Rail Car Coupler

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The current type E Janney coupler has not been significantly modified since the original patent was filed in 1873. Couplers commonly undergo mechanical failure, knuckle fractures, and the railcars detach while in use and cause major delays costing rail companies and customer's time and money. The main objective of this project was to increase the lifespan of the coupler through design and material changes, without affecting the freight car or train operations.

Introduction

The current Janney railcar coupler has not seen many changes for a long time. An increase in strength, reduction in weight, and improvement in design could yield a more reliable and effective coupler for the industry. Alternative materials are being considered to increase fatigue life and decrease weight. This Senior Design team has researched the current failure modes, potential design modifications and potential changes in materials. In order to be implemented in industry, the coupler needs to be compatible with all current types of the Janney coupler in use and have relatively the same cost. The main stakeholders in the project are the design team, National University Rail Transportation Center (NURail), Michigan Technological University, private railroad companies, coupler manufacturers and railroad workers. There is little incentive for innovation within private industry due to the requirement that designs are compatible, forcing new designs to be shared. Once a year, the three major coupler manufacturers meet to test components for compatibility between couplers produced by all manufacturers. Railroad workers stand to benefit from potential maintenance reduction and increased ease of use. Railroad companies would benefit from a decrease in time lost due to trains that stop to replace broken knuckles. NURail is a transportation consortium that focuses on rail related research and hopes to promote innovation within the industry through promoting projects like the railcar coupler.

Figure 1. Type E Janney Coupler

Design/Modification

The final concept focuses on geometric and material changes to maximize service life. Material is added to the coupling face of the knuckle to reduce the amount of slack that exists between knuckles. Material changes are were considered and evaluated in an effort to increase the lifespan of the coupler. The knuckle was reverse engineered based on interior cavity and exterior geometry. The final design was validated with finite element analysis (FEA) and MAGMA5 software. The interior cavities were adapted from the current material to Austempered Ductile Iron, requiring changes to ensure similar strength and fatigue properties. A mold pattern with draft angles for casting purposes was then created. The final cast results from the Michigan Tech foundry still had minor material issues, such as porosity, and hot tearing. These are currently unresolved due to the team's lack of experience casting, as well as the limitations of the Michigan Tech foundry. Future work will also need to consider that the knuckles provide a safety feature to the coupling system. Knuckles should be designed to fail before reaching levels that would damage the draft gear or other car components to which they are attached

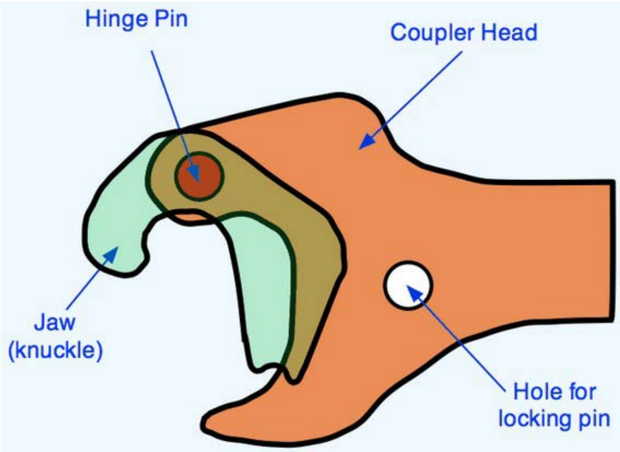

Figure 2. Components of a couples

Results

To implement a material change, the static stresses in Austempered Ductile Iron (ADI) need to be less than or equal to Grade E steel. Due to the lower yield strength of ADI, trial and error was used to adapt material reductions within the knuckle. The simulations were run under two conditions, with and without the hinge pin as a fixture. By design, the pulling lugs should be the only fixture, as that is where the applied force on the face of the knuckle is transferred. However, Amsted Rail found the hinge pin does act as a fixture when the knuckle is close to failure. The FEA shows what happens in normal use (no hinge pin) and when the knuckle is close to failure (hinge pin as a fixture).

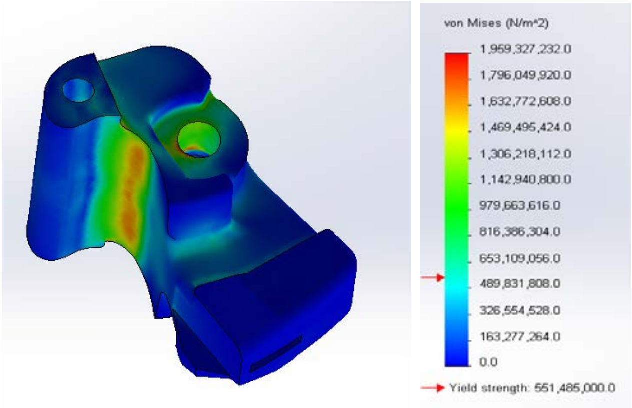

Figure 2(a). FEA of Model with Hinge pin

Material: ADI
Fixtures: Hinge Pin and Pulling Lugs
Load: 650,000 lbf
Result: Highest stresses occur near hinge pin. Failures will occur in this location. (Desired result)

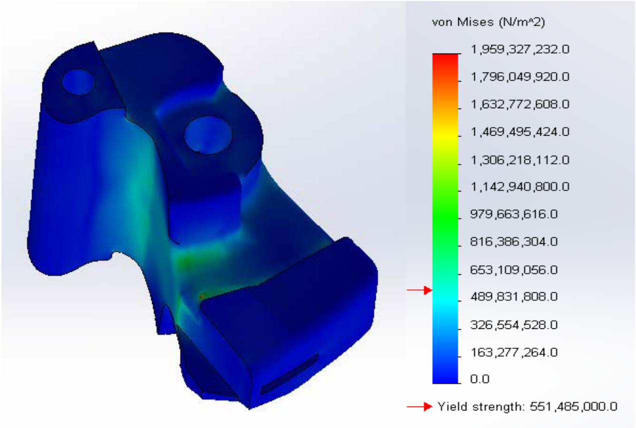

Figure 2(b). FEA of Model without Hinge pin

Material: ADI
Fixtures: Pulling Lugs
Load: 650,000 lbf
Result: Highest stresses occur near hinge pin and pulling lugs. Failures will occur in either location. (Not ideal).