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POPULAR SCIENCE

Portable microscope for analyzing wear surfaces on rails

Microscopio portátil para el análisis de superficies de desgaste en rieles

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Abstract

The interview was conducted by JST's National Director of Railway Incident Investigations, Eng. Diego Di Siervi, with Eng. Maximiliano Zanin, Secretary of Research, Innovation, and Graduate Studies of the UTN Haedo Regional Faculty. They discussed the importance of the wheel-rail contact phenomenon in the railway industry and the development of an experimental portable microscope for evaluating profiles and wear surfaces on rails.

Resumen

Entrevistamos al Ing. Maximiliano Zanin, secretario de Investigación, Innovación y Posgrado de la Facultad Regional Haedo de la UTN, quien nos habló sobre la importancia del fenómeno de contacto rueda-riel en el ámbito ferroviario y el desarrollo de un microscopio portátil experimental para la evaluación de perfiles y superficies de desgaste en rieles.

How did you become involved with trains?

I became interested in trains when I was very young. In Villa Regina, my hometown in Río Negro Province, where trains were the long-distance means of transportation. In the 80s, when I was a boy, I eagerly awaited family members who were coming from Buenos Aires. Although 1000 km is not that far today, at that moment it meant waiting for our cousins "coming from far away", and who we got to see once a year. It was wonderful. Just like travelling by train to visit them, of course.

Later, I was always curious about seeing the routes, studying about train history, and the Argentine railway technology. Bit by bit, I was introduced to this world without being a railroader in the strict sense. Let's say that I see myself as a railroader by choice.

Which is your field of work in Mechanical Engineering?

I work both investigating and teaching. I analyze materials, mechanical damage, surface tear caused by wear, and evaluate solid lubricants or self-lubricants. All these lines of work target the industry in general, with a special focus on the transportation industry, but also on other applications.

What is your investigation focus in the railway field?

Railway transportation in Argentina has been slowly resurfacing in the last few decades. It is known that the proposed goal of our various country-wide projects is to increase the railway vehicles' speed and load capacity. Therefore, we need to study the various mechanical systems adapted to already existing technologies, including the study of wheel-rail contact.

What does the wheel-rail contact phenomenon mean?

This is probably the most characteristic phenomenon in railway research, since it crucially impacts on the dynamics of this means of transportation. It is a type of contact between metallic pair sets where the rail surface is harder than the wheel to increase its service life, since its maintenance and replacement involves more work than replacing the wheels.

Which are that the factors involved?

The nature of this contact is influenced by actuating forces, vehicle kinematics and contact geometry. The latter refers to a cross section of the rail and a radial section of the wheel. In addition, stresses may vary due to differences in curvatures in the contact profile.

Friction and wear in railway systems are caused by the relative movement between the wheel and the rail. These are associated with the type of material, the characteristics of the contact, the surface shape and topography. A freight train running in dry areas with sandy and windy environments is not the same as one running in wet or coastal areas.

It should be considered that surface unevenness can cause a random local contact with variations in the friction force, thus boosting an increase in the wear rate at the wheel-rail interface.

> ***"This is probably the most characteristic phenomenon in railway research, since it crucially impacts on the dynamics of this means of transportation"***

Why is the wheel and rail wear study important from a safety viewpoint?

Well, it's clear that from a safety viewpoint, the wear in wheels and rails could cause head checks, surface deformations, rippling, etc., causing an eventual cracking which may lead to unwanted outcomes.

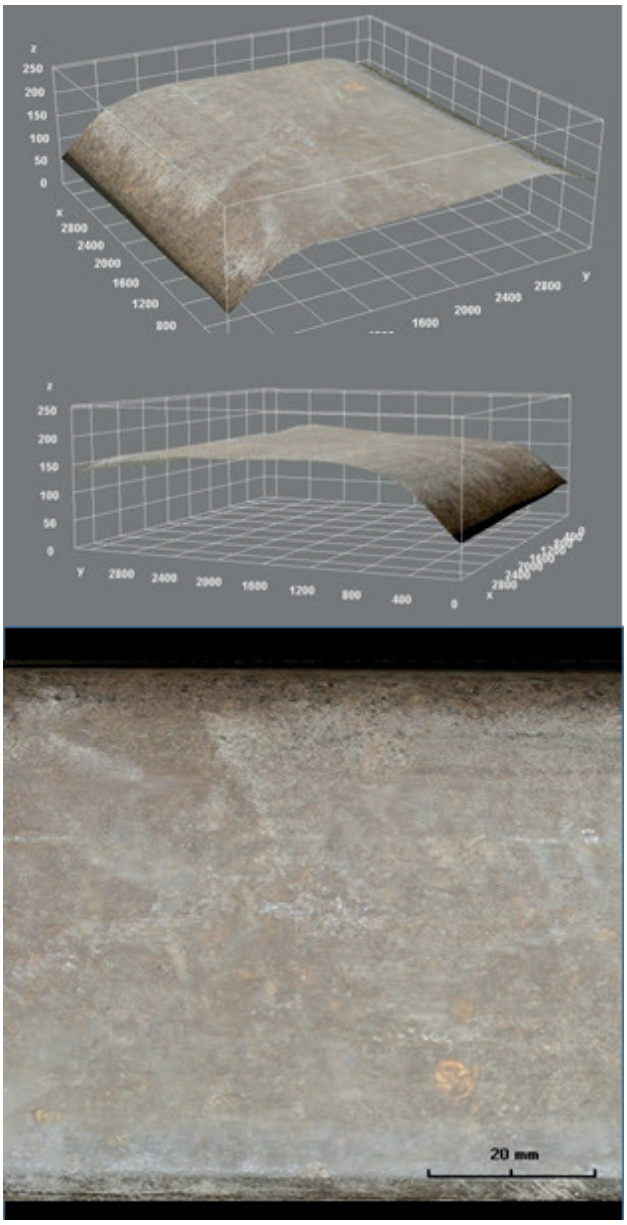
The rail wear study may provide valuable information at the time of examining contact conditions. It is estimated that rail wear is stronger in curves, railway switches, and rail connections. Additionally, predicting the wheel and rail wear is increasingly more relevant for the system performance based on design parameters, such as profile shapes for a specific track type, among other variables.

The study of wear surfaces in rails using high resolution imaging would clearly facilitate a determination of the different wear mechanisms and their causes.

About the latter, what is the purpose of the microscopic observation device developed by your team?

The development of an "experimental portable microscope to examine rail profiles and wear surfaces" is intended to examine rail profiles using digitally processed images which may be overlapped on the model of a new primitive rail. These images, when focused, have a capturing position, which allows for 3D modelling using actual images. Through this development, the surface and global geometry of the analysis area may be examined.

Figura 1. Imágenes de un perfil tridimensional y de la superficie de un riel elaboradas con técnicas de stitching y stacking



How did the idea come up and when did it start being materialized?

The idea came up by observing and studying critical wear areas in curves and rail connections. In 2016, with the recently created Wear and Solid Friction Group of the Railway Rolling Stock Associate's Degree course of the UTN, together with Engineer Nicolás Urbano Pintos[1], we completed a tridimensional lineal movement platform to capture images, which allowed us to compile and digitally process such images.

1. D. student in engineering with a specialization in signal and image processing at the Universidad Tecnológica Nacional (UTN), Facultad Regional Buenos Aires. From 2016 to 2021 he served as secretary of the Railway Rolling Stock Technicature at the UTN, Haedo Regional Faculty.

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> ***"Friction and wear in railway systems are caused by the relative movement between the wheel and the rail. These are associated with the type of material, the contact characteristics of the contact, the surface shape and topography."***

Cristian Donato, from the Instituto de Investigaciones Científicas y Técnicas para la Defensa, participated in the design and printing of 3D parts and was in charge of the mechanical assembly of the device

How does the portable microscope work?

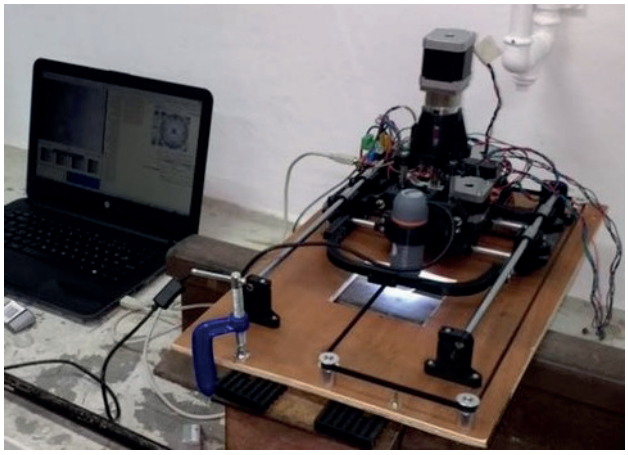
Engr. Urbano Pintos took the conceptual idea of the first ad-hoc microscope as basis to assemble a low-cost device, to examine rail profiles using digitally processed images which can be overlapped on the model of a new primitive rail.

At first, the idea was to create a good-resolution image using the stitching technique, through which multiple images are combined to create a high-resolution image by fitting together or overlapping individual images. Then, under a continuous improvement process, images started being processed using the stacking technique, though which an image is created based on a series of images of the same position, captured from different focus angles. This allowed creating a high-resolution image eliminating out-of-focus areas.

How is this device composed?

It is mostly made by parts that have been modelled using a 3D printer, with commercial stepper engines and a commercial USB connection camera. The idea was to create a low-cost device with a basic design.

Figure 2. General view of the device in a laboratory rail profile analysis.



Is the software used to examine images friendly for daily use?

It is still an experimental development. Various free trial softwares have been used, each having their own pros and cons. The faster processing software require more powerful processors, while the user friendlier software does not provide much information or based on the number of images captured, they do not properly "stitch" images resulting in a somewhat blurred panoramic image.

Could the device be used by any infrastructure staff member?

Of course. Any careful person with a basic knowledge of the computer programs applied may capture and process images on site. Although the analysis could be more feasible using higher-resolution displays.

Have tests or trial runs been already conducted?

Currently tests are only experimental. Although the equipment is conceived to be portable, some lighting adjustments are required. The capture of images with natural light needs to be improved to make the most of out the images that are taken, so that it is not difficult to create a global image

What were the results?

Test results were successful, although certain detail adjustment is necessary, such as adjusting light when capturing images on curved or shiny metal surfaces

What is the scope of this item?

The microscope, with a minor redesign and adjustment of its parts, may be a broad-scope device. In the railway field, it could also be used to determine the wear in the axles of assembled pair sets, tire profiles, roll bearings, etc. It may be used in the railway industry as well as in metal-mechanic or other industries, where knowing the wear of parts that are in contact with each other, or in constant friction, is required.

> ***"From a safety viewpoint, the wear in wheels and rails could cause head checks, surface deformations, rippling, etc., causing an eventual cracking which may lead to unwanted outcomes."***

Considering that safety is based on minimizing risks in ordinary work operations, what would be the benefit of implementing the use of this microscope?

Through this development, an inspection plan could be put in place, considering variables of train circulation on railway connections, curves, and track switch gear, etc., or give indications of wear on inner rail flanks which could be associated with lubrication issues.

Could the use of this device be implemented in a maintenance plan?

Sure. It can be implemented in all potentially critical areas, considering all associated variables, such as heavy load, and speed, among others. There could also be a compilation of data to assess the evolution of surfaces and contact profiles.

Do you think that, upon implementing the use of this microscope, we are going into a proactive system?

Yes, because an item like this, used, for example, for track inspection works would help obtain much more accurate information on the wear condition in curves, straight lines, rail connections, track switch gear, etc., from high-resolution images, which could be used to develop future maintenance plans, thus avoiding cracking or tearing that could trigger accidents.