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Boiler & Engineering Skills Training Trust

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Boiler & Engineering Skills Training Trust

Steam Locomotive Repair and Overhaul

Module LM1

Wheels and Axles

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March 2016 – version 2

Module BESTT LM1

WHEELS AND AXLES

Aim

This unit will give learners and understanding of how wheels and axles function in relation to Steam locomotives and how to inspect and suggest methods of repair.

INTRODUCTION

The wheels and axles represent the very essence of a railway vehicle that has to operate in many cases on the network of a third party, where the standards to which that network is maintained might be an unknown quantity.

In order to ensure that the wheels of a vehicle can operate safely on the various networks involved, rigorous specifications laid down in documents (like MT276 & GMRT 2004 for running on the National Network) must be adhered to for safe running.

Steam locomotive wheels have traditionally had a steel cast centre onto which is shrunk a steel tyre. The tyre is the wearing component, which has to guide the locomotive over the tracks, crossings and points of the network. The wheel centre is attached firmly to the axle by a key.

The two wheel assemblies are fastened firmly on to the steel axle so that no relative rotational movement between a pair of wheels (called a wheelset) is possible. The tyre has two principle parts which come into contact with the rails; The tread and the flange. The treads are machined usually to have a slightly conical surface so that the wheels can vary the contact diameter between wheel and rail and enable the wheelset to negotiate curved track where the outer rail is longer than the inner rail. The wheel is able to adjust its lateral position on the track so that it presents a larger diameter to the outer rail. This ensures that no slip takes place between wheel and rail.

The flange, which is the raised portion of the tyre surface at the inner edge of the wheel performs an essential role in guiding the wheel assembly through bends points and crossings where the movement required is in excess of the amount that can be achieved by the conical guidance system described above. The flange is created to have a shape that guides the wheels without tearing or abrading the metal of the track and the tyre. Different thicknesses and profiles of flanges are laid down in the standards so that the various duties expected that a flange will perform can be accommodated. So for example an express passenger locomotive will have extra thick leading bogie axle flanges to accommodate wear expected on entering bends, and the centre driving wheels will have extra thin flanges to accommodate the side movement required from the wheelsets when the long rigid wheelbase of the locomotive negotiates a bend.

The measurement of the flange and the state of the tread is tricky because there is no easy datum to refer to. We are fortunate that the back side of the wheel and the tip of the flange never get abraded or worn in normal use so we are able to use these referenced to measure accurately against.

Wheels where the profile of tread or flange gets excessively worn can be re-profiled in a wheel lathe to re-establish the new profile However there is a limited number of fresh turnings that can be given to a tyre as eventually the amount of tyre that is left to withstand the shrink fit becomes so reduced that it can become unsafe. Therefore scrapping thickness tolerances are specified, after which the tyre has to be cut off and replaced. Remember that steam locomotives generally have friction tread brakes, which put the kinetic energy of braking the train into the tyre as heat. This causes the tyre to expand and can lead to loosening under certain circumstances.

Tyres are held on to wheels by the shrink fit discussed earlier but there needs to be a positive method of retaining the tyre onto the wheel in case the tyre ever comes loose. There are three principle satisfactory methods of anchoring the tyres to the wheels and these are discussed in the module.

The examination of wheelsets within a locomotive can tell us a lot about what is going on and what might be right or wrong. The state of the treads and flanges as well as the chamfers on the outside of the treads can indicate problems. In addition the way the locomotive sits on straight and level track can indicate alignment issues. Back-to–back dimensions can be checked. The steel key that holds the driving wheel onto the axle is invariably painted over and any discontinuity in the paint line over the key in the wheel centre will indicate problems. Spokes on driving wheels, although apparently always in compression due to the tension in the rim can sustain very harsh forces from the reciprocating masses and checks for cracks in spokes are essential.

Axles on heritage railway vehicles can harbour and then encourage propagation of minute cracks, which can be disastrous if not found early and remedied. Axles tend to fracture just inside the wheel seat or at the mid-point depending on the application. Ultrasonic examination of axles is mandatory, and the frequency depends on the age of the vehicle. Although this *Non Destructive Testing* is carried out by specialists it is good for the engineering organisation responsible for the locomotive body to get familiar with how the equipment works and its method of operation. The cracks are sought out by bouncing an ultrasonic signal down the length of the axle and back again. Cracks interfere with the smooth path of that signal to the end and show up in the returned signal.

It is hard to separate the understanding of wheelsets from locomotive axle-boxes but the lubrication and understanding of what happens in an axle-box located within the frames and supported on springs will be covered in a separate axle-boxes module.

Learning Outcomes

LO1

1. Wheel Profiles - Types of profiles that are available
2. What each particular profile is for
3. Measurement of wheel diameter when all relevant surfaces are tapered
4. Understand why similar wheel diameters is of paramount importance.
5. Understand the symptoms of unequal wheel diameter
6. Understand why spokes on coupled wheels may crack
7. How to examine and find cracks and the consequences of not finding them
8. The effect of friction braking on a wheel with a tyre

LO2

1. Tyre and wheel construction
2. Tyre turning
3. Tyre and Wheel measurement
4. Significance of the back-to-back measurement
5. Wheel Alignment_ Although this matter will be fully covered in the Frame Erection Module it is vital that checks are made on the wheels and axles to check for misalignment of axles within the frames at both the erection and repair stages.
6. What to look for when inspecting a locomotive wheel set. Much can be gleaned from an inspection of the wheels, both in and out of the frames.
7. Low-loading steam locomotives from rail to road and vice versa. The distress that locomotive wheel sets and frames, especially large ones, can be put under by misunderstanding what is happening and can be catastrophic

LO3

1. Wheel and Axle fitting - the role of the key
2. Understanding the issues involved around wheel pressing with crankshaft axles
3. The “weighing” of locomotive wheel sets - correct weight on every individual wheel
4. Correct adjustment
5. Methods of checking the process.

LO4

1. Understand Wheel quartering.
2. Special arrangements pertaining to three and four cylinder engines where the inner and outer cylinder sets are inclined at different angles.
3. Understanding what is happening during the quartering process, being able to describe it, and being able to check the accuracy of quartered wheels is vital

LO5 – Practical Unit

1. Tyre Examination
2. Tyre fastenings
3. Tyre flats
4. Thermal Damage
5. Tyre wear
6. Spokes

On completion of the module the trainee should be able to use correctly and safely the following equipment:

- Measuring instruments
- NDT equipment
- Profile gauges

Assessment

Learners could demonstrate competence in this unit by:

- Documental evidence
- Photographic evidence
- Witness statements e.g. written or verbal statement from a competent person stating that they have completed tasks satisfactorily.
- Underpinning knowledge questions e.g. written questions, multi choice answer sheets, online tests, and assignments.
- Practical training tasks

LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
LO1 1	Wheel profiles	Draw diagrams of the different profiles	Classroom	
LO1 2	Use of the differing profiles	Explain where the different profiles would be used	Classroom	
LO1 3	Measurement	Describe how to measure a wheel and carry out a measurement recording your results	Classroom & workshop	
LO1 4	Wheel set diameters	Explain why similar wheel diameters is of paramount importance	Classroom	
LO1 5	Unequal wheel diameter	Describe the symptoms of unequal wheel diameter	Classroom	
LO1 6	Cracked Spokes	Describe why spokes on coupled wheels may crack	Classroom	
LO1 7	Examination of spokes	Describe how to examine for cracks. Carry out an examination of a spoked wheel	Classroom & workshop	
LO1 8	Friction braking	Describe the effect of friction braking on a wheel with a tyre	Classroom	

LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
LO2 1	Tyre and wheel construction	Draw diagrams of tyre and wheel construction	Classroom	
LO2 2	Tyre turning	Describe how a tyre is turned	Classroom	
LO2 3	Tyre and Wheel measurement	Describe how you measure a tyre and wheel. Carry out measurements and record your findings.	Classroom & workshop	
LO2 4	Back to back measurement	What is the Significance of the back-to-back measurement?	Classroom	
LO2 5	Wheel Alignment	Describe how to check for alignment and carry out an alignment check	Classroom & workshop	
LO2 6	Inspection of wheels	Describe what you are looking for when inspecting wheels. Carry out an inspection and record your findings	Classroom & workshop	
LO2 7	Loading/unloading of locomotives for transport	Describe the damage that can occur when loading/unloading a locomotive and how to prevent it	Classroom	

LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
LO3 1	Wheel and Axle fitting	Describe with diagrams the role of the key	Classroom	
LO3 2	Pressing of wheels onto crankshaft axles	Describe the issues involved around wheel pressing with crankshaft axles	Classroom	
LO3 3	Weighing of locomotive wheel sets	Describe why wheels should be weighed	Classroom	
LO3 4	Adjustment of weight	Describe how to correctly adjust weight	Classroom	
LO3 5	Checking	How would you check the process has been carried out correctly?	Classroom	

LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
LO4 1	Wheel quartering	Describe wheel quartering.	Classroom	
LO4 2	Differing effects depending on cylinder arrangement.	Describe the arrangements pertaining to three and four cylinder engines where the inner and outer cylinder sets are inclined at different angles.	Classroom	
LO4 3	Prevention of quartering	Describe how to check the wheel quartering on a conventional two cylinder locomotive	Classroom	

LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
LO5 1	Tyre examination	Check tyres for any sign of movement. Hammer test tyres	Workshop	
LO5 2	Tyre Fastening System	Check tightness of tyre fastenings, e.g. Gibson ring	Workshop	
LO5 3	Flats	Check wheels/tyres for any flats/damage	Workshop	
LO5 4	Thermal Damage	Check tyres for evidence of thermal damage	Workshop	
LO5 5	Tyre wear	Measure tyre wear and record measurements using form ‘M’ (see MT276)	Workshop	
LO5 6	Spokes	Check spokes for cracking, use NDT methods on major overhaul	Workshop	
LO5 7	Locomotive stance	Loco parked on straight level track, asses the relationship between wheels & track & the way the locomotive is lying	Workshop	

BESTT Locomotive repair and overhaul - Module LM1

Assessment Record for: **Training Centre:** **Year:**

LO1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	8	
Supervisor Initials and completion date									
LO2	**1**	**2**	**3**	**4**	**5**	**6**	**7**		
Supervisor Initials and completion date									
LO3	**1**	**2**	**3**	**4**	**5**				
Supervisor Initials and completion date									
LO4	1	2	3						
Supervisor Initials and completion date									
LO5	1	2	3	4	5	6			
Supervisor Initials and completion date									

Witness Statement

The trainee has completed the Learning outcomes to a satisfactory standard

Supervisor signature: **Print Name:** **Date:**

Verified by BESTT Assessor **Name:** **Assessor Number:** **Date**