AXLE BOX BRASSES AND CAST STEEL WEDGES - WEAR, CAUSES AND REMEDIES

(As Experienced By The Perth Electric Tramway Society Inc)

Presenter: Bob Pearce
Session Chair: John Pennack
Session Secretary: Martin Grant

Editor's Note:- This presentation was illustrated by overhead projected slides and samples.

The tram is a vehicle generally powered by electricity and supported by a single truck or two bogies. The truck consists of two axles and four wheels while a bogie tram consists of two bogies each of two axles and four wheels. Both trucks and bogies have one or two motors and assorted brake gear. Each axle has two axle boxes, one at each end of it, where the axle passes through the frame of the truck or bogie and the frame of the truck or the bogie actually sits on the axle box. The whole weight of the tram is carried on the bearings inside the axle box. Therefore, they form a most integral part of the running characteristics of the tram.

The tram may be perfectly restored to operating condition in a museum, but forget the axle boxes, and, though the tram may go, it won't for very long. A strange burning smell will emanate from below the floor, a loud torturous scream will rend the air and passengers will cry out in alarm and jump off in droves. In short, if the axle boxes are not well cared for then give up trying to run trams.

Now, all tramway systems experience the problem of axle movement, either laterally or rotationally (in addition to the normal turning of the axle), when the tram car is in motion, whether along street or enclosed track (such as in Melbourne or Bendigo) or on open track (such as in most museum environments including Perth).

This movement is caused by the axle to which the wheel sets are attached, being forced to move as the wheels move within the confines of the two rails, and by the movement of the motor which is connected to the axle by gears.

Because rail is not perfectly straight, nor is it perfectly aligned in smooth radius curves, and it does not matter how much effort is applied to attaining those ideals, the wheels will be forced to move from side to side as the tram moves along. This will cause the axle to move laterally, while rotational movement occurs every time power is applied to the motor and the wheels turn.

The rotational movement to which I refer, is not the normal turning of the axle that occurs when the tram is moving, although that in itself will be the cause of some of the problem in any case, but the additional stress that occurs when the tram motor is put into, or out of, power.

The axle will move or jerk and it is that which causes the axle box brass to try and move in sympathy with the axle. Naturally, the axle box brass will always try and turn in sympathy with the axle when it is moving in any case but it is the sudden start or jerk of the axle that causes most rotational problems.

I hasten to add that the problem will not occur when the tram is standing still, and as I do not know of any one who will pay to sit in a tram at a museum instead of being taken somewhere, I don't think that that is the answer to the problem.

Ideally, the portion of the axle contained within the axle box has been manufactured and carefully machined to tolerances in accordance with the design specifications.

Gun metal axle box brasses, an excellent load and backing material for a journal lined with white metal, a low coefficient of friction material 1.6mm thick is provided to give long journal life. Cast steel wedges, to keep the brasses in their proper location, are inserted into the axle box to prevent this lateral movement and restrict the effect of the jerking or uneven rotational movement that occurs every time a tram is put into power or the bogie runs over uneven track.

In order to minimise that wear process as well as the build up of heat which is occasioned by the friction of the metal surfaces rubbing against each other, lubricants are used in one form or another.

To ensure the even transference of the lubricant to all surfaces within the axle box, the use of some material, such as wool packing, or, as we are now doing in Perth, poly pads wrapped in 'chenille' soak up the lubricant from the sump of the axle box and carry it to the bearing surface where it is squeezed out by the weight of the axle upon it. This permits the lubricant to flow freely over all of the wearing surfaces.

The poly pad is a sponge like material that soaks up the lubricant while the chenille, which wraps around the poly pad, is packed against the metal surfaces of the axle. This transference of lubricant from the sump to the axle journal through the poly pad, (or wool packing or other material that may be used) is called (by Westrail) 'siphoning'.

One advantage we have found with the polypad is the decrease in the amount of lubricant required for each axle box. We initially kept the level at 12mm below the bottom lip of the axle box, but found that the polypad was so efficient that the whole of the journal, the top of the brass and the wedge plate were covered in oil and was also leaking from the axle box lid.

By reducing the oil level by 7 to 8mm to 20mm below the lip we have found that the same amount of coverage of the journal and the underside of the brass is still maintained, but the loss due to leakage has been eliminated.

Another advantage is the wear factor (amount of use) of the polypad. We, and other operators no doubt, but especially Westrail, had found that simply topping up with oil and not carrying out any cleaning or other maintenance of the wool (or other material used in the axle boxes) invariably led to the destruction of it, and in fact, during these days of austerity, the necessary attention to wool packing by Westrail staff was not done as often as it should.

This led Westrail to developing the idea of using some other material to replace the wool skeins used at that time. This was based partly on the fact that regular attention to cleaning the wool and repacking it into the axle box was fairly labour intensive and time consuming, and with the changeover to polypads, such process would not be required. Also, as can be seen from the sample and the slide, to remove and replace the polypad is extremely simple. Most importantly, however, the amount of contamination is almost non-existent compared to wool or other material (such as cotton waste) used in packing axle boxes.

Our introduction to the polypads came about because our museum was looking for a cheap and reliable source of wool. While enquiring at Westrail, I was told that they had changed over to polypads some time before, but there was some wool still available in the store which we could purchase at a price (the going price that Westrail had paid). With the rapid changeover to roller bearings from conventional axle bearings, polypads and chenille were available in large quantities from the salvage office at Midland Workshops (Westrail). As a result, with a sample for the council meeting to look at and for Noel Blackmore to evaluate, and taking into consideration the price differential between wool and polypads, we obtained most of the available stock from the salvage office and have now started a programme of progressive change from wool to the polypads.

At present, all axles of W2 393 have been done and one axle of 426 (the original trial car) as well as W2 368. When the bogie exchange takes place as part of the refurbishment of bogies for W2 329, polypads have been used instead of wool. W2 329 has run for 40,000 kms with polypads and no need to replace - ie four years compared to about three years to clean/replace wool.

The cost comparison between wool and polypads is as follows:-

Wool purchase price $100/kg (100 skeins/kg - 1989 prices).
Four skeins/axle box (.4kg/axle box $4) = $16.00
Polypads approx $2.00 each (1/axle box) = $8.00

However with all metal to metal surfaces where one or both surfaces move against each other, and no matter in what way it is used or what preventative action is undertaken, there will always be wearing of the surfaces in contact with each other, and it is no different to the surfaces inside the axle box.

The usual effect of this wear is to cause the erosion or wearing down of the white metal, which then exposes the gun metal to the axle. Under normal conditions, the axle brass is removed for machining and realigning with white metal before the gun metal brass is exposed.

However, during the period of time that the brass is in use in the axle box, not only is there wear to the white metal, there is also wear to the end of the brass, which is caused by the lateral movement of the axle. This may continue to a stage where the white metal or brass is not effectively restricting the lateral movement of the axle within the axle box, usually indicated by excessive hunting or flogging of the wheel sets as the tram moves along.

As the clearance between the journal end flange and the brass increases, so does the wear rate, because the mass of the tram forces the axle to move sideways and the brass is worn more. As the unrestricted clearance gets larger, so the movement increases and the wear will proportionally increase in a logarithmic scale. This will then place ever increasing stresses on wheel flanges, and through them, the track.

Inspection of the axle box brass usually shows that the white metal surface has been worn almost, or completely, away. Also it is possible that the size of the brass has been reduced by such a degree that it is so far out of design tolerance that an excessive amount of rebuild is needed to bring it back to design specification.

Using large amounts of white metal to build up the end of the brass is not successful because the white metal, being very soft, will eventually be squeezed out by the movement of the axle. Remember that the white metal is a very soft material, consisting of some 75% lead.

The usual remedy is to remove the old brass and replace it with a new unit, and if necessary, also replace the cast steel wedge securing the brass in position.

By looking at the slide, it can be seen that the greatest amount of wear is both on the bearing surface and more importantly at each end of the brass, although more so at the leading (outside end) edge of the axle. This circular wear is directly caused by the fact that the axle is not snug within the box and is rubbing up against the end of the brass. Hence the lateral movement of the axle is causing the wear.

To replace the whole brass unit is a costly exercise and for a long time, our resident electrical and mechanical supervisor Noel Blackmore, had been searching for a solution that would not only solve the problem of the wear, but also would be relatively cost effective, bearing in mind the limited financial resources of the Museum.

Noel knew that the old Perth Electric Tramway used Brill bogie and wheel set equipment and Brill had fitted a "replaceable" brass alloy (we are not sure what the brass alloy was) check plate onto the ends of the axle within the axle box and the question was, therefore, would such a device have practical implications on MMTB axle box brasses. Some four years ago, Noel came up with a proposal that would need some trialing but appeared, on paper anyway, to be the answer to the problem.

The Brill check plate sits in a groove machined into the end of the particular type of axle having a check plate journal, while the axles used by the MMTB are "MCB" type axles. Because many ex-Melbourne trams went to various museums, with six coming to Perth plus one ex-Ballarat, all of the trucks under the bogie trams were equipped with "MCB" journals. The trucks obtained from Japan are Mitsubishi built Brill 77E trucks, also with "MCB" axles. Consequently Brill type check plates would not work and to have the axles machined to take them would be a horrendous task, as well as a huge financial burden on any museum contemplating the task. (Note: MCB - Master Car Builders).

Noel came up with a different idea which is based on the Brill idea but has to be necessarily different to comprehend the MCB journal. However, it does the job just as well.

The worn brass requires 8mm to be machined off the worn end to ensure a full and resultant square face. Room was therefore available to fit a replacement phosphor bronze wear plate onto the end of the brass and this became the new wearing surface. The profile of the wear plate is identical with that of the axle box brass. Two screw holes were drilled and tapped into the end of the brass and the check plate was secured into position by 8mm diameter stainless steel countersunk screws and "Loctite" compound.

At first there was thought that a problem may exist with the rotational movement of the axle causing the brass to move and possibly fracture the two screws due to the force of the movement exerting great pressure onto the wear plate and the screws holding it in place. It was found, however, that the cast steel wedge was long enough to sit directly over the top of the wear plate and restrict any turning movement.

The exercise worked so well and improved the running characteristics of the trams so much, coupled with the dramatic lessening of costs of replacement (re white metalling or new axle brasses), that we have undertaken a program of fitting wear plates to all axle box brasses as they come up for replacement.

The situation now is when the wear on the replaceable wear plate is such that replacement is required, it will become a matter of simply removing the screws holding the worn wear plate in position, and fitting a new unit.

The benefit is that with a new wear plate in position, a greatly reduced clearance exists between the end of the axle and the axle brass, and this prevents almost all of the lateral movement of the axle and the effect is very noticeable on the running characteristics of the tram.

Where it is found that the axle box brass is beyond repair because it is so far out of tolerance or design specification, then a new unit is provided, but it is fitted with a wear plate at the outset of its life within the axle box.

The old unit is not thrown away, however, it is kept until sufficient are on hand, when it is melted down and made into new axle box brasses, which of course also assists in keeping down production costs.

At present, the costs to make a new axle box brass and wear plates are as follows:-
Axle box brass:- Between $225 to $260 (own material supplied).
Wear plate:- Between $50 and $60 (*own material supplied).
*This includes the cost of machining the axle box brass, and drill and tap for two screws.

If a batch of 25 or more replacement wear plates are made, this cost reduces quite dramatically to about $30-$35 each, including the correct sizing (journal diameter etc) and final fitting.

We are now investigating the design of a wear plate to fit the inboard end of the axle box brass. This has been brought about because, although the original length of the axle journal was designed to be 177.8mm, we have encountered MMTB axles with an average journal length of 180.9mm with the worst case of 188.9mm.

One reason why the journal lengths are so different to the original design length is because serious scoring of the journal may have occurred due to a hot axle (hot box) or other cause. As a result, the journal is built up with chrome steel or similar and then machined to the designed profile, so that the axle box brass will sit within the standard 3.175mm clearance.

To build up an axle at the inboard end for machining is not recommended because the heat to the area caused by the application of the hot metal, had been known to severely weaken the axle and has been listed in derailment reports as the cause of axle fracture and/or collapsed wheels.

During the course of the machining, the length will be increased, even if only 1 or 2mm each time. But when considering the age of some of the axles in use on our trams in museums today, it is likely that some axles are anywhere between 40 and 60 years old and have probably been machined many times, so it should be no surprise to find the journal length very different to the original size. To measure the journal length (inside the axle box), Noel designed and made this device, which is shaped to fit the outboard and inboard radii.

We found that, although we were restricting movement at the end of the axle by fitting the wear plate, there was still sufficient clearance at the inboard end to allow the axle to move and create additional thrust on "one" wear plate. This has made it necessary to provide an additional wear plate at the inboard end of the axle box brass.

This will increase the bearing length (axle box brass and wear plates) to cover the whole of the journal within the axle box thus a greater load sharing of the thrust forces will be achieved. When this treatment is done to an axle, it is necessary to do both ends at the same time.

W2 393 had new axle box brasses fitted in November 1990 and currently has run approximately 40,000kms. On the November 1994 inspection, it was found that the brasses now require the installation of wear plates. This is expected to cost around $400 compared with $2100 for complete replacement of the brasses.

If white metalling only is required, that cost would be approximately $1200. The re-use of whitemetal can only be done two or three times without re-constitution. If the brasses had already been whitemetalled more than two or three times, then a metallurgical analysis would be required to establish whether the white metal was suitable for re-use. However, as a cost basis, to undergo a full white metal treatment is still some 3.5 to 4 times more expensive than to fit wear plates, assuming that the journal face is still is satisfactory condition. Where it is not, then a replacement brass (fitted with a wear plate) would be provided in its place, bearing in mind that what is done to one end of an axle must be done to the other.

We will advise museums of the outcome of our work if interest to it is shown by those which may be having a problem in this regard.

Cast Steel Wedge Plates

We have found that these have had excessive wear on each end of the plate and the 6.35mm bullnose radius was so badly worn to be almost non existent and also distorted. The axle box end locating lugs were also worn.

The original design length of the wedge plate was 165.1mm, but we found some of ours had worn down to a worst case of 161.0mm. We also found that some had gone out of square with one side being 161.0mm and the other 165.0mm making the wedge plate also a major problem.

To rectify the problem on the wedges that were still repairable, we built up the bullnose by electric welding and then re-machined to the standard 6.35mm radius. At the opposite end, we built up the locating lugs and then machined them back to the design overall length, plus 1.016mm oversize to allow for wear on the upper edge of the axle box.

We then squared the underside face of the wedge plate and machined in flat to maintain full face contact of the axle box brass.

Where these plates are uneconomical to repair or are so out of square as to render them impossible to build up and machine to the required profile, we will replace them with new plates at an approximate cost of $50 each. The material used to make them will be CMA 1 manganese bronze (a very hard wearing bronze, so hard that it is almost impossible to machine).

Already we have made patterns for these units to be made, along with patterns for brasses to fit MMTB No.1 and 9 axle boxes. We are investigating their use on No.15 axle boxes. We have now also produced a pattern for the manufacture of axle box brasses for the brill 77E trucks we obtained from Japan.

If other museums are interested in acquiring brasses, or in modifying their existing brasses to take the wear plates, contact us and we will advise prices to have the work done using our manufacturers, thus saving expense in setting up the process with a local supplier in your home area, and we will soon be able to provide brasses for Brill 77E trucks if required.

Editor's notes:-

1. At the end of the Speaker's address, the time available for the session had expired. Therefore it was not possible for any discussion or questions/answers on the subject.

2. Photocopies of the overhead projection slides were supplied by the Presenter. Printing advice is that they would reproduce poorly in this publication. Therefore it is suggested that anyone interested in copies should contact the Presenter direct.