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Failure analysis of railroad couplers of AAR type E

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ABSTRACT

The paper is about the failure of Railway couplers of AAR type E. Most of the couplers are being replaced before their expected life due to the high stress concentration near pulling lug region, cage-hole and pivot-hole. Knuckle, a part of coupler is designed and analyzed to determine the key regions of failure. A change in the design has been proposed and analyzed to compare the original and modified version of the knuckle. The results of analysis allowed assessing the failure reasons. A set of dimensions are chosen and the response surface methodology (RSM) technique has been implemented to obtain the optimum values for the design variables within given constraints. Life of the new design shows significant increase in life over the original design.

1. Introduction

A coupler is a device used to connect two rolling stocks of a train. The trains can have about 150–250 cars. Each car is capable of carrying about 100–150 tons of loads. There is a great deal of force involved in rolling the cars over great distances. Coupler plays a key role in connecting the two cars with forces acting on it. Knuckle is one of the key components in the coupler that fail frequently in railway couplings.

AAR (American Association of Railroads) coupler is also known as knuckle coupler, Janney coupler, alliance coupler. The type E coupler was first designed in 1932 which does not interlock in the vertical direction.

There are numerous causes that contribute to the failure of the knuckle in the coupler. Some are related to casting processes (ASM Metal Handbook. Castings) that resulted in cavities due to various reasons such as improper degassing, insufficient venting, and lower pouring temperatures and shrinkages due to incorrect gating and feeding, interrupted metal pouring, and insufficient liquid metal in riser (ASM Metal Handbook. Failure Analysis and Prevention). Also, slack inclusion in casting can cause failures. Other causes are related to the actual operation of the trains. One such prominent failure is attributed to the fatigue (ASM Metal Handbook. Fatigue and Fracture) and was reported by the Transportation Safety Board of Canada [1]. The quoted sentence from the report is "Failed Knuckle was the E-type knuckle made from Grade E steel. The fracture surface had an appearance consistent with fresh overstress fracture. Two small regions of pre-existing fatigue, measuring about 1/4 in. long by 1/8 in. deep and 1/2 in. long by 1/8 in. deep, were observed along the edge of the fracture surface".

The objective of this study is

- To determine the key regions of failure and modify the design of knuckle of AAR type E coupler to increase its life.
- To apply RSM technique for the design optimization of knuckle.

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