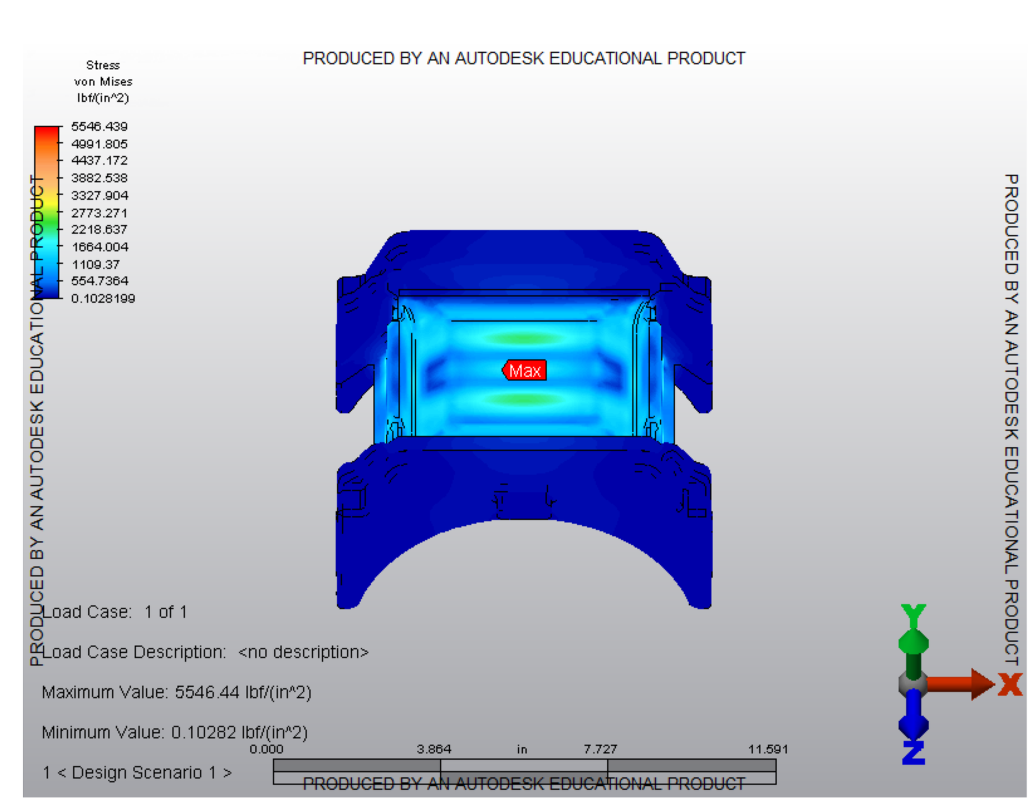


Figure 4: Sample FEA for Original Class E Adapter with full raceway support

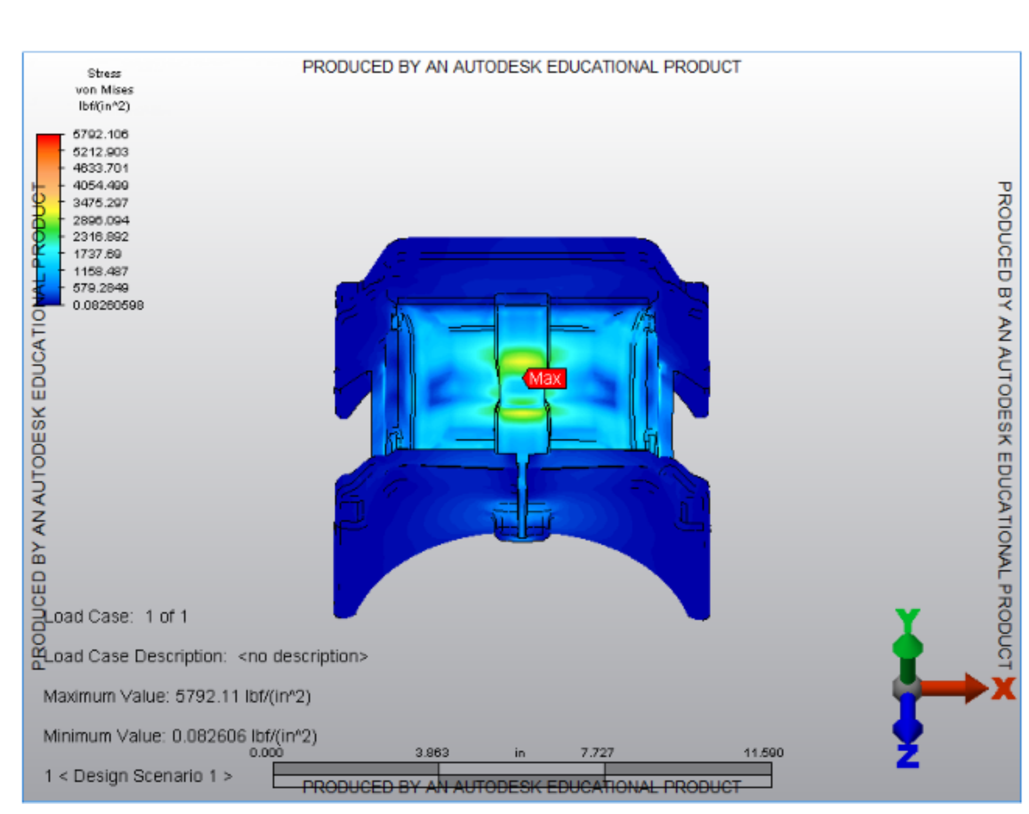


Figure 5: Sample FEA for Modified Class E Adapter with full raceway support

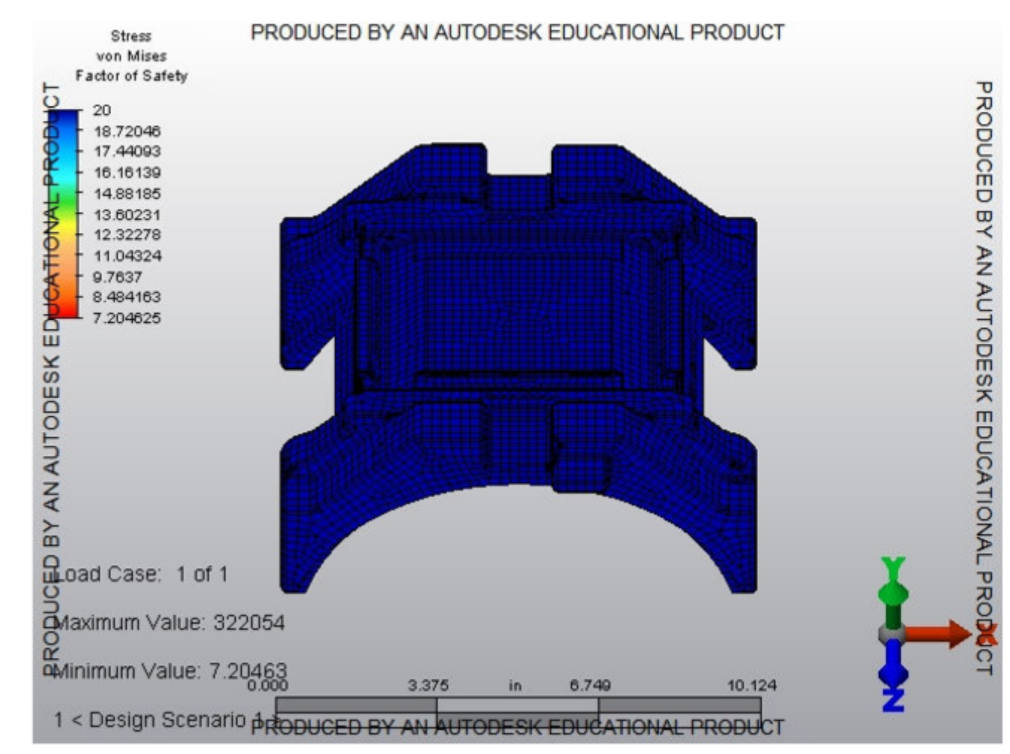


Figure 6: Sample FEA for Class K Original Adapter with full raceway support

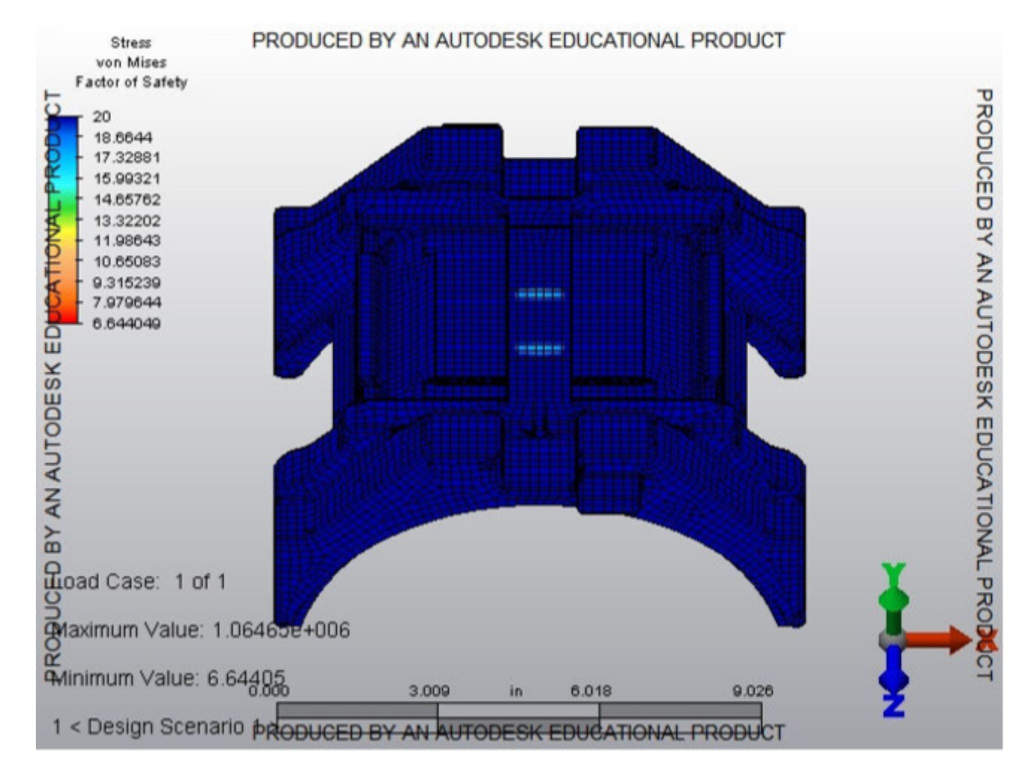


Figure 7: Sample FEA for Class K Modified Adapter with full raceway support

Table 1: Class E & K Bearing Adapter Results

Adapter Type	Machined Cutout	Mesh Size [in]	Von Mises Stress [psi]	Factor of Safety
Class E	Yes	0.17	5792	6.91
	No	0.17	5546	7.21
Class K	Yes	0.15	6,360	6.64
	No	0.15	5,556	7.20

Conclusions

Ongoing work shows that the stresses on the adapter with the cutout are higher, so the factor of safety of the component decreases. However, the difference is not very significant on the initial conditions studied (see Table 1). Studies on different boundaries conditions will continue to be made in order to find the worst case scenario the adapter would be exposed to. Also, a study on how the number of cycles or the lifetime of the adapter will be performed. A few cases of interest will be validated experimentally.

Acknowledgements

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Reference:

[1] Saenz IV, Lorenzo, (2012). Calibration and Optimization of a Load Sensor Embedded in a Railroad Bearing. Master of Science Thesis, Mechanical Engineering, The University of Texas-Pan American.