# Rail Car Coupler


Michigan Tech

Rail Transportation Program
Michigan Tech Transportation Institute • Michigan Technological University

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NURail Center

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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

From left to right: Janney (1873), Type E (1930), Type F (1954)

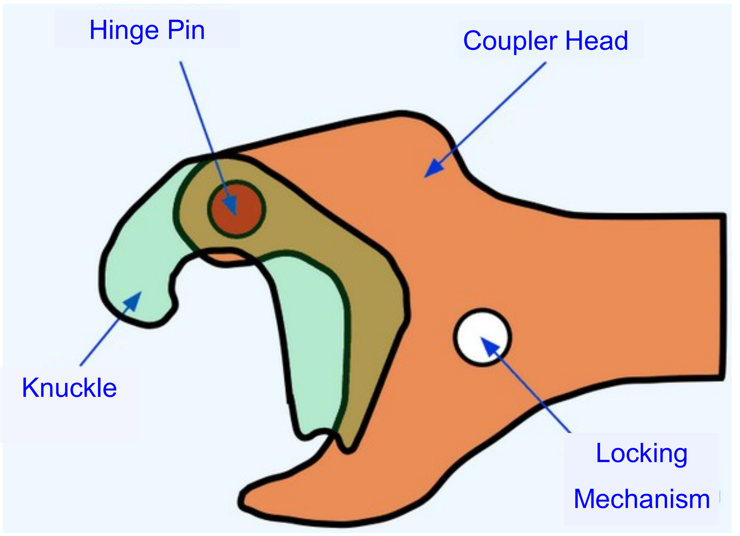


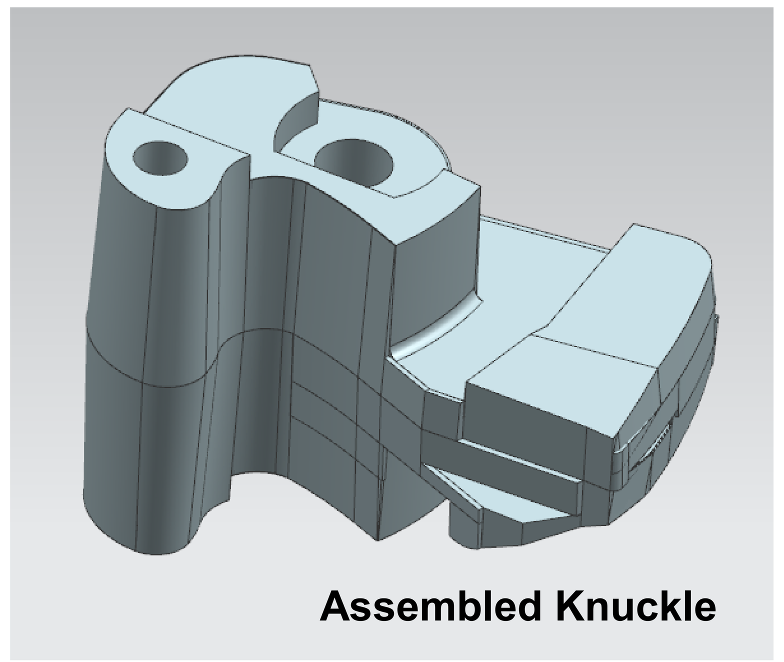

Photo credit:http://vnrailway.blogspot.com/2010/09/couplers.html

- 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

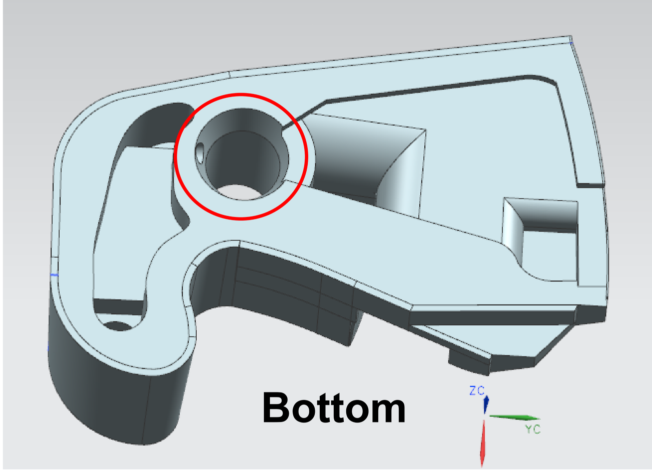
- Knuckle is fail safe to protect train car
- Want to fail in coupling face or around hinge pin
- Failure in tail section prohibits replacement in the field
- Knuckles fracture due to fatigue cracks

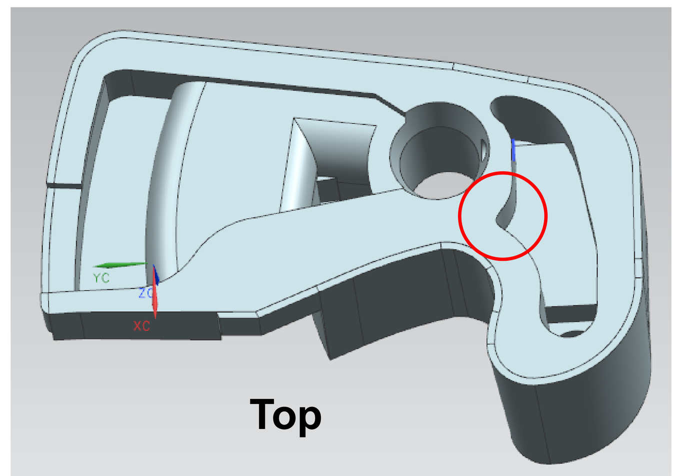
Type E made by Buckeye in 1976, provided by LS&I Railroad

## 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.




## Design Considerations

### Constraints

| Constraint | Method of Measurement | Limits |
|---|---|---|
| Backwards Compatible | Tested by Amsted Rail | Must fit 10-A contour gauge |
| No change to car | Limit changes to knuckle | No change to freight car or coupler |
| Standards | Meet AAR Regulations | Must meet minimum requirements |

### Objectives

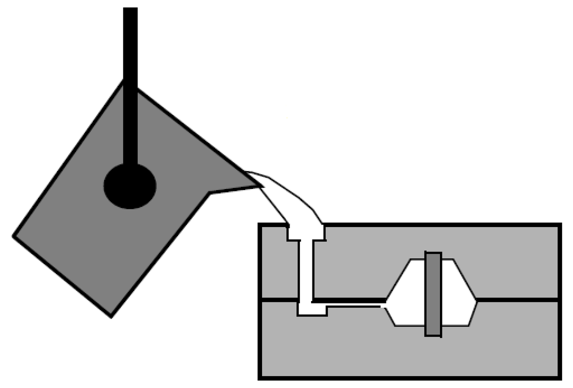
| Objective | Priority Rating | Method of Measurement | Direction | Target Met |
|---|---|---|---|---|
| Life span | 5 | AAR Standard M-216 | Maximize | In Progress |
| Strength | 4 | AAR Standard M-215 | Maximize | In Progress |
| Weight | 4 | Weigh final product | Minimize | Yes |
| Cost | 3 | Cost of manufacturing | Minimize | No |
| Replacement Time | 1 | Down time caused by failure | Minimize | TBD |

## Prototype Realization

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

Right: Example of knuckle mold pattern used by Amsted Rail

- Cast in Michigan Tech foundry from ductile iron using green sand casting process



Left: Schematic of casting process from *Metal Casting* by Prof. Karl Rundman

- 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.

- Ship to Amsted Rail for performance testing on full scale static tensile and dynamic fatigue test equipment

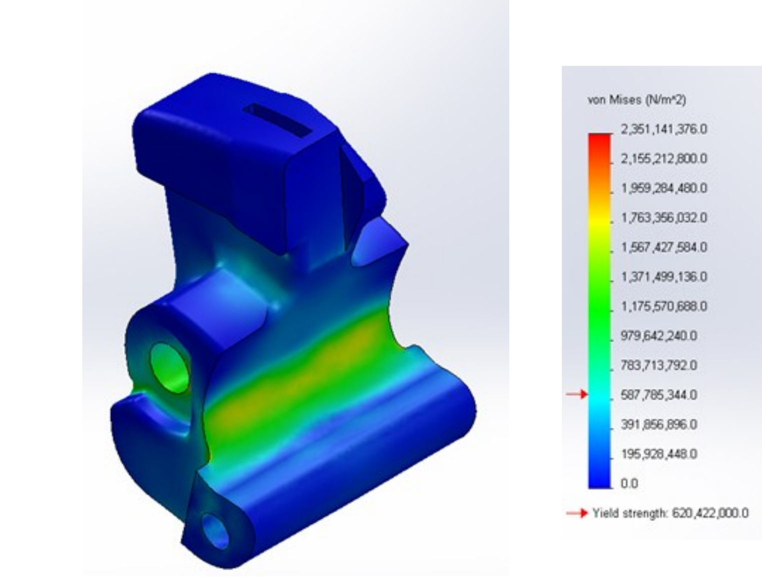
Amsted Rail

- Knuckles will have to fit standard AAR gauges, such as the A-10 contour gauge (shown left)

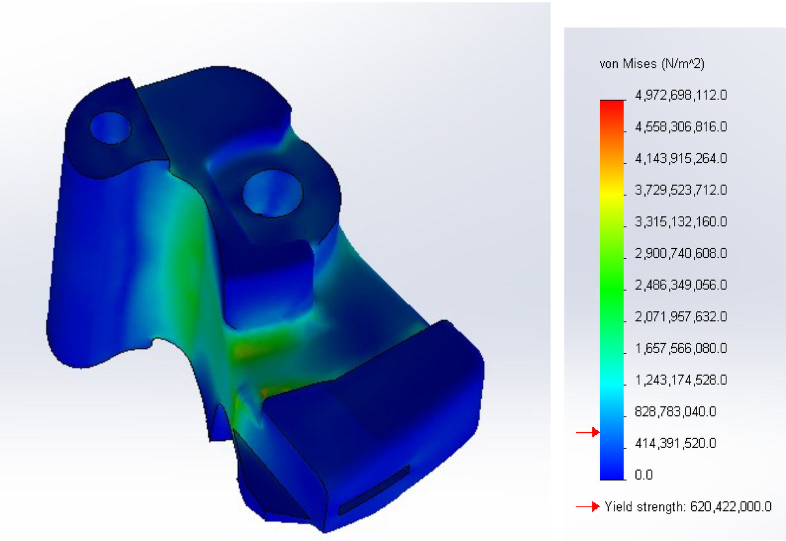
- Dynamic fatigue machine built by Amsted Rail will be used to evaluate the design

## Finite Element Analysis

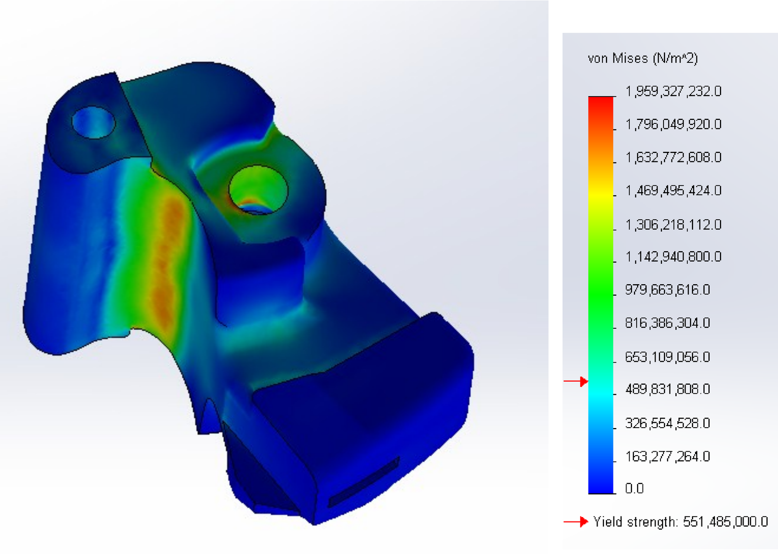
To implement a material change, the static stresses in Austempered Ductile Iron (ADI) need to be less than or equal to Grade E steel. Due to the lower yield strength of ADI, trial and error was used to adapt material reductions within the knuckle , as shown in the CAD model. The simulations were run 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).



**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:** Grade E Steel
**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)



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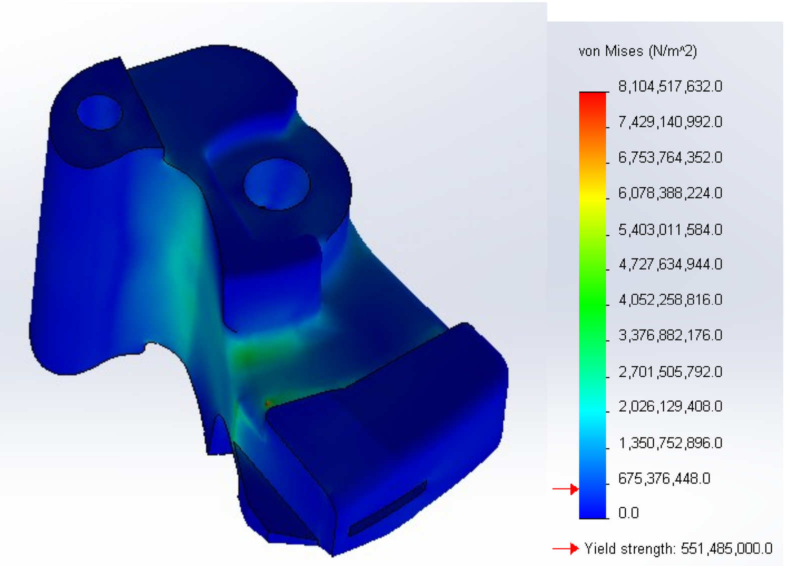

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