Wheel Profiling Processes in Relation to Wheel Climb in Switch Point Guards

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Overview

Slow speed locomotive derailments in switches related to wheel climb on point guards has been of increasing concern as evidenced by the article in Technology Digest authored by Hui min Wu and Scott Cummings with the Transportation Technology Center (TTCI) in September 2014 titled *Causes of Locomotive Wheel Climb at Switch Point Protectors*.

This article documented an investigation by TTCI which lead to recommendations which included;

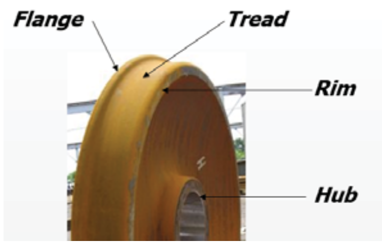
- additional training regarding optional locomotive wheel cutter head lateral positioning and its importance
- Industry wide standardization of locomotive wheel widths and locomotive wheel truing profiles including the possibility of using a radius instead of a chamfer
- Improve the lateral alignment method of cutter heads to minimize the chamfer size, and eliminate the sharp corners

This paper reviews these recommendations with regards to wheel truing processes and machines.

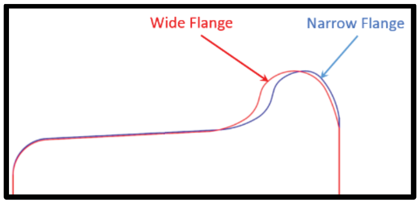
Wheel Truing and Truing Processes

What is wheel truing? Wheel truing is restoration of the profile of a wheel tread by removing material from the rim of the railway wheel while in place on the locomotive or rail vehicle.

The running profile of a railway wheel is part of a guidance system that includes rail geometry and condition as well as vehicle type and suspension. There are a large variety of profiles in use across rail vehicles and systems. The selection of a system wheel profile takes into consideration many operating factors and can change when factors change or as system knowledge changes. Regardless of which profile is implemented in a particular system, wheel profiles have common features with varying dimensions across rail operating systems. Common features include; flange width and height, flange angle and shape, flange tread transition or throat, the gaging point, tread taper, the tape line, and the tread rim face transition also known as the field side relief.



The most commonly used locomotive tread profile currently in use in North America is the AAR 1B which has both wide and narrow flange versions. The following illustration compares these profiles.



While the wide flange profile is the shape for new wheels, both wide flange and narrow flange profiles can be produced by wheel truing equipment. Which profile a particular machine is producing is an operating system's choice. Some operators elect to true worn wheels to a narrow flange profile because it reduces the depth of cut required and will result in a larger final wheel diameter. Some operators true wheels to the wide flange profile because the increased flange thickness can extend the operating period before the wheel has to be trued again or pulled from service because it has reached condemning limit.

The truing of mounted wheels may be required for a number of reasons. Steel wheels rolling on steel rails will cause wear as the surfaces run against each other. The replacement of wheels is a much simpler process than the replacement of rail so the wheel is produced with a softer material than the rails. For this reason the primary driver for wheel truing is due to wear on the flange and tread. Other reasons for wheel truing is to remove defects on the wheel including; flat spots, shelling or built up tread, cracks, roundness, and parity of wheel diameter on an axle, in a truck, and over the locomotive.

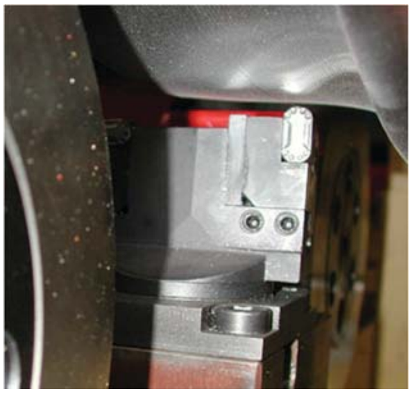
The most common process for wheel truing of freight locomotives is milling. The milling process uses many cutting tools called inserts placed on a rotating cutter.

Installed Milling Cutter

The milling cutter engages the entire wheel tread so that the cutter produces the full wheel profile. The cutter is constructed of multiple blades each holding up to 13 inserts.

Advantages of the milling process is the generation of small chips and the slow rotation rate of the locomotive wheel during the process. The slow rotation rate, or feed rate, of the locomotive wheel is the consequence of the fast rotating speed of the milling cutter. A typical wheel truing cycle takes 3 rotations of the wheel in the machine at about 7 minutes a revolution for a total period of about 25 minutes.

Another process for truing of wheels in place on a rail vehicle is turning using a lathe. The turning process utilizes two carbide inserts mounted to a rigid tool that moves on a path across the surface of the wheel tread as it rotates.



Turning Tool in Lathe

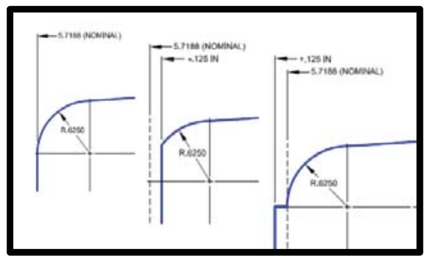
Turning a wheel requires a wheel rotation of about 22 RPM to obtain 185 surface feet per minute to generate the force required at the insert to cut the tread of the wheel. A modern lathe utilizes a computer (CNC) to control the path the tool moves however older machines remain in service that utilize hydraulic tracing systems for tool control. The advantage of the turning process for producing a wheel profile is that the tool path can easily be adjusted as required by wheel dimensional features such as width.

Alignment of Wheel Truing Processes

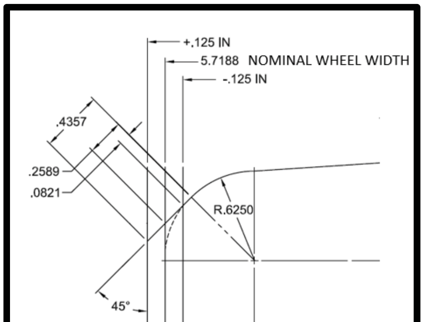
A critical part of a wheel truing process is the alignment of the cutter with the wheel. Correct alignment not only results in an accurate profile, it controls the space or gap between the running wheel and rail. Misalignment of cutter and wheel can result in issues such as; wide or narrow flange, out of gage, incorrect tread taper and flange angle, and field side transition out of specification. The effects of a wheel that is trued out of tolerance or specification can range from negligible to contribution to derailment or wheel failure.

Regardless of the wheel truing process (milling or turning), the cutter must be aligned with the inside face of the wheel rim. This alignment produces an accurate flange profile and positions the wheel gage point in the correct location. As noted by the TTCI Technology Digest Article, locomotive wheels do not have an industry standard wheel width. In the case of the milling process, the full profile cutter is not adjustable therefore the field side transition must accommodate the variation in wheel width.

If the milling cutter were to produce a radius on the field side of the wheel, the cutter would be designed to produce a full radius at the nominal width. If a wheel is under nominal width, only a portion of the radius would be produced when truing is completed. In this instance there would be a sharp transition between the radius and the rim face. If the wheel width exceeded the nominal width then the blades of the milling cutter would contact the wheel and result in damage to the cutter. The following diagram illustrates wheel width variation if a radius was produced by the milling cutter.



The application of the chamfer in the milling cutter on the field side of the profile accommodates width variance. When a narrow wheel is trued, the resulting chamfer is small. When a wide wheel is trued, the resulting chamfer produced is large. The wheel width variance impacts the chamfer length as illustrated in the following diagram.



Field Relief Chamfer Variance due to Wheel Width Variance

This variation of chamfer length is a direct result of variation in wheel rim width when the milling cutter is correctly aligned to the inside rim face. The field relief chamfer can also impacted by misalignment of the cutter to the wheel.

The milling cutter alignment process utilizes a device called a "J Gage". A J Gage is specific to a cutter and in the alignment process, is manually positioned by the machine operator against the inside wheel rim face.

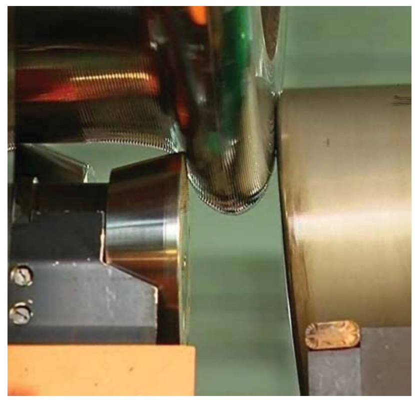
Once the J Gage in in the proper position, the operator will move the cutter laterally to align the cutter to the wheel.

This milling cutter alignment process is dependent on;

- Using the correct J Gage for the particular milling cutter
- Calibration of the J Gage
- Training, skill, and attention of the operator using the gage

The length of the chamfer on the field side transition of a trued wheel will be impacted by any deviation of alignment with the J Gage.

In the turning process on a lathe, the cutter alignment with the inside face of the wheel rim is done by an automatic probe system. The probe cycle is initiated by the operator and then automatically moves through a cycle contacting the wheel in multiple locations.



The dimensional data collected by contacting the wheel includes both the inside and outside rim surfaces. By contacting both surfaces, the lathe determines the wheel width and can automatically generate a tool path that will adjust for wheel width variation. The measured width of the wheel and the ability to modify the tool path gives the turning process the advantage to generate a radius on the field side relief of the wheel.

Good Intentions – Saving a Wheel

On occasion the depth of cut to restore a narrow flange profile of a worn wheel will reduce the wheel diameter to condemning limit or less. Using the turning process the tool path can be adjusted to reduce the flange to an acceptable thickness below full profile thus reducing the depth of cut and saving the wheel. Attempting to "save a wheel" by reducing the flange thickness in the milling process requires shifting the cutter towards the gage side of the wheel which will result in a larger chamfer on the field side and increasing the potential for a derailment in a switch point guard.

Summary

The recommendations identified during the TTCI investigation and documented in the Technology Digest article do address the wheel climb problem in switch point guards;

- additional training regarding optional locomotive wheel cutter head lateral positioning and its importance

Alignment of the cutter is paramount in controlling the size of the chamfer on the field side transition of a trued wheel. The machine operator must understand the importance of this alignment and how critically important it is.

- Industry wide standardization of locomotive wheel widths and locomotive wheel truing profiles including the possibility of using a radius instead of a chamfer

Standardization of the wheel width and restraining the allowable tolerance of the width will control the width of the chamfer. The milling cutter cannot produce a radius unless the allowable tolerance of the wheel width is tightly controlled. If a wheel width standard with tight tolerance was implemented, it would take many years until wheels already in operation are replaced and milling cutters with radius can be introduced without concern for cutter damage.

- Improve the lateral alignment method of cutter heads to minimize the chamfer size, and eliminate the sharp corners

Lateral alignment is operator dependent. Increasing training and the introduction of chamfer measuring devices will increase operator attentiveness.

A Key Note

It could be construed from this paper that the implementation of a wheel turning process in place of a milling process would provide the ability to generate radius on the field side of the wheel is the solution to the wheel climb issue in switch point guards however this singular ability is not sufficient to make a judgement about which process to utilize in a given system. There are many factors to be considered when selecting a wheel truing process some of which are equally if not more important than this ability.