WHEEL INSPECTION SYSTEM ENVIRONMENT QUALIFICATION AND VALIDATION

Final Report for Public Distribution

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Abstract

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Keywords

Non-contact wheel measurements, Wheel profile, EMAT, Wayside system

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Executive Summary

The safe and efficient operation of railroads requires regular and consistent maintenance of the train car wheels. Constant force and the stress caused by steel running against steel at the juncture of rail and wheel work to alter the original shape and dimensions of wheel profiles. This can lead to improper wheel dimensions and wheel failures due to cracks and other flaws and constitute the primary cause of railway accidents, including major derailments with loss of life, serious injuries, extensive property damage, and downtime for both equipment and railways. Improper wheel measurements also affect ride quality and energy efficiency.

Railroad cars are carrying heavier loads and traveling at higher speeds for longer distances as the industry tries to face today's demands with fewer personnel. The wheel inspection methods of the past are still in use today and lag far behind these demands. Manual steel J wheel gauges are inefficient, inaccurate and unreliable and can lead to expensive, and in some cases, unsafe operations. New techniques are required to ensure safe and efficient railway operations.

International Electronic Machines Corporation (IEM) has developed and is now marketing a state-of-the-art Wheel Inspection System Environment (WISE). WISE provides wheel profile and dimensional measurements, i.e. rim thickness, flange height, flange thickness, flange angle, diameter, reference groove; brake pad thickness measuring; and flags out-of-roundness and flat spots. WISE's modular architecture easily integrates with existing way-side equipment and works seamlessly with existing railroad rolling stock management systems.

IEM has completed the successful installation of WISE at the CSX Transportation hump yard in Selkirk, NY. The system includes three primary wheel measurement modules: the wheel profile system, brake pad management system, and crack detection along with a variety of support systems to monitor and control the system. The Profile and Brake Pad Management systems are fully automated and have easily integrated with the computer system already in place in the CSX yard. The module for Crack detection is undergoing further in house testing before it will be ready for implementation.

WISE provides the following benefits:

- More thorough and uniform wheel inspections leading to safer operations;
- Better profile maintenance contributing to superior ride quality and better overall performance at high speeds;
- Elimination of the time-consuming process of manually measuring the wheels and thereby reducing labor costs;
- Improved scheduling of wheel maintenance activities leading to a reduction in equipment down time and improved ride quality;
- Better understanding of wheel wear patterns which leads to a reduced inventory of replacement wheelsets;
- Better understanding of when to intervene with a wheel true, and the development of new and more cost effective wheel profiles which in turn result in longer wheel life;
- Extended track, tie, and rolling stock life due to elimination of flat and out-of-round wheels.

Introduction

Identification of the Transportation Problem

Wheel inspection, maintenance and replacement are among the most important duties of a railroad mechanical department. Wheels are the most expensive component of freight car maintenance and account for about two-thirds of the lifetime cost to maintain[1]. According to the Association of American Railroads (AAR) data, last year railroads spent about $330 million to replace 320,000 wheelsets with tread damage. Since they are subject to high stress and wear during use, train wheels require a substantial amount of routine inspection, repair, and replacement. A high standard of maintenance is essential to avoid damage to track, cars and contents from rough, broken or deformed wheels. More importantly, the failure of a single wheel can result in a derailment with potentially catastrophic consequences (See **Figure 1**).

Figure 1: Broken wheel which caused a lethal 2004 derailment

According to the Federal Railroad Administration (FRA) safety data, over a recent nine year period, there was an average of 90 accidents per year attributable to wheel failures. Increasing train weights and speeds and the advent of high speed rail systems in the inter-city passenger industry are increasing the catastrophic potential of wheel failures.

The safety data points out the need to improve wheel inspection techniques. Current inspection techniques have lagged far behind the demands of the modern train industry. These techniques rely heavily on visual inspections which are often hampered by poor lighting, poor weather, and limited supervision due to reductions in the employee hours in the railroad industry.

When wheel accident data is broken down into type of wheel defect, it shows that worn flanges are the single greatest cause of train derailments. This is distantly followed by Broken Rim, Broken Plate and Other Causes respectively. Based on this data, any system that effectively identified flange and rim wear has the potential to significantly reduce the overall number of derailments in the railroad industry.

The freight car fleet is aging but must carry heavier loads at higher speeds for longer periods of time. Inspections become more and more important, but the work force available for inspections is being reduced. At the same time, the growth of unit train operations is reducing the opportunities and time available to conduct wheel inspections. These inspections are being conducted manually and rely on practices that have not changed significantly since the 1920s. Although the overall safety performance of the industry has been improving dramatically, there has not been as great a reduction in the number of wheel accidents. A solution must be found.

The WISE Solution

IEM has spent several years bringing together a number of technological solutions to the problems identified above. The result is the development of a comprehensive system called the ***Wheel Inspection System Environment*** (WISE). WISE promotes the ***reliable and accurate measurement of train wheels***

[1] Progressive Railroading website: "Technology Update: Tread-Conditioning Brake Shoes" by Jeff Stagl, November 7, 2008

and detection of the types of wheel flaws that are most often associated with failure and accidents. In fact, WISE ***can detect the eight most common wheel defects*** that account for more than 90% of all defective wheels.

IEM has completed commercial development of WISE and has successfully completed the installation of WISE at the CSX Transportation, Selkirk Yard. This particular installation provides the following direct benefits to CSX:

- ***More thorough and uniform wheel inspections*** leading to safer operations;
- ***Better profile maintenance*** contributing to superior ride quality and better overall performance at high speeds;
- ***Elimination of the time-consuming process of manually measuring the wheels***; contributing to reduced labor costs;
- ***Improved scheduling of wheel maintenance activities*** leading to reductions in equipment down time and improved ride quality;
- ***Better understanding of actual wheel wear patterns***; leading to reduced inventories of replacement wheelsets;
- ***Better understanding of when to intervene with a wheel true***, and the development of new, more cost-effective wheel profiles which in turn will result in longer wheel life; and
- ***Extended track, tie, and rolling stock life*** due to elimination of flat and out-of-round wheels.

Benefits

WISE offers significant and impressive environmental and economic benefits for both New York State and the United States.

Environmental Benefits

A generally accepted figure in the industry, used in many train modeling approaches, is that fuel economy degrades by approximately 7%, on average, due to flat spots, out of round wheels, and other wheel related issues. By providing a reliable and accurate means of detecting virtually all instances of these conditions, and doing so in locations where servicing should be immediately available (near or within rail shops/yards), WISE will be able to drastically reduce this average.

While there is no way to entirely eliminate such losses, IEM estimates that 5% of that degradation of fuel economy could be eliminated with deployment of WISE on a nationwide basis. For diesel freight services, ***this translates to a savings nationwide of over one hundred fifty-four million gallons of diesel fuel***, or, with approximately 20,000 locomotives in service, over ***7,700 gallons per locomotive***. For electrical transit services, such as the New York City Transit Authority (NYCTA), the results are equally impressive; ***a 5% improvement would save 93,778,800 KW-h of electricity for New York City alone***.

A savings in fuel equates not only to an energy savings but also a reduction in environmental impact. Approximately 1 ton of CO_2, a known greenhouse gas, is released for every 14 million BTUs of electricity used. A savings of nearly 94 million kilowatts of energy for the NYCTA would account for 22,000 tons less CO_2 being released into the atmosphere. The reduction in diesel emission has similar savings. For each locomotive, a 5% reduction in fuel use equates to 71 tons less CO_2 for a nationwide reduction of 1.42 million tons. Other pollutants associated with diesel emissions will also be reduced.

Economic Benefits

Energy saved by the train industry translates directly to immense economic savings. For the NYCTA alone, a WISE system could mean a savings of over $6 million in operating costs. For diesel locomotive operators, it could be a savings of over $150 million per year nationwide due to fuel economy. The savings improves further with a reduction in wear and tear on the trains, tracks and wheels resulting in a decrease in track maintenance, car maintenance and other associated costs.

IEM estimates that the market demand for WISE will range from two to ten units per year domestically. All of these systems will be designed and built in New York State in one of IEMs two locations in Albany, NY or in Troy, NY. This will lead to new jobs in manufacturing, sales and engineering jobs for the company and for New York State. It will drive the growth of IEM and other affected businesses.

Safety Benefits

As previously described, poor wheel conditions are a cause of stress on all parts of the rail system. They exacerbate already existing flaws; and can, in the case of flat spots, be the direct source of other wheel flaws and failures. The failure of any component of the riding system of a train can lead to derailments and crashes. By detecting wheel flaws as early as possible and in the most efficient manner, the chances for such flaws to cause accidents is drastically reduced.

Installation of the WISE System

During the summer and fall of 2006, IEM constructed and installed the first field prototype for WISE at the CSX Transportation rail yard in Selkirk, NY. The purpose of this project was to develop and implement a test and evaluation plan that would document WISE's capabilities in a real world environment, in a number of key areas.

The WISE installation is situated at the hump yard where incoming trains are broken and directed to a set of classification tracks for building outgoing trains. The hump yard provides an efficient method for identifying cars with bad wheels and quickly redirecting them to a Car Shop for needed maintenance and repair.

Both the Profile and Crack Systems were installed in November 2006 and initial system testing and debugging began shortly thereafter. The Profile System became operational in December 2006, and on April 10, 2007, began 'bad ordering' condemnable wheels. The Crack Detection module was removed from the hump yard shortly after installation due to durability issues. It has since been returned to the hump yard for testing purposes. The Brake Pad Management system which was not originally part of this project has now been fully integrated into the system.

WISE Modules

IEM's Wheel Inspection System Environment provides a modular, comprehensive, rail-based system that consolidates multiple modes of railroad-wheel monitoring.

The CSX installation of WISE consists of:

- Control and Reporting Module (CRM);
- Wheel Profile Module (Profile)
- Brake Pad Management System Module (BPMS)
- Crack Detection System (Crack)

Wheel Profile Module

The Wheel Profiling System (Profile) uses IEM's patented method to measure the flange thickness, flange height, and rim thickness of the train wheel. The system then determines whether a wheel must be condemned and removed for repair according to AAR rules or FRA regulations.

Testing Profile

The most critical process for Profile to undergo is calibration. The careful and dutiful completion of this step provides a baseline of performance for the mechanical and software components of the Profile system. Therefore, IEM recommends that a full system recalibration be performed every six months.

There are two types of calibration that can be done to the Profile module. The first is to calibrate the system using a frame that is bolted to the track and remains in place while several different steps are taken to be sure that all of the elements of the system are calibrated. This requires a substantial window of time which is hard to find on the hump which has close to 10,000 cars passing over it each day. Thus, it is not feasible to use the frame on a regular basis.

For this reason, IEM built Calibration Segments. The segments are of a specific profile and can be used quickly to calibrate the system.

The measurement accuracy of any process is determined by comparing its results to a reference value. The reference value should be the result of an independent measurement process of equal or higher accuracy. A Steel Wheel Finger Gage (SWG), which is the standard tool for manual measurements, is capable of producing measurements of the flange thickness, flange height and rim thickness that could be used to validate the measurements of the Profile, but it measures in 16ths of an inch which is not accurate enough for establishing reference measurements. IEM's Mini Electronic Wheel Gage (EWG) is also able to produce the needed measurements and has been validated by both IEM and the AAR Transportation Test Center (TTC) for equivalence to AAR standards. Since the EWG is accurate to $1/64^{th}$ of an inch, it was better suited to create reference measurements for Profile.

Repeatability based on specific new wheel measurements was another way to validate Profile's measurements. During the period of December 12, 2007 to January 3, 2008, wheel measurement data was searched to find wheels that had passed through the system more than once and also matched the AAR dimension requirements for new wheels (see **Table 1**). There were 115 wheels that matched these criteria. The measurements taken during the first and second passes were compared to each other to check for accuracy. The measurements of the repeated new wheels was found to be nearly identical or within the expected range.

When the Profile module was first installed at Selkirk, the system needed to be tested to determine if its measurements were accurate. IEM worked with CSX to do what was called a 'yard test'. The cars that were in the yard that were run through the system were re-measured by hand. This involved the hand measurements of hundreds of wheels. While the test results were crucial to making the initial adjustment to Profile and for calibration, it was quickly determined that the results were not as accurate as they could be. Human error and the deviations in wheel wear were two of the obstacles that were encountered in the hand measuring. Thus, the calibration segments were designed to verify the system's accuracy.

Profile Measurement	**New Wheel Dimensions Inches**
Flange Height	1.07 ±0.07
Flange Thickness	1.46 ±0.04
Rim Thickness	1.55 ±0.07

Table 1: AAR dimensions for new wheels

The most useful test of the system was the large volume of cars that pass through the system on a daily basis. When a car is bad ordered by Profile, workers at the shop verify that the wheels are indeed in need of repair. Hand measurements of the wheel are taken at nine different points along the wheel to check the measurements of the system to minimize the human and wheel deviation issues.

The Profile system uses two lasers and two cameras on each side of the wheel to ensure that a good image is taken of the wheel profile. The two systems must see the same condemnable measurements in order for a car to be bad ordered. This ensures that good cars are not sent to the car shop. Adjustments were made in the system to try and make certain that the cars being re-routed to the shop were indeed in need of repair.

Adjustments of False Positives

After the WISE system was up and running and bad ordering cars to the CSX car shop, it was important for IEM and CSX to look at the number of cars that were being flagged for failing to meet condemnation limits versus those wheels that were at the AAR limits, or 'false positives'. The cost of false positives to the yard is significant, but failure to identify condemnable wheels has potentially disastrous implications. There is a balance point to be achieved between accurately sending wheels that fail to meet AAR condemnation limits and sending wheels that actually meet the condemnation limits.

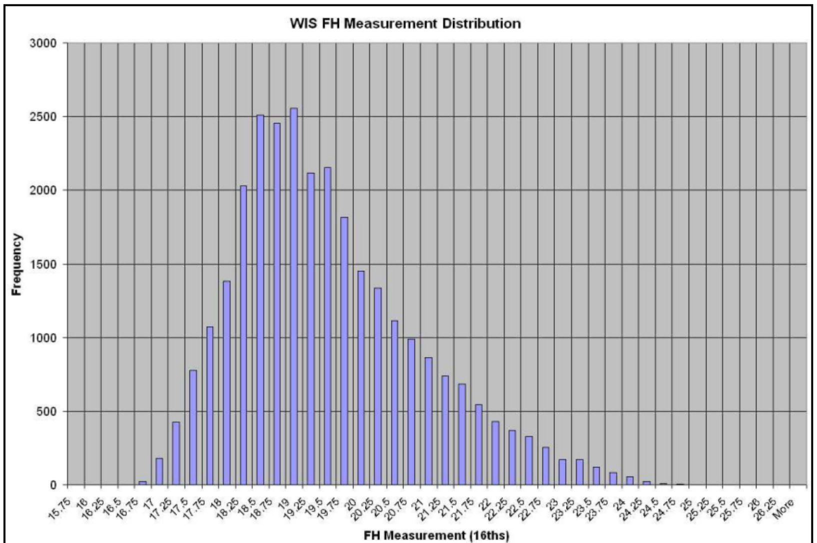

Figure 2: Histogram sample of FH measurements from WISE

IEM quickly discovered that an "at the exact limit" approach was not going to work. There would be a very large flow of cars entering the shop with a large number (close to 50%) found to be false-positive. The ideal configuration for the system was to be one in which the margin of error just barely reached the AAR limit.

In order to find the appropriate point to set as a limit, IEM sampled the extensive amount of wheel measurement data and generated a series of histograms for each of the three key measurement parameters, FT, FH, and RT.

Figure 2 shows a histogram for Flange Height taken from a sample of approximately 30,000 wheel measurements (about 3 days worth of measurements at Selkirk) representing a fairly normal statistical distribution. Deciding where to set the condemn limit for WISE involved evaluating the right side of this curve. If the limit of condemnation was set at 24.25-sixteenths, WISE would have sent 34 of these wheels to the wheel shop for validation, which is in line with CSX expectations. With the limit set at 24-sixteenths, which is the AAR standard limit and a difference of only 1/64-inch, WISE would have condemned **88 wheels**. Measurement errors alone, caused by things such as a dirty wheel, suggest that some portion of those 54 extra wheels would actually have passed the AAR standard of 24-sixteenths. By carefully studying the data, IEM was able to establish appropriate limits to maximize the number of condemnable wheels sent to the shop while minimizing the number that ultimately proved to be false positive.

To track false positives, IEM worked closely with the CSX Selkirk Wheel Shop staff to carefully evaluate every false positive sent to the shop. IEM compared the running record they kept of every car that was bad order to the form that was filled out by the CSX personnel during the manual inspection. Based on these two records, IEM was able to analyze the reasons for each false positive encountered.

According to the analysis, one of the major reasons found for false positives stemmed from a problem with interpreting the wheel diameter. AAR standards relate the condemnation limit for Rim Thickness to the ***original diameter*** of the wheel. WISE, however, measures the *actual diameter* of the wheel, not its original diameter. Using the actual diameter resulted in a faulty evaluation of the condemnation standard for rim thickness of the wheel. To correct this problem, IEM re-wrote the algorithm used for calculation of Rim Thickness condemnation.

Brake Pad Management System

The Brake Pad Management System (BPMS) was not part of the original plans for the WISE system that was installed at Selkirk and was not initially included in this Qualification and Validation study, but it is an important addition to the system. The BPMS captures an image of the brake pads of each car as it passes and determines if the brakes of that car need to be given further evaluation. The system consists of

Figure 3: The BPMS module at the Selkirk installation

four wayside cameras and illuminators, a pair on each side of the car (See **Figure 3**). The first camera is positioned to view the upper portion of the brake pad and the second camera views the lower portion as visible through the truck (See **Figure 4**). The truck and brake elements are identified, and the region identified as the pad is further analyzed to produce a measurement. Measurement results that are below the AAR rules or FRA regulations are flagged for additional inspection.

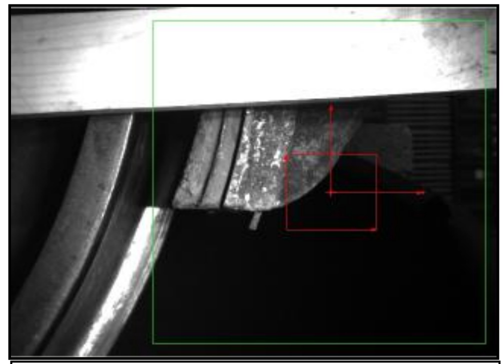

Figure 4: Brake pad as seen by BPMS

There are many challenges to an optical system such as BPMS. Brake pads often show pathological wear patterns, obstructions can make obtaining good images impossible, and environmental conditions can interfere with the imaging process. Despite these obstacles, IEM has successfully deployed the BPMS system at the CSX Selkirk yard. The BPMS is fully integrated into the WISE system.

Testing BPMS

Calibration of the BPMS was required for the optical system to determine the relationship of the camera field view and the physical dimensions of the passing brake pad. This included repeated measurements of the same car as it passed through BPMS on different days which allowed IEM to formulate a precision baseline for the system

After BPMS had proven to be a reliable and calibration had been achieved, validation testing began. During the period of June 1, 2008 through July 21, 2008, BPMS made measurements of 127 brake pads of passing cars, some more than once. On July 22, CSX supplied IEM with a list of cars awaiting service which had been measured by BPMS during this time frame. IEM worked with CSX personnel to remove 77 brake pads from these cars and measure them by hand using a digital caliper to validate the measurements found by the BPMS. As it is impossible to know the exact spot used by BPMS for the measurements, the pad was measured in several areas at least 1 inch from the edge to establish a range of measurements for the pad. The manually identified regions can be best defined by their minimum and maximum thickness measurement. The results of the comparisons of these two measurements established the physical accuracy of BPMS.

As with Profile, IEM needed to carefully set the limits of BPMS. Due to the nature of visual processing technology, brake pad elements can be misidentified by BPMS. For this reason, BPMS acts conservatively by choosing the larger visual element for measuring. This will bias individual measurements away from the condemnable limit. Since BPMS can independently measure both segments of a bake pad, the risk of missing a condemnable pad by overestimation is reduced. This bias also acts as an additional assurance that when a pad is identified by BPMS as condemnable there is a very high certainty (samples suggest 95%) that this judgment is correct. Most of the measurements produced during testing of this system were within the measurement tolerance of ±1/32 of an inch.

The 4% of measurements that were under tolerance were all within 1/8 of an inch of the actual pad thickness. A post-measurement study was done on the actual BPMS images. It was found that in all but a very few situations, BPMS made the correct measurement. Because it was not possible to find the exact source of the error (possibly human), the 4% error rate is considered conservative. IEM believes that the true rate is much smaller, closer to 1%.

Crack Detection System

The Crack Detection system uses Electro-Magnetic Acoustic Transduction (EMAT), an IEM patented technology, to detect flaws in the metal rail wheels as they pass over the system. Two Crack Detection modules are set down into each rail (See **Figure 5**) and rise up to make contact with the wheel as it moves along the rail. An electro-magnetic pulse is sent out and the signal is received back. The signal and its echoes are then interpreted by the module to find any flaws in the wheel. Two units are used to be sure a good reading of the whole wheel is achieved and to validate the readings.

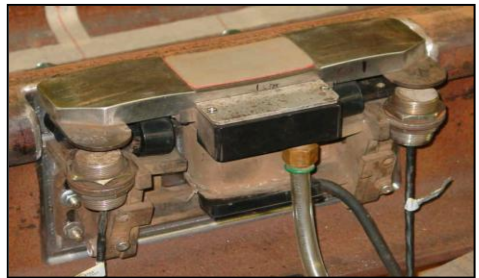

Figure 5: Crack Detection module set into rail

The Crack Detection module was turned on and began operating at Selkirk in 2007, but after receiving a small amount of data, the system was penetrated by debris and needed to be removed. After being worked on in house for almost a year while Profile was concentrated on per the customer's request, Crack was again installed at the hump yard. At this time, there are two of the Crack modules at Selkirk and two in house. This allows for the components to be studied at IEM then applied to the freight yard to be tested in that environment.

Testing Crack

The testing of the Crack system was to verify that it was an operational system and to validate its findings. Shortly after testing commenced, the survivability of some components became an issue. Due to the hectic and harsh nature of the freight train yard, which averages 10,000 cars a day, the longest length of time that the system remained operational was two weeks due to various factors. Due to the cleaner environment of a transit rail yard, it is thought that the Crack system will do better in this type of location.

The rail that holds the Crack foot must be tooled to create a pocket so the module can set down within it. Shortly after the rail was installed at Selkirk, it cracked and needed to be replaced which delayed the installation of the Crack module. While the age of the rail was thought to be a contributing factor to its failure, it was concluded that the rail would need to be periodically retooled and occasionally replaced.

The component of the system that takes the most abuse is the pad which is on the top of the foot and makes direct contact with the train wheel. IEM knew that the pad was going to need to be durable to survive being impacted by moving train wheels. However, it was thought that a composite material would be strong enough to withstand those forces. It did not. The pad was quickly damaged by flakes of metal, probably from shelling wheels, and other debris being pushed down through the pad's surface and into the sensitive electronics below. Research into other materials was done. Kevlar was tried, but the weave of the Kevlar was too large to stop the small particles from entering. At this time, IEM is using an epoxy composite with a Formica-like hardness. It has also experienced the same problems as the other materials.

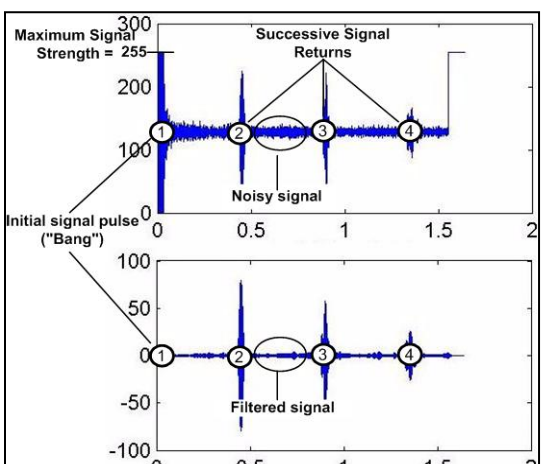

Figure 6: A noisy, unfiltered graph (top) and a filtered signal data graph (bottom)

To find a solution, IEM has investigated the reasons for this damage. The damage that is caused by flakes of metal being pushed down into the pad could be caused by the magnet. When the magnet is engaged, the metal flake on the pad 'stand up' and the impact of the wheel drives them through the composite material. To combat this, a timed air blast could be used. The air blast, which would be initiated just after the system is activated and the magnet engages, would blow across the pad and remove or push down the metal flakes and grit. In conjunction with the air blast, modulating the strength of the magnet could be part of the solution to minimize the impact of the pad with the wheel. Of course, as new composite materials are brought to market, IEM will continue its quest for a material with more survivability.

Even with the durability issue is resolved, the pad on the Crack foot will need to be replaced periodically. Knowing that time on the hump is at a premium, IEM modified the replacement procedure to fit within the 15 minute window that maintenance personnel have to make repairs. Each pad can be replaced in just a few minutes.

While the mechanics are being refined for durability, the detection capabilities of Crack are also being fine tuned. Crack is designed to listen for the original ‘ping’ from EMAT followed by a second and third signal that should be received in an expected span of time. This would indicate that no flaws were found. If there is a flaw in the wheel, the return signal will come sooner than anticipated by the system and will be flagged as a flaw within the wheel.

Noise reduction software and hardware are used to reduce spurious noise caused by outside sources. **Figure 6** shows a graph with a noisy signal and a filtered signal. The bottom graph is the ideal signal with all noise reduced to negligible levels and easy to detect return signals.

In the real world setting of a freight train yard, even with noise filtering, the data graphs looked less than ideal. Over 27,000 data graphs were generated by the traffic at the Selkirk yard, and it was quickly evident that noise was going to make the detection of possible flaws very difficult (see **Figure 7**). The graphs that were being generated did not resemble any type of expected pattern.

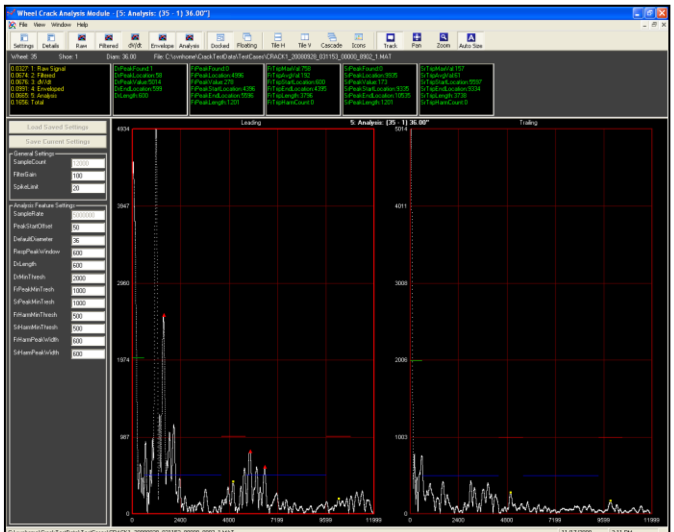

Figure 7: A data set from the Selkirk hump yard showing unreadable data due to signal noise

As the data sets were being generated from the Selkirk yard, IEM attempted to understand the variations in the signals. It was difficult to determine the cause of some of the findings due to the number of circumstances that could account for them. For instance, if there was no return signal, a common problem, the cause could be attributed to the trigger not activating at the right moment. It could also be caused by the pad and the wheel failing to make solid contact perhaps because of a hollow tread. Older wheels can harden and become ‘metallurgically dead’ and absorb the signal, and shelling can also stop the signal. In the end, it was impossible to determine the exact reason for a failure to return signal.

Despite spurious noise and signal variations, gathered data did show that flaws can be detected by Crack. During the testing at Selkirk, the data pattern associated with a flaw was found. **Figure 8** shows the expected pattern of a wheel with a flaw generated at Selkirk**.** The return signals are

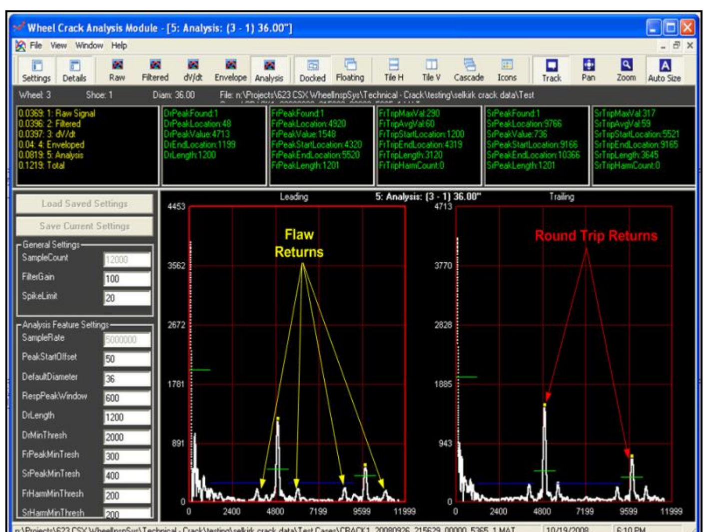

Figure 8: Graph of flaw found at Selkirk yard.

where they are expected and show as taller spikes on the graphs. The signals that were returned from the spot of the flaw are tiny fluctuations on the graph before and after the return signal. The presence of the flaw is verified in the data gathered when the wheel passed over the second shoe.

Once a flaw is identified, the issue becomes validating the finding. A crack that is located under the tread cannot be found by a manual or visual inspection, but it can be found by the Crack module. The only way to truly verify the findings of the system would be to destroy the wheel and find the flaw. As this is not a feasible validation tool, verifying the detection of a flaw is difficult.

To make validation of the system more feasible, IEM developed a hand held model of the crack detection foot. During in house testing, metal loops made to resemble the tread of a train wheel are being used to test and validate the crack detection module. The foot is set on the wheel and a reading is taken (See **Figure 9**). By moving the foot along the wheel, the operator is able to use the data graphs to find the crack in the loop. The smaller returns will be closer to the expected, strong return signal as you move closer to the flaw. To test the Crack system in house, IEM utilized three loops, one with no crack and two with varying degrees of cracks. The use of a hand held foot for validation or for calibration purposes is being considered.

Figure 9: Hand held Crack Detection foot setting on testing loop

If the flaws that are found by Crack could be validated, the limits or measurements for a condemnable car based on a cracked wheel would need to be better defined. At this time, those limits are unclear. The rules for condemning cars due to a crack in the wheel are obscure and do not list any condemning measurements for length or depth of a crack. This makes it difficult to set limits for the Crack system to avoid false positives.

Despite the issues that not yet fully resolved, the Crack Detection module is capable of collecting data from moving train car wheels and has shown the ability to detect flaws. IEM is continuing to work on increasing the durability of the system and decreasing the signal noise to make flaw detection easier. While this system will be better able to withstand the rigors of the transit rail environment, the application of crack detection in the freight industry is important. As EMAT is the best non-destructive way to detect cracks in train wheels as they are moving through the hump yard, it is important to IEM to continue to address the issues found at Selkirk.

Marketing WISE

The testing and validation study that was done at the CSX Selkirk hump yard has been invaluable in establishing a marketing plan for WISE. The greatest tool for marketing this type of product is to have the ability to demonstrate a successfully functioning system with copious amounts of data to back up those claims of success. With the WISE validation results and the functioning Selkirk system, IEM has this means at their disposal.

A tour of the Selkirk hump yard demonstrates the ability of WISE to operate in a freight environment using the latest advanced technology to accurately measure and analyze multiple inspection points in less time and in greater detail than currently possible with visual and manual methods. The data from 10,000 cars a day will be used to show the accuracy of the system and its ability to limit the cars it sends to those that exceed condemnable limits.

Using WISE, a railroad could increase its billings to private car owners and other railroads by avoiding misread measurements that allow condemnable wheels to pass through the system when they should be changed. Additionally, a railroad could enjoy a savings in both labor and parts costs by passing through wheelsets that do not require repair.

This study demonstrates the need for WISE and the benefits to potential customers. As IEM goes forward, this information will be used to market the system to railroad companies in both freight and transit transportation, and both nationally and internationally.

Summary

During the course of this project, IEM has installed, tested and achieved a successfully functioning Wheel Inspection System Environment at the CSX hump yard in Selkirk, NY. The system has been proven to be a reliable means of profiling wheel measurements and brake pad thickness through an abundance of data. The Crack Detection module has shown the ability to collect data that indicates a flawed wheel, but has yet to go on line at the Selkirk yard. IEM is working to improve the module's durability and noise filtering so that it can survive in a freight train environment. The Crack system is expected to perform successfully in the cleaner transit environment.

WISE is now ready to be marketed and a marketing plan has been implemented to grow national and international sales.

The benefits of WISE for CSX and for future potential customers are:

- Safer and more efficient operations due to more thorough, concise and uniform wheel inspections;
- Reduced labor costs through the elimination of the time-consuming process of manually measuring the wheels;
- Better wheel profile maintenance contributing to superior ride quality and better overall performance at high speeds;
- Reduction in equipment down time through improved scheduling of wheel maintenance activities;

Figure 10: WISE at the CSX Selkirk location

- Better understanding of wheel wear patterns leading to a reduced inventory of replacement wheelsets;
- Improved understanding of when to intervene with a wheel true, and the development of new and more cost effective wheel profiles which in turn result in longer wheel life;
- Extended track, tie, and rolling stock life due to elimination of flat and out-of-round wheels.