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IMPROVED TRUCK CASTINGS – INDUSTRY SURVEY AND COST-BENEFIT ANALYSIS

SUMMARY

The Federal Railroad Administration (FRA) sponsored work conducted by Transportation Technology Center, Inc. at their facility. The current work builds on the results of the two previous phases of this project, which involved investigating alternative materials to reduce or prevent brittle failure of truck side frame and bolster castings.

The previous phases investigated alternative steels that offered improved mechanical properties compared to the currently used Association of American Railroads' (AAR) Grade B+. Each considered ultra-weldable steels, which would not require heat treatment after repair welding, as well as low temperature steels, which show greater fracture resistance at low temperatures.

A cost-benefit analysis (CBA) was performed during this phase to determine the potential additional cost and benefits for producing truck castings from the alternative materials.

An industry survey was conducted among members of the AAR Coupling Systems and Truck Castings Committee (CSTCC) concerning the necessity of using alternative steels with improved mechanical properties. Each member was asked whether brittle failure of side frames and bolsters occur frequently, as well as the need for improving the fracture resistance of these components.

Accident and derailment data from both FRA and AAR was examined for side frame and bolster related causes to determine potential benefits.

Cost projections for side frames and bolsters made from HSLA 65 and HSLA 100 steel show increases between 5 percent and 33 percent. Some of the lower cost increases might be acceptable to railroads purchasing these components, but it is unlikely the larger price increases would be acceptable.

For the low temperature steels, the projected cost increases were higher and ranged between 12 percent and 51 percent. Side frames and bolsters from these materials would probably be cost prohibitive, except for specialized applications.

The survey of stakeholders revealed that brittle failures are rare at any temperature under normal operations. When these failures do occur, they are due to metal quality issues or abnormal occurrences during operations. Based on this information, there does not appear to be an industry need for truck castings made from these alternative materials.

Four derailments per year were reported due to bolster and side frame related cause codes from 2015 to 2017. Broken bolsters were the leading cause of these derailments. Due to the small number of derailments, no trend was observed that could be related directly to low temperature derailments.

Car Repair Billing (CRB) data for 2015–2017 revealed that side frame and bolster wear was the leading cause of both side frame and bolster removals at 69 percent and 55 percent, respectively.

BACKGROUND

This work is a continuation of research to evaluate the use of improved steels in the production of truck castings, specifically side frames and bolsters.

The research had two objectives. The first involved ‘ultra-weldable’ castings, which do not form hard, brittle phases during or after welding, such as would be performed during repair or reconditioning. These castings would not require post-weld heat treatment.

The second objective involved low service temperature steels. These materials maintain their ductility, or ability to deform without fracture, at temperatures below -40 °C. Some of these steels are used for pump and valve bodies that require adequate ductility at low temperatures.

Two previous phases of this work were performed. Each phase considered both the ultra-weldable steels and the low temperature steel objectives.

Phase I, conducted from August 2010 to December 2013, consisted of a literature search and considered a wide range of steels. This was narrowed to five potentially ultra-weldable steels and six potential low temperature steels that are currently used in applications below -40 °F.

Phase II, performed from June 2016 to October 2017, evaluated the selections by mechanical testing, specifically tensile and Charpy impact testing. Based on the test results, two potentially ultra-weldable steels, HSLA 65 and HSLA 100, were selected for the next phase.

Two of the low temperature steels, LC3 and LC9, were selected as having the best low temperature properties. These steels use nickel to maintain their low temperature ductility. LC3 contains 3–4 percent nickel, while the LC9 contains 9–10 percent nickel.

OBJECTIVES

The current work was conducted between April 2018 to September 2018, and is designated Phase IIA. This phase examines the costs and benefits of producing truck castings from these alternative materials. It also examines the need for such components, based upon feedback from stakeholders.

METHODS

A CBA was performed to determine the potential additional cost for producing truck castings from the alternative materials.

The projected order of magnitude cost to produce castings made from these materials was calculated. The 5-year average price of each alloying element was used to calculate the cost.

An industry survey was conducted among members of AAR’s CSTCC concerning the necessity of using alternative steels with improved mechanical properties. Each member was asked whether brittle failure of side frames and bolsters occur frequently, as well as the need for improving the fracture resistance of these components.

To understand the side frame and bolster component safety risk, FRA reported data from 2015–2017 was reviewed. The CRB database also was reviewed for leading causes of side frame and bolster removals.

RESULTS

Using the proposed ultra-weldable steels would result in a price increase, based on higher material cost. Nickel, copper, and other alloying elements are more expensive than iron. The percentages of cost increase are summarized for 70, 100, and 125-ton side frames and bolsters in Table 1.

The low temperature steels also showed projected cost increases. The high nickel levels of these steels resulted in significantly higher costs, also shown in Table 1.

Table 1. Percent cost increase for using ultra-weldable or low temperature steels in truck castings.

	Ultraweldable		Low Temperature	
	HSLA65	HSLA100	LC3	LC9
Bolster 70 ton	5%	23%	12%	36%
Bolster 100 ton	5%	27%	14%	41%
Bolster 125 ton	6%	29%	15%	45%
Side Frame 70 ton	6%	33%	17%	51%
Side Frame 70 ton	6%	30%	16%	46%
Side Frame 70 ton	6%	32%	17%	49%

An additional consideration is heat treatment of these castings. Side frames and bolsters must undergo a normalizing heat treatment, per AAR Specification M-201 and a tempering step is permissible, at the manufacturer's option. Many manufacturers do not perform this step. The HSLA 65, HSLA 100, and LC3 steels need to be normalized and tempered. The LC9 would need to be quenched and tempered. These additional steps would add to the cost slightly. Due to the proprietary nature of some heat treat processes, the additional cost is unknown and was not considered in the cost projections.

Members of the CSTCC were surveyed and four Class I railroads and one casting supplier responded. None indicated that brittle failures were a major problem, except in cases where poor chemistry or other quality control issues were found. Similarly, brittle failure of truck components in low temperatures was reported to be rare. When it did occur, it was often associated with high impact forces during humping operations. The respondents did not believe new or alternative materials with improved mechanical properties were needed for side frames and bolsters.

Four derailments per year were reported due to bolster-related cause codes over the 2015–2017 review period. Broken bolsters were the leading cause of these derailments. The damaged track and equipment cost was approximately $1.3 million annually.

These derailments represented only 2.5 percent of the total number of equipment-caused derailments. Due to the small number of reported derailments, there was no discernible trend related directly to low temperature derailments.

CRB data for side frame and bolster removals during 2015–2017 revealed that side frame and bolster wear was the leading cause of side frame removals at 69 percent. Broken or cracked side frames accounted for 13 percent. The leading cause of bolster removals was also wear, at 55 percent, followed by broken or cracked bolsters at 36 percent.

Table 2. Side frame removal counts 2015–2017

Why Made Code	Frequency	Percent	Cumulative Percent
Worn out	4,226	68.8	68.8
Broken	824	13.4	82.2
Bent Beyond Repair	523	8.5	90.8
Bent	515	8.4	99.2
Cracked	52	0.8	100.0

Table 3. Bolster removal counts 2015–2017

Why Made Code	Frequency	Percent	Cumulative Percent
Worn out	2,166	54.9	54.9
Broken	1,085	27.5	82.4
Cracked	347	8.8	91.2
Bent Beyond Repair	134	3.4	94.6
Bent	131	3.2	97.9
Broken Outside of Bolster	82	2.1	100.0

CONCLUSIONS

Cost projections for side frames and bolsters made from HSLA 65 and HSLA 100 steel show increases between 5 percent and 33 percent over the baseline cost of these components as manufactured currently. Some of the lower cost increases might be acceptable to purchasing railroads, but it is unlikely the larger price increases would be.

For the low temperature steels, the projected cost increases were higher and ranged between 12 percent and 51 percent. Side frames and bolsters from these materials would probably be cost prohibitive, except for specialized applications.

The survey of AAR's CSTCC members revealed that brittle failures are rare, even under very cold conditions. When these failures do occur, they are due to metal quality issues or abnormal operating conditions.

Side frame and bolster related derailments caused 2.5 percent of the total derailments from 2015–2017. The leading cause of removals for both bolsters and side frames for the same period was wear, at 55 percent and 69 percent, respectively.

Based on cost-benefit results and survey responses, further research into these materials, such as producing castings with alternative steels, is not recommended at this time.

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KEYWORDS

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