**Rail Car Coupler**

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### Background

- Janney coupler has not been significantly modified since 1873
- Any modifications must be shared for compatibility between all cars in use
- Little motivation for product development by manufacturers

![Image of coupler](http://vnrailway.blogspot.com/2010/09/couplers.html)

**Type E (1859), Type F (1954)**

- Couplers that fail in the field cause major delays
- Costs rail companies and customers time and money.
- Focus on knuckle which is most likely to fail

**Focus on knuckle which is most likely to fail**

- Knuckle is fail safe to protect train car
- Knuckles will have to fit standard AAR gauges, such as the A-10 contour gauge (shown left)

**Prototype Realization**

- Two part CAD Model translated into a mold pattern with Stereolithography (SLA) rapid prototyping

**CAD Model**

- No CAD model of the knuckle was available, so the team created a model by reverse engineering a type E coupler obtained from LS&I Railroad
- The knuckle was created in two parts (shown below left and right) to enable modeling of inner cavities
- Draft angles were added to facilitate casting
- Design changes, due to FEA results, circled in red.

**Assembled Knuckle**

- Knuckles will be commercially heat treated to undergo the process of austempering to form Austempered Ductile Iron (ADI). ADI was chosen because of similar properties to the current material, and excellent wear resistance. There is interest in the industry, but currently no incentive to develop further.

**Prototype Realization**

- Dynamic fatigue machine built by Amsted Rail will be used to evaluate the design

**Finite Element Analysis**

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, as shown in the CAD model. 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 to. 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).

**Finite Element Analysis**

- **Material:** Grade E Steel  
  **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)

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