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RAIL TEMPERATURE CONTROL SYSTEM FOR IMPROVED RAILWAY SAFETY

SUMMARY

Physical Sciences Inc. (PSI) has developed a tunable passive solution for limiting the maximum temperature of railroad track. The Rail Temperature Control System (RTCS) demonstrated the capability to reduce the maximum steel rail temperature by 20 °F during thermal cycling. This Phase I Small Business Innovative Research (SBIR) program was funded by the Federal Rail Administration (FRA) and conducted between August 2015 and February 2016 at PSI's facilities in Massachusetts.

Thermal expansion during hot days can result in stress in railroad tracks leading to buckling and derailments. The RTCS is a set of low profile rectangular devices that can be attached to the rail to mitigate temperature spikes during hours of peak solar exposure. The RTCS can be tailored to specific temperature ranges and rail neutral temperatures to most effectively limit the maximum temperature of the steel rail and minimize thermal expansion.

The RTCS absorbs thermal energy from the steel as the rail undergoes solar heating and can keep a rail from reaching the 130 °F to 140 °F temperature danger zone. The system has been engineered to absorb heat from the rail at a point that will minimize steel expansion and peak temperatures allowing the track to operate safely during what would normally be slow order conditions.

PSI conducted device development and thermal cycling testing on a one yard scale in a laboratory setting during the Phase I SBIR program. The goal of the Phase I program was to develop a device that will limit the peak temperature of a rail system.

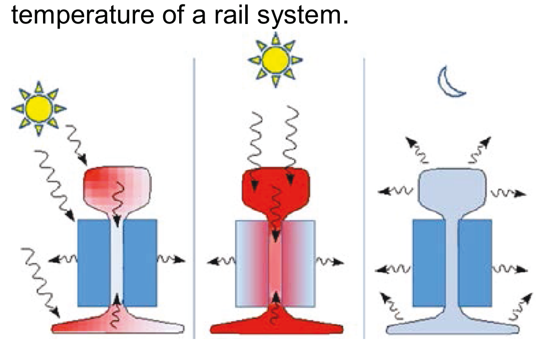

Figure 1. Schematic of PSI's RTCS attached to the web of the rail. As the sun heats the rail, the RTCS absorbs thermal energy acting as a heat sink and lowers the maximum temperature. At night, the system cools and resets for the next day of heating.

BACKGROUND

Steel railroad rails are continuously exposed to the elements resulting in contraction and expansion based on the season. Excessive expansion during high sun in the summer can lead to track instability and buckling. Railroads issue temporary slow orders in an attempt to minimize the potential for costly and dangerous derailments due to buckling. While new sensors are being developed to more accurately anticipate unsafe conditions, new, low-cost solutions are required to limit the rail maximum temperature.

PSI's RTCS represents a flexible, cost effective and scalable solution to limiting rail stress by reducing temperature. Reducing the rail stress will improve rail safety and operating efficiency by limiting the occurrence of buckling conditions and increasing rail lifetime. The passive devices could be deployed on continuous welded rail

(CWR) in high temperature trouble spots or near fixed structures such as bridges to limit thermal expansion of the railroad track. PSI's RTCS offers the opportunity to create safer operating conditions, while decreasing maintenance cost and extending rail lifetime.

OBJECTIVES

The objective of the Phase I program was to design a device that demonstrated the ability to absorb enough heat from 115-lb/yd steel rail to drop the maximum rail temperature 20 °F. PSI engineered a modular system using commercially available components that when attached to operational rail tracks would limit the maximum temperature each day.

METHODS

Development and testing of RTCS devices were performed in a laboratory setting at PSI. A radiative heating protocol was developed to mimic direct radiative solar heating on a steel rail for 6+ hours. This testing protocol was designed to allow a steel rail to reach 130 °F to 140 °F, while the ambient temperature of the testing area remained between 90 °F and 100 °F to mimic real world conditions.

Devices that measure 1 foot in length were designed to attach to the inside and outside gauge of the rails and were thermally cycled using the radiative heating protocol. One foot and 3 foot sections of steel rail were used to determine the effect of full coverage and space coverage of the device on a small scale. Temperature measurements were recorded at various points along the rail surface, as well as on the surface of the devices and inside the device interior. Temperature data was used to show the effect that the RTCS has when providing full coverage to the rail and to understand the area of effect of the thermal absorption devices when they are not applied to the full length of the rail.

Devices were tailored to show maximum temperature reduction given the temperature range produced by the radiative heating test. Thermal cycling was performed on the devices in the full coverage and spaced configurations to show the ability to absorb heat during heating (daytime) and reject heat during cooling (nighttime).

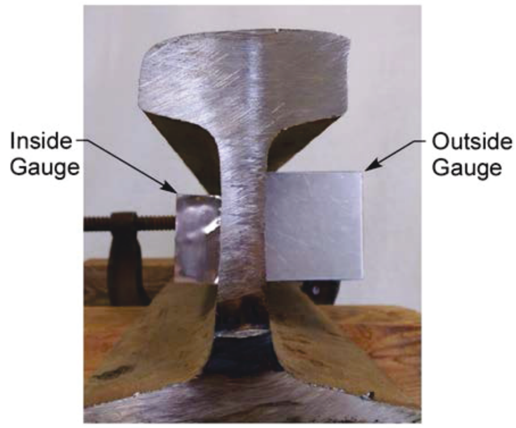

Figure 2. Low profile RTCS devices attached to rail surface provide a thermal absorption capacity and a solar reflective capability to lower rail temperature.

Figure 3. Testing setup using radiative heating to thermally cycle one yard rail sections with RTCS prototype device.

RESULTS

The RTCS designed by PSI demonstrated the ability to provide 20 °F temperature reduction for a steel rail during high thermal load exposure. PSI's RTCS was tested in a laboratory setting with full coverage of the rail. During radiative heating, the control and experimental rails were tested side by side. The rail with RTCS remained cooler than the control throughout the full 7-hour test. The control rail temperature plateaued above 130 °F while the experimental rail reached 110 °F. Full coverage provided a 20 °F temperature reduction over the control rail after more than 5 hours of direct radiative heating. The RTCS absorbed thermal energy directly from the steel rail, while also acting as a reflective surface to the thermal radiation.

Additionally, the thermal testing showed a temperature reduction along the steel rail outside of the area in which the device had been installed. The RTCS has the capability to draw heat from the steel rail and influence a larger area than the device length.

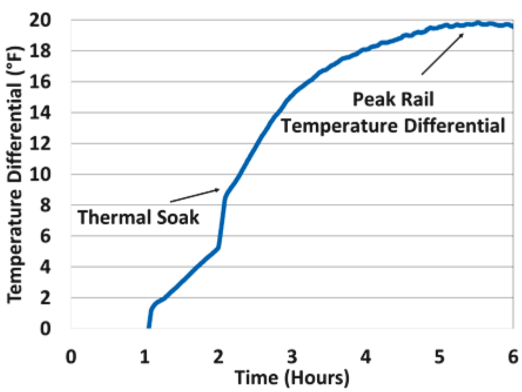

Figure 4. The RTCS demonstrated a temperature differential of 20 °F between the control rail and the experimental rail during radiative heating by reducing the temperature from 130 °F to 110 °F.

CONCLUSIONS

The Phase I testing effectively demonstrated the RTCS device capabilities in a simulated laboratory setting. The RTCS has the capability to lower the maximum temperature of steel rail 20 °F during direct thermal exposure.

FUTURE ACTION

Extended large-scale testing on operational CWR has been proposed for a Phase II SBIR program. Large-scale testing is needed to further analyze the impact that the RTCS has on temperature reduction on continuous rail. Proposed testing will use multiple device spacing layouts to determine optimal spacing for thermal trouble spots. Additionally, large-scale testing over a period of weeks would measure the impact of the RTCS on the stress that occurs on thermal cycling. Large-scale testing would provide a pathway for demonstrating the impact that the system could have on rail safety and maintenance.

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KEYWORDS

passive control, thermal adsorption, steel railroad stress reduction, maximum temperature reduction, buckling