XJS inboard-braked handbrake improvement

The Jaguar inboard-braked independent double wishbone rear axle is a classic of axle design, and if properly set up and regularly greased it will last indefinitely in a road car. Usually, the differential will need rebuilding before any other part of the axle requires repair. This axle, essentially unchanged, was progressively fitted by Jaguar to all of its road cars starting with the first E Type in the early 1960s and continuing until the late 1980s. The axle had disc brakes mounted directly to the differential output shafts, with separate mechanical handbrake callipers acting upon the same discs. After the adoption of this axle, the first Jaguar car fitted with a different rear axle design was the XJ40 in 1987, which used an outboard-braked axle that even so, incorporated many of the features of the original.

As car manufacturers have found, it is technically extremely difficult to fit a reliable, maintenance-free, mechanically-actuated handbrake to a disc braked axle. So much so that the modern practice is to fit a small drum-braked handbrake system to an axle that has disc brakes as its main braking system. Indeed, for the later facelifted versions of the XJS until its cessation in 1996, Jaguar did not adopt the XJ40 axle, but modified the original by fitting outboard disc brakes with a small drum-type handbrake system.

This paper explains in detail what the problems are with the mechanical handbrake mechanism as fitted to inboard-braked Jaguar double rear wishbone axles; it also explains how one enthusiastic owner has attempted to improve its performance and reliability.

Handbrake problems

The normal problem with handbrakes acting upon discs is that the calliper requires frequent manual adjustment to keep the pads close enough to the disc surface to provide effective braking within the limits of the travel of the handbrake lever. Jaguar overcame this problem by fitting a self-adjusting mechanism to its handbrake callipers, which works quite effectively providing its lubrication does not solidify – a problem easily overcome with modern synthetic heat resistant greases.

The next problem - which the Jaguar inboard braked axle suffers from – is that the handbrake pad is often extremely small in area. Consequently the retardation provided by the handbrake is poor, and though it will hold the car effectively at rest it will not withstand modern rolling-road type roadworthiness testing. If the handbrake is used in anger, or if it is accidentally left engaged while the car is driven off, the pad can easily be torn from its backing plate. So great is this problem that many owners make a point of never using the handbrake! Furthermore, if even one of the four handbrake pads is torn off, the entire handbrake system stops working as lost motion in the system overwhelms the lever travel available.

The mechanism itself relies upon a fixed-position fulcrum at one end of the calliper arm and a pulling mechanism at the other, so that when the handbrake is applied the pad pivots on the fulcrum towards the disc in an arc, rather than perpendicularly. This means the braking effort is not being applied evenly along the pad. To ameliorate this problem it is imperative that the pad, when in the “off” position, is fitted extremely close and parallel to the disc. If this is not done, only one end of the pad will be in contact with the disc reducing braking effectiveness, while this uneven contact will cause a “tearing” effort on the pad-to-backing plate join, particularly so if only the “upstream” end of the pad is contacting the disc.

To make matters worse, on an XJS at least, it is impossible to replace the handbrake pads without removing the entire axle on its subframe from the car! The author of this piece has twice suffered from the handbrake pads being torn off their backing plates as a result of bi-annual roadworthiness tests that were carried out on a rolling road-type handbrake testing apparatus. This provided ample motivation for these modifications.

Apart from the fragility of the handbrake pad-to-backing plate join, the rest of the handbrake mechanism is extremely robust.

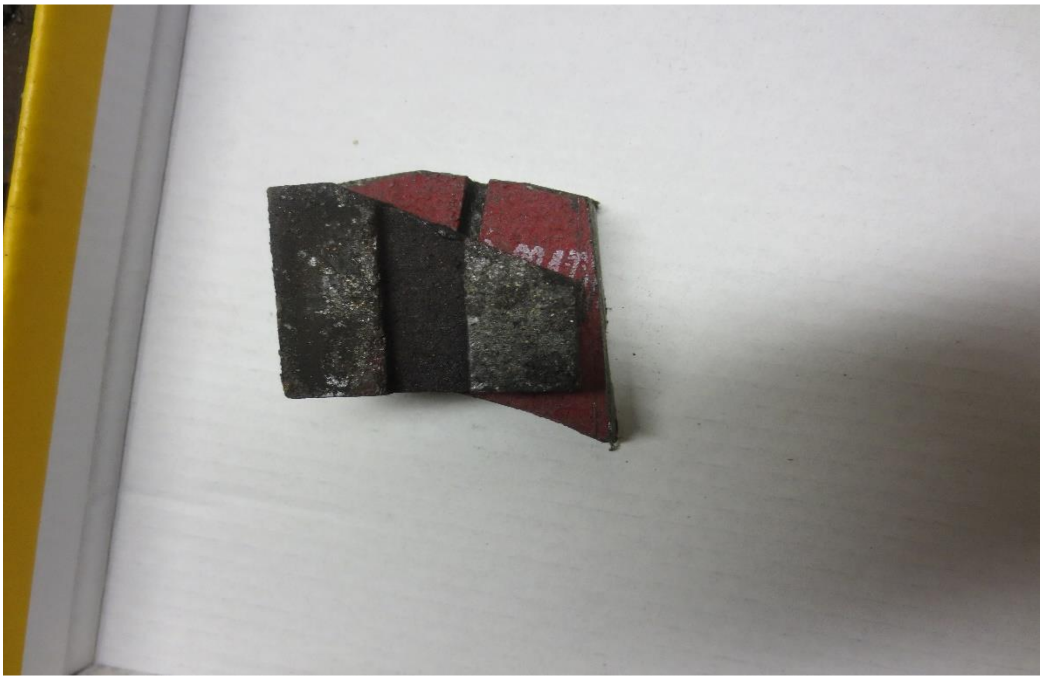
Handbrake fixes

In view of these problems, the author decided to see if the handbrake mechanism could be modified to overcome the weaknesses described. These fixes concentrated upon:

1. Enlarging the pad area
2. Improving the bond between the pad and its backing plate
3. Supporting the pad material against the torque of the disc so that the pad-to-backing plate bond was not the sole torque-load bearing part of the mechanism
4. Removing as much lost motion from the system as possible and aligning the pad with the disc precisely
5. Robustly attaching the pads to the calliper arms

Modifications

1. Enlarging the pad area: The photograph below shows the difference between the standard pad and the author’s modified pad.



It is estimated that this gives around 30% more pad area. There is scope for a substantially greater increase in pad area, as the unswept part of the disc in this photograph shows:

The problem with using this unswept area would be that more than half of the pad would not be directly supported by the calliper, but be "hanging" out of the bottom of it. Whether this would be a problem in practice, as the pad and its backing is bolted to the calliper, is not known. However caution was exercised and a much larger pad was not used in this first stage of modifications. It would be possible to weld an extension onto the calliper arm if testing proves extra pad area is necessary.

2. Improving the bond between the pad and its backing plate: The standard handbrake pads now available are very poorly bonded to the pad material. A sharp tap with a small hammer is often all that is needed to separate the two. Therefore a search was made for a more substantial item, and a very kind friend found what it is hoped will be the solution. It transpires that an entirely new system of attaching the pad to its backing has recently been invented and commercialised. Details of this system can be found here: http://www.nucap.com/products/backing-plates/nrs/

The system relies upon the pad material being held onto the steel backing by thousands of tiny Velcro-style hooks created in the steel itself, looking like this:

EBC brakes in the UK supply pads using this attachment system, but do not offer Jaguar inboard handbrake pads. Therefore the author decided to make a set of handbrake pads from an EBC pad that used this system, thereby hopefully obtaining a pad that would be resistant to separating from its steel backing under load. A set of Volkswagen rear footbrake pads was purchased and they were cut to fit the calliper. These were chosen because they were the cheapest available from EBC with the new backing plate system. Pad cutting and fitting is a time consuming, but straightforward task, once a suitable template has been made. The aim was to have the backing plate fitting very tightly into the calliper shoulders. Careful grinding to exact size achieved a slight interference fit.

3. Supporting the pad material against the torque of the disc so that the pad-to-backing plate bond was not the sole torque-load bearing part of the mechanism:

In addition to using a pad with a better backing plate attachment system, the calliper arm was modified in two ways:
The indentation in the arm into which the pad fits is only about 2mm deep. This was machined out by a further 2.5mm in order that the pads used (which are slightly deeper than the original pads and have a thicker steel backing plate) would be located in the calliper arm more securely. It is not known how essential this machining is to the handbrake working in an improved manner, as the better pad-to-backing join described above, plus the extra supporting shoulder described below, might well be sufficient on their own to locate the pad properly. However, if the pad needs shimming to achieve good contact with the disc (see point 4 below) the extra indentation may be important. Equally, without the arm being machined, shimming may not be needed, rather the pad need sanding down instead! Below is a photograph showing the OEM pad in a machined calliper arm. The extra depth can clearly be seen, as before machining the OEM pad backing plate was only just below the level of the indentation in the arm:

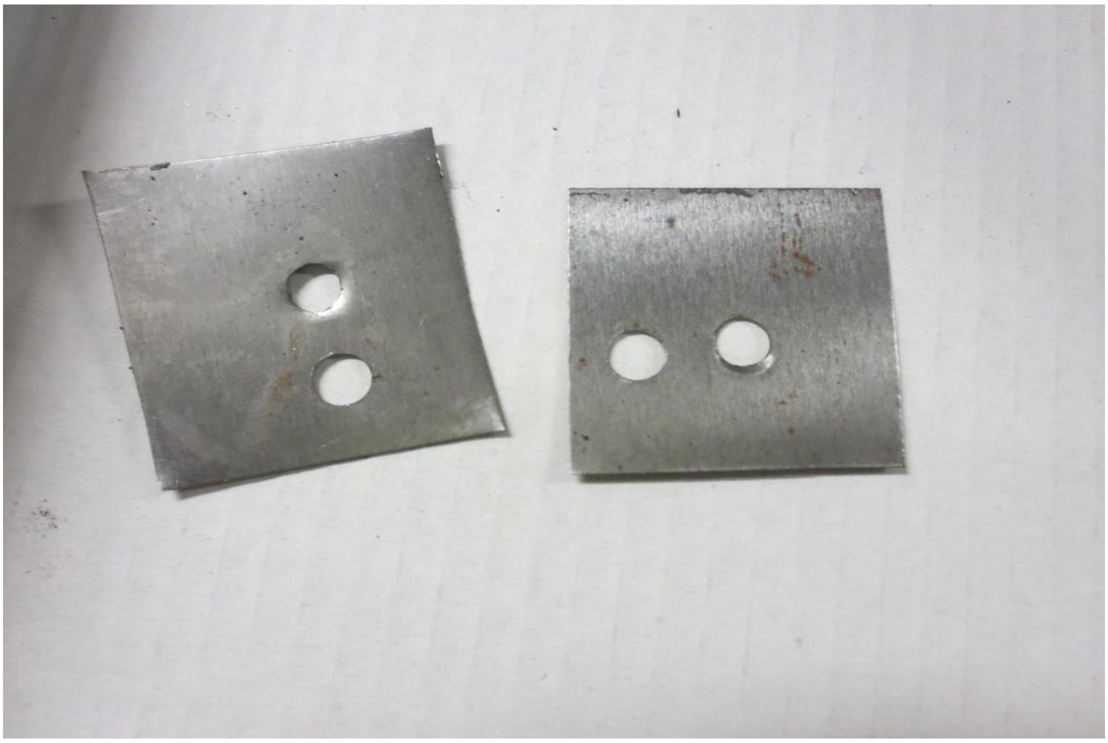
Additionally the pad material was supported by welding an extra shoulder to the calliper which would support the pad material directly, so that the pad-to-backing plate join was not the sole load-bearing surface. Below is a photograph of this modification:

The welded shoulder is at the downstream end of the calliper, thus the torque of the disc will push the pad material against it. As this end is also the fulcrum end of the calliper, wear will be far lower than at the free end, as the pad will wear into a triangular profile with the fulcrum end experiencing the least wear. Therefore there is no danger of this extra shoulder contacting the disc.

The new type of pad fitted to the modified calliper arm, with the pad material butting up to the newly welded shoulder, is shown here:

4. Removing as much lost motion from the system as possible and aligning the pad with the disc precisely: The mechanism does not push the pad evenly and squarely against the disc, but in a swinging motion pivoting at one end of the calliper and moving inwards towards the disc at the other. Therefore it is essential to trial fit the calliper arm, with the pad attached, against the disc to ensure a close and parallel pad to disc fit.

The aim of the trial fit is to then adjust the pad position by using shims (or by sanding down the pad if it is too thick) so that the pad is, at rest, about 5 thou from the disc and parallel to it. If not, when the handbrake is applied not all the pad area will act on the disc, and consequently brake effectiveness will be reduced and the pad-to--backing plate join will be stressed. The photograph above shows the author trial fitting a calliper arm which is swinging on its pivot; the pad has been shimmed between the backing plate and the calliper arm and is sitting evenly against the disc and close to it. The photograph below shows some of the shims used:

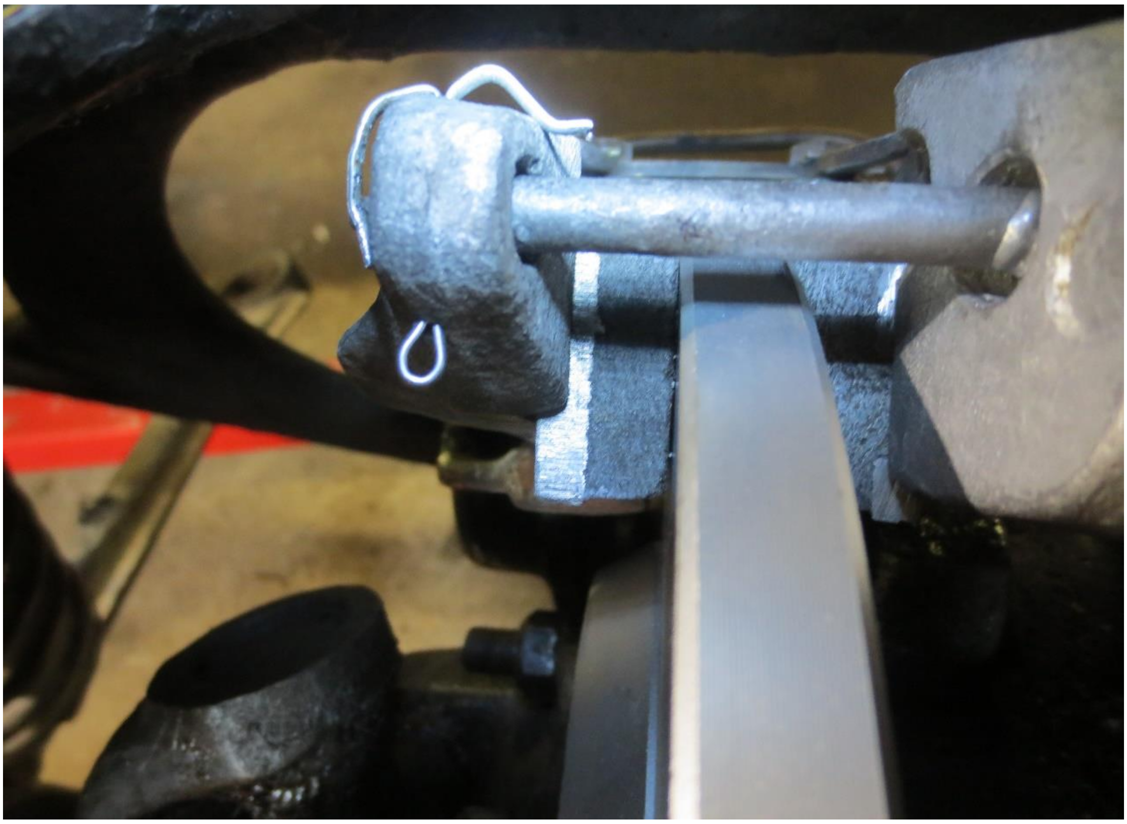


In the photograph below of the finished job, a shim used can just be seen between the calliper arm and the pad:

Finally, the automatic adjustment system that compensates for pad wear has a threaded screw that sets the pad position initially. It is then locked into position by means of a split pin that anchors a slot in the screw head to the calliper arm.

Therefore the screw, which has a coarse thread, has to be adjusted a minimum of half a turn at a time, which is too coarse an adjustment in the author's view, who was aiming for a 5 thou gap at rest between the pad and the disc. The photograph above shows a second slot that was cut in this screw head to allow quarter turn adjustments.

This photograph shows the adjustment screw in position and locked with a split pin:



5. Robustly attaching the pads to the calliper arms: The type of pads being used are cut-down footbrake pads, EBC reference number DP 680, which are 15mm thick in total. The original pads are 13.5mm thick in total of which the backing plate is 2mm. On the original pads, a T headed bolt slips into an indentation in the pad material and a nut is threaded onto the bolt where it protrudes through the back of the arm, as shown in the photograph below

On the replacement pads the backing plate is 6 mm thick, and so quite thick enough to be tapped in order to bolt the pad to the calliper arm. The author replicated the essentials of the original attachment system on the replacement pads, by drilling and tapping the 6mm backing plate of the new pads and bolting them up to the arm with a ¼ inch UNC stainless Allen headed bolt as shown here:

Conclusion and road test

The author intended that after these modifications the handbrake will be considerably more effective than as standard. The original setup has no adjustment system to ensure the pads contact the disc evenly, no adjustment system to set the pad to disc gap, the handbrake pad is weakly attached to its backing plate, and it has an unnecessarily small pad area. The author has tried to ameliorate all these deficiencies. A subsequent road test has produced the following results:

Handbrake performance:

a. With the car left in drive at 20mph, foot off the throttle, the handbrake will stop the car.
b. On a loose surface in neutral it will lock the back wheels at 15mph.
c. It will hold the car stopped in drive with engine doing 1500 rpm.
d. The pads did not tear out.
e. There is no driveline "shunt" or slight movement when the handbrake is applied and the footbrake released, it locks the wheels very solidly.
f. If the handbrake is on, it is impossible to pull away without noticing it is applied, as the car will hardly move. This is a very substantial improvement on the original.

After the road test the cable needed a great deal of adjustment at the adjuster behind the lever under the carpet on the rear inside sill, maybe 3/4 inch. The author puts this down to cable stretch as it has not had much use, if any, beforehand. It is also possible that the calliper mechanism and the pads/shims were bedding in further, in spite of the care taken to remove lost motion from the system. Lever effort is noticeably higher than before (greater pad area, new discs?) and it needs to be applied with decent effort; however it is probable that as the discs and pads wear off their break-in surfaces, this will reduce.