FAST Mechanical Equipment Test Results to Date - Future Plans

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ABSTRACT

This paper summarily describes the results to date, after approximately 66,000 miles of train operation, on the mechanical experiments being conducted at the Facility for Accelerated Service Testing (FAST). Specific results are presented on wheel flange wear, wheel failure modes and premium truck performance. Future plans for FAST mechanical testing are also described.

INTRODUCTION

As reported in a number of recent AAR and FRA technical reports and presentations, the FAST program is a cooperative FRA, AAR, RPI research program concerned with both track systems and mechanical equipment components. This paper will be concerned with only the mechanical equipment aspects of the FAST program.

The FAST test consist is composed of a total of 89 test vehicles. Specifically they are made up of the following types and sizes. Sixty-five of the test vehicles are 100-ton open - hopper cars. There are three 100-ton capacity bathtub coal cars and three 70-ton Trailer-On-Flat-Car (TOFC) units also are included. The remaining 18 test vehicles are 100-ton tank cars.

The typical test consist in any one day is normally made up of 76 cars. The motive power has been typically 4 four-axle diesel-electric locomotives providing a test train of approximately 9,500 total gross tons.

With regard to FAST operations the following information is provided. The FAST train is operated up to 16 hours per day - five days per week at an average speed of approximately 42 miles per hour. The remaining eight hours of each test day are used to take measurements and perform track and vehicle maintenance. Each day a block of four test cars removed from the FAST train and are routed to the shop for measurements. This shopping cycle is repeated every 22 test days.

Car position in the consist is rotated by removing eight cars from the front of the train each day and placing them at the rear. In addition, to equalize wear on both track and rolling stock components under test, the direction of the train movement as well as its orientation are reversed in a four-day cycle.

As mentioned above four cars are removed from the FAST consist each day. Depending on which experiments are included on these cars, literally hundreds of measurements are made. For example 71 cars require the following wheel measurements. Three types of measurements are made at two locations (180° apart) on each of the eight car wheels. Flange thickness, rim thickness and flange height are measured using the Standard AAR Finger Gage. Wheel profiles along with tread and rim hardness are also measured at these two locations.

Twenty-four cars are specifically involved in the truck experiment of which 12 car sets are equally divided among four premium trucks the remaining 12 car sets are comprised of two Types of commonly used trucks under six 100-ton hopper cars and the trucks used on the three "Bathtub" and three TTX cars. As with wheels a great number of measurements are made on the trucks under test and include the following. Both wear and surface hardness measurements are made on the friction castings and mating surfaces, bolster gibs, side frame column wear plates and column guides. In addition, measurements are also taken on bolster and side frame rotation stops as well as bolster and transom lateral stops.

There are 10 other component/system areas under investigation in FAST and they too undergo a similar measurement and inspection cycle. However, to date, the amount of wear on these components has not been significant or the results statistically significant. In addition to the static measurements obtained on the various freight car components, selected cars in the FAST consist have been instrumented to measure their dynamic response characteristics. Both a low mileage car and a car normally accumulating mileage in the consist were each instrumented with a total of 20 channels of accelerometers to assess the effects of the various track section configurations, their wear and the car component wear on freight car dynamic performance. An instrumented wheel set was also installed on the low mileage car to measure the dynamic lateral and vertical rail/wheel loads continuously as the car traverses the FAST loop. In addition to running on the FAST track, each car is also operated on a tangent section of the Railroad Test Track (RTT) to provide a relatively invarient reference track input for obtaining car transfer functions.

RESULTS

During the first 11 months of FAST operations, the test train has accumulated approximately 66,000 total miles. The average individual car mileage, however, is somewhat lower than this maximum due to lost time for scheduled car measurement and maintenance shoppings and unscheduled bad orders. Although the mileage accumulated to date has not been sufficient to assess the comparative wear rates and performance of several of the components under evaluation, others have developed definite wear and performance characteristics and are discussed in the following paragraphs.

Wheel Flange Wear

The component experiencing the major wear and replacement to date has been wheels. Wheel flange wear has been excessive since the beginning of the test due primarily to the high percentage of curves in the FAST Loop. In contrast, tread wear has been minimal. An example of the flange wear experienced on FAST is shown in Figure 1. Flange thickness measurements have been analyzed for a limited population of wheels in the wheel wear experiment.

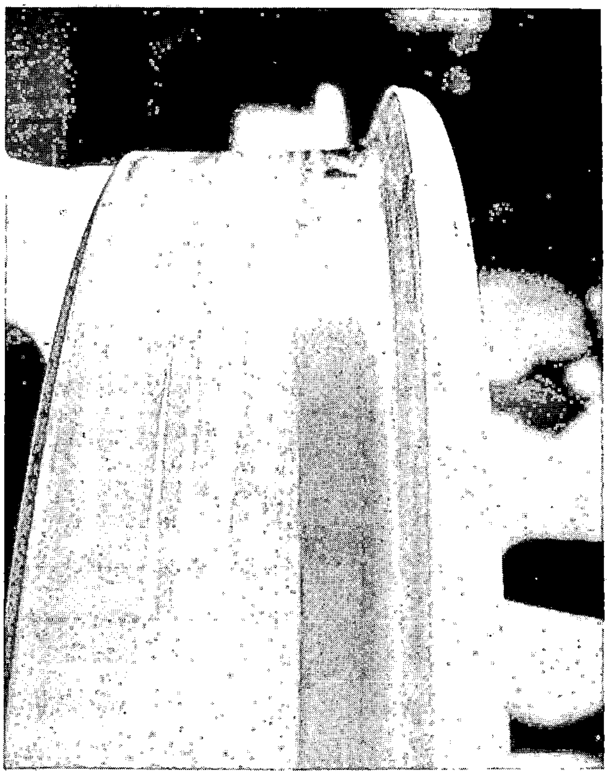

Fig. 1, Typical Wheel Flange Wear on FAST

For each of the variable six parameters (wheel manufacturing process, hardness, one wear, two wear, profile, center plate size, and truck type) contained in the experiment matrix, a nominal sample of 16 wheels was used to compare wheel flange wear. For each parameter considered, an equal mix of wheels representing the other parametric variations was included in the sample of 16 wheels. For each 22-day measurement cycle, the mean value of flange thickness decrease was calculated. In addition to the six parameters identified in the original experiment, a comparison was also made to determine if there is any significant difference in flange wear for the two types of brake rigging.

The only statistically significant results to date in this experiment is shown in Figure 2. As shown for the first 20,000 miles the rate of flange wear on Class U wheels has been approximately twice that experienced on Class C wheels.

One additional phenomenon that was observed is depicted in Figure 3. The difference between rates of flange wear on each axle set of the truck shown was observed on all of the cars in the wheel experiment and the data on each car was typical of that shown but not identical. The exact cause of this effect has not been determined, however, it is generally accepted as occuring in revenue service.

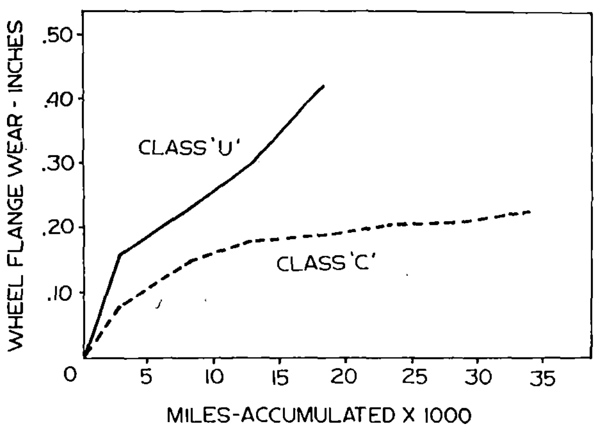

Fig. 2, Comparison of Flange Wear on Class U and Class C Wheels

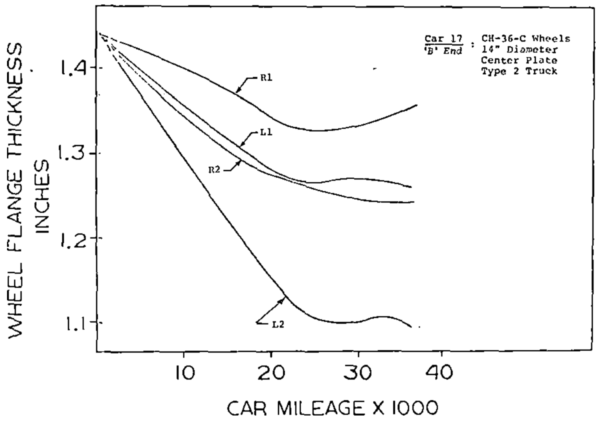

Fig. 3, Example of Flange Wear Variation with Wheel Position

Wheel Failure Modes

After approximately 40-45,000 miles a number of wheels were found to contain small cracks across the flange of the wheel. This phenomenon is depicted in Figure 4. A probable cause for this phenomenon is the unique wheel/rail wear pattern as shown in Figure 5. This pattern is due to the use of cars with the majority of wheels having uniform flange heights. Figure 6 shows an actual cracked wheel flange section mated with a worn section of high rail. An enlargement of the flange apex (Area A) is provided in Figure 7. This enlargement shows that on the gage side the flange material has plastically deformed and small subsurface cracks have been identified. This preliminary AAR study has indicated that the nucleation of the flange cracks is a subsurface phenomenon associated with the plastic deformation of the wheel steel which occurs near the apex of the flange due to wheel/rail contact in this area. As mentioned previously, such a condition has developed because of the characteristic wheel and rail wear at FAST. It is suggested that the flange cracks nucleate from the longitudinal cracks develop due to subsurface rolling contact fatigue. The phenomenon appears to be very similar to the formation of shells and detail fractures in rails.

Fig. 4, Typical Wheel Flange Cracks

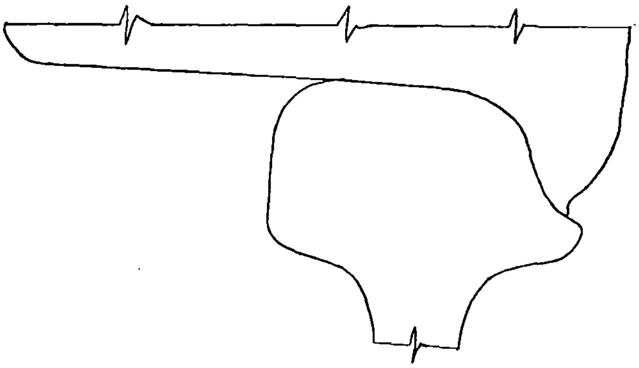

Fig. 5, Wheel/Rail Wear Pattern

The second failure mode that has been noted is comprised of tread cracks and wheel rim shelling. These phenomenons are depicted in Figures 8 and 9. This condition has just recently been observed, and investigations to date have not resulted in a conclusive determination for the cause of this failure.

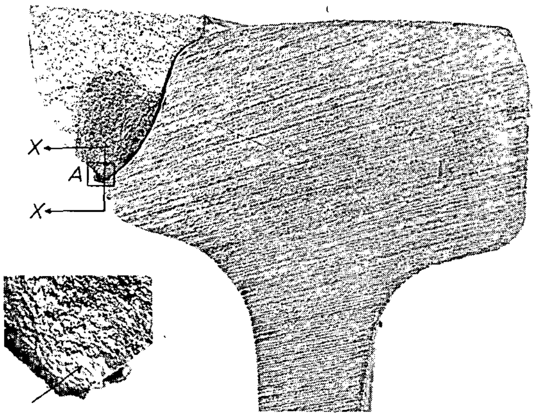

Fig. 6, Sections of Cracked Wheel Flange and Worn High Rail

Fig. 8, Wheel Tread Cracks

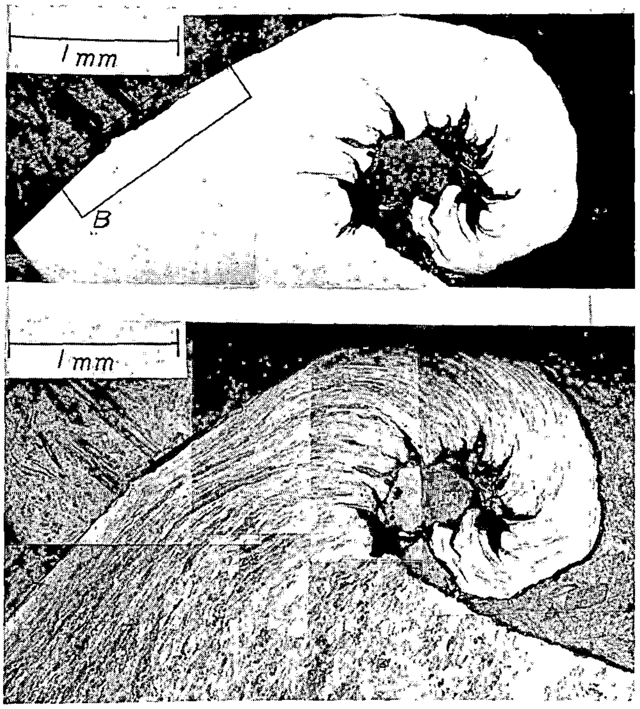

Fig. 7, Unetched and Etched Sections of Flange Apex (Area A) shown in Figure 6

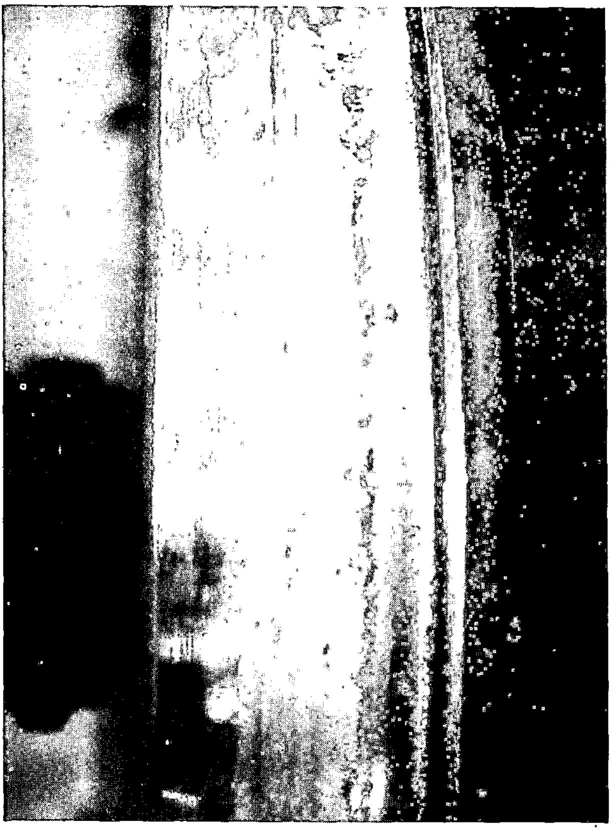

Fig. 9, Wheel Rim Shelling

Table 1 gives a summary of the total number of wheel sets removed in the 32 car wheel wear experiment. The cause of removal is depicted as well as the distribution according to wheel class.

Table 1. Total Number of Wheel Sets Removed in Wheel Wear Experiment

Cause For Removal	Class U	Class C
Thin Flange	70	11
Cracked Flange	10	3
Tread Cracks/ Shelling	20	49
Thin Rim	5	1
Over Heated Bearing	2	4

Premium Truck Performance

The results to date indicate that one of the three-piece premium truck designs is experiencing greater gib wear than the other two. One of the other three-piece truck designs has experienced cracks in some of the side frame column wear plates which have since been replaced by the manufacturer. This truck design has also experienced a small number of spring failures. Lastly, the fabricated truck design has undergone changes in the body bearing mount design and the hydraulic snubber design as well as experiencing a number of broken springs.

It should be emphasized that the amount of data collected to date has not been significant enough to draw firm conclusions on the performance of these premium trucks. This data is reported, however, to indicate the type of results that are being achieved in the FAST program with regard to truck performance and that the manufacturers of these trucks are able to take advantage of this FAST experience.

Other Components Performance

As mentioned above a great deal of mileage has not been accumulated on the test cars in FAST to date, however, other component performance can be reported at this time. For example some grease loss was reported on one supplier's roller bearing early in the FAST program. As a result of detecting this failure in the bearing seals, the manufacturing process has been modified to include a vibration test as part of the quality control procedure for these bearings. Since this process has been initiated there has not been a reoccurence of this failure.

One of the constant contact side bearing designs has been removed from the FAST test program due to the development of cage fractures and tears in the elastomeric blocks. These failures are being reviewed by the manufacturer. Lastly, there has been some minor deterioration of composition brake shoes due to metal accumulated from the rail and resultant sparking. This is not a typical operational situation but is reported for consideration should this phenomenon occur in a unique operational railroad application.

Dynamic Performance

Conclusions related to the objective of quantifying the dynamic response of freight vehicles to different track structures are as follows. Variations in track structures such as ballast shoulder width and depth, spiking patterns, tie material, and rail anchors had little if any effect on truck and carbody accelerations or wheel forces. In contrast, curves greater than 4°, and discrete events such as turnouts had a marked effect on vehicle dynamics. The highest carbody accelerations were experienced on Section 5 of the FAST track which contains unsupported bonded joints. Since mode accelerations were moderate to low over this same section of track, it can be hypothesized that this particular track structure excites a resonance in the vehicle suspension system.

FUTURE PLANS

Using the existing consist, which is nominally a 100-ton unit train, the current test configuration is planned to continue for a total of 400 to 450 MGT which is equivalent to approximately 230,000 vehicle miles. With regard to the mechanical experiments it is planned that the 32 car set wheel wear experiment will be repeated with the addition of some high flange wheels in the balance of the consist to prevent the unique wheel/rail wear pattern that was encountered in the data shown above.

Also, a new concept of management has been added to the FAST program in the form of FAST Experiment Managers. Ten Experiment Managers, five related to track and five related to rolling stock, now have the responsibility to review the existing FAST experiments and plan future experiments. These individuals have been earnestly working for several months now and the results of their constructive efforts are already being felt.

For example with regard to mechanical experiments the side bearing experiment and the brake shoe experiment have been terminated because of the limited speed capability on FAST and the inability to have long periods for programmed air brake testing, respectively. Also, in the interest of efficiency and costs the truck spring experiment has been deleted since the AAR mechanical committee has approved the use of alloy springs. Failure rates on springs of both alloy and carbon steel will be maintained to provide assurance on the capabilities of alloy springs.

And lastly, in the interest of efficiency and accuracy a large number of measurement fixtures have been designed and fabricated and are being put into service to assure repeatable accurate measurements on components such as center plates, side bearings and gibs.

OVERVIEW OF FREIGHT SYSTEMS
R&D REPORT NO FRA/ORD-77/58
OCTOBER 1977

ERRATA

"Rail Dynamics Laboratory Requirements and Hardware Configurations"

Page 90 first sentence under Fig. 6, Vibration Test Unit should read as follows:

"The vertical excitation modules (each under independent servo control) are designed around a 60,000 lb (27,216 kg) hydraulic actuator, equipped with a 200 gpm (.0126 m^3/s) high performance servo-valve."

Page 90 first sentence of second major paragraph from bottom starting "The hydraulic flow demands ..." should be changed to read as follows:

"The hydraulic flow demands of the various excitation modules and hydrostatic bearing elements at peak excitation levels can be as high as 1000 gpm (.0631 m^3/s) @ 3,000 psi (20,684,271 N/m^2). This has been provided for via three 360 gpm (.0227 m^3/s) variable volume pumping systems each capable of delivering the rated flow at 3,000 psi (20,684,271 N/m^2)."

Overview of Freight Systems Research and
Development, US DOT, FRA, Office of Freight
Systems, Office of Research and Development,
1977 -25-Goverment Policy, Planning &
Regulations