

THE OPTIMISATION OF THE PROPERTIES OF HIGH-  
STRENGTH SPRING STEELS FOR RAILWAY  
APPLICATION.

Velaphi Jeffrey Matjeke

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## **Abstract**

Bogie springs are critical safety components because they are responsible for the safe operation of railway vehicles. They are also responsible for providing railway vehicles with smooth rides and stability by acting as shock absorbers, bearing load, and controlling motion. However, frequent maintenance interventions owing to premature spring failure result in derailments, logistical disruptions, and financial loss. The aim of this study is to provide a solution to premature spring failure and material scarcity in South Africa. To address these problems, a system thinking approach was used, in which existing failures were studied from the perspective of spring design and material. Additionally, the study investigated spring design using finite element analysis and developed tolerances to avoid operational defects and failures. The study also investigated the fundamental causes of premature spring failure on a newly designed spring that was supposed to fit on a recently purchased locomotive. The causes of the premature spring failures were found to be design related and were linked to an inadequate heat treatment process. The pitch angle contributed to spring coil contact, resulting in notches that accelerated fatigue crack initiation and fatigue failure, while quench cracks formed as a result of deteriorating quenching oil. Therefore, the pitch angle had to be carefully considered to avoid coil contact during loading and unloading of the springs, and the quenching oil had to be monitored to ensure that it did not lose its cooling capabilities over time. The material used for the springs was the Society of Automotive Engineers 5160 spring steel, which the original equipment manufacturer recommended. But because the local steel mill was unable to generate enough orders to keep the production line going, the availability of the recommended material became a concern. Additionally, the government enacted a local content legislation to encourage the localisation of skills and technology, which are not easily available in the country, and steel was deemed a local commodity by the Department of Trade, Industry, and Competition. As a result, alternative materials that can be used as a replacement had to be found. This presented the opportunity to research alternative spring steel grades and optimise heat treatment processes to manufacture bogie springs that are suitable for the existing design and configuration. A unique heat treatment was deployed by considering various quenching oils with different cooling rates that affect the steel grades differently. Quenching oils were also chosen based on the compositions of the different steel grades to avoid quench cracking, as well as quenching oils with the ability to produce desirable mechanical properties and microstructures. The exact critical transformation temperatures and oxidation rates along with

the optimum soaking time and tempering temperature were also determined and measured for each steel grade.