ELECTRIC WELDING IN RAILWAY SHOPS.

*Paper communicated by G. H. CHADWICK, Member,
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Although I am no longer directly connected with railway work, having resigned the position of Locomotive Superintendent of the Central Railway of Peru at the beginning of 1921, when I joined the Vulcan Iron Works Co. here in Callao as Superintendent of their Marine Section, I am still very interested in matters connected with railway work, and particularly with locomotive work.

As a desire has been expressed that I should write a Paper for the benefit of the Institution of Locomotive Engineers covering my experience with electric welding in the shops of the Central Railway of Peru, I have pleasure in outlining the tremendous help and saving it brought to that road, whose locomotives, with the exception of a few side tank and switching engines, were all fitted with steel fireboxes and steel tubes. When I joined the road in 1910, engines were failing at the rate of one per day, 90 per cent. of these failures being due to tube leakage.

All our locomotives were oil burners, and due to this and the fact that the greater part of the mountain freight engines were considerably under-boilered, the tubes would not stand up to the work.

In 1913 we purchased six new Mikado type locomotives, which were all fitted with superheaters of the fire-tube type. Although these had ample boiler capacity, trouble soon commenced with the superheater flues leaking.

This became so serious that we decided to instal an electric welding outfit in our main shops.

We therefore ordered a 400-ampere set, made by the C. and C. Co. of Garfield, New Jersey, and at the same time obtained the services of an electric welder specialist for four months.

This welder generator was direct coupled to a General Electric Co.'s alternating current motor, 60 h.p., 440 volts.

As soon as we got it into commission we commenced welding in tubes. Our specialist, however, was not experienced in locomotive boiler work, though very smart on bench work.

Our first attempt was to weld tubes in the firebox end of a locomotive that had been running several weeks with new tubes. This was unsuccessful, although we cleaned the tube sheet with acid and roughened the tube ends and tube sheet.

The tubes in this boiler had been set in the usual manner, *i.e.*, with copper ferrule and the tube beaded over as Fig. 1. We thought the trouble was due to the copper ferrule, and possibly to oil and dirt having got under the bead of tube, so I then had a set of tubes fitted in another boiler without ferrules and without bead, as Fig. 2.

With this system we were able to make a successful weld; the engine was placed in service and freedom from leakage was noted during several months.

After two or three months a few tubes began to leak, and these leaky tubes were expanded with the ordinary roller expander. As the tubes were not fitted with copper ferrules, expanding the tubes did little good. We tried re-welding the leaky tubes, but the weld never held for long.

Following this, we set all tubes with copper ferrules and beaded them according to our previous practice, and then welded round the bead. This proved to be the most satisfactory method, as when any tubes began to leak, after several months' service, they could be rolled and made tight.

Previous to welding in tubes it was impossible to get more than 30,000 kilometres out of a set of tubes in engines working mountain freight. With welded tubes we easily got 80,000 to 90,000 kilometres per set of tubes.

Even after making that kilometrage, the tube ends were not at all bad, but the heavy scale made it necessary to take the tubes out for cleaning.

Engine failures from tube leakage were reduced from thirty per month to three or four. The saving in £ s. d. could hardly be figured out, as it meant quicker movement of freight, less overtime for engine and train crews, and that our shop forces were able to cope with increasing traffic, and the staff of boilermakers at outside stations was reduced by 50 per cent.

We found that welding in tubes decreased the life of tube sheets by 50 per cent., as we got more cracked bridges; this, however, was insignificant compared to the gain in other directions.

We were not long in finding out the tremendous saving that could be effected in other ways.

Quite a number of our engines had been built to operate on coal fuel. These engines had longitudinal seams in the inner firebox, that is to say, the crown sheet was joined to the side sheets by a single riveted lap joint. Whilst this method of construction is quite all right for locomotives operating on coal and on level roads, it is very undesirable construction for oil-burning locomotives working on continuous 4-per-cent. grades, such as the Central Railway of Peru.

These seams gave lots of trouble, so we made a trial on one engine, cutting out the seam with oxy-acetylene torch (Fig. 3) and welding in a new strip with the electric welder (Fig. 4); this proved entirely successful, and the Central has engines running to-day that were so treated four years ago. Anyone who has had experience with oxy-acetylene welding will appreciate the advantage of being able to weld overhead.

Although our welder was put in purely for boiler work, we found it so convenient and economical for general welding and building up on worn parts that the 400-ampere set could not handle all the work we had for it. For two years it was constantly at work, and oftentimes all night. We therefore decided to instal another set of the same size—a duplicate of the original set which had proved so successful.

Now as regards operators for the electric welders, we found that the Peruvian workman took a great interest in the work, and it only takes a couple of weeks to train a youth, usually from the boiler shop, to become a good welder.

We, of course, started them on simple bench work jobs, and gradually got them doing more important welds, so that in less than six months' time they are competent to undertake the most difficult weld, which is an overhead weld.

Several mining companies on the Coast have gone in for electric welding in their shops, and have drawn on the railroad for its operators.

We found the electric process excellent for welding on safe ends to superheater flues, and out of the hundreds thus welded never had to record a single failure. The flues and

safe ends were cut in the lathe and turned with a bevel edge (Fig. 5). In order to secure the safe end perfectly in line with the flue, a special clamp (Fig. 6) was devised, having four openings in the body, and the safe end tacked to the flue with the welder at these points. The clamp was then removed and the weld completed.

The following is a list of the work we found could be done advantageously and at great economy with the electric welder :—

1. Boiler Work.

- (a) Welding all tubes at firebox end.
- (b) Welding lower edge of new half tube sheets.
- (c) Welding in patches round firehole (Fig. 7).
- (d) Welding around corners of leaky mud rings.
- (e) Welding on bushes round worn wash-out holes.
- (f) Welding patches on smokeboxes.
- (g) Welding safe ends on superheater tubes (Fig. 5).
- (h) Welding patches or caps on return bends of superheater units.
- (j) Welding instead of riveting petticoat pipes.
- (k) Welding patches in fireboxes.

2. Tank Work.

- (a) Welding all joints of new oil tanks for locomotive tenders, whether cylindrical or rectangular, eliminating riveted seams (Fig. 8).
- (b) Manufacture and repair of sand boxes, cabs, running board, etc.
- (c) Repair and manufacture of travelling oil and water tanks.
- (d) Small tanks of all descriptions such as are used around railroad shops.

3. General Work.

- (a) Building up on piston rods for crosshead fit.
- (b) Building up on slide bars whose edges have worn round through work on sandy sections.
- (c) Welding broken locomotive frames, bar type.
- (d) Building up on valve spindles, crosshead fit.
- (e) Building up on worn faces of coupling and connecting rod straps.
- (f) Filling up flat spots on locomotive, tender and car wheels.
- (g) Building up on sharp flanges on switch engine driving tyres.

- (h) Building up on the outer worn collars of car axles.
- (i) Welding pads on the ends of top leaves of driving springs instead of jumping up the leaf in the smith's shop (Fig. 9).

We have not had occasion to use the carbon arc for welding as we found the metal electrode process covered the whole of our needs.

We made use of the carbon arc for burning off the welded beads of tubes when removing tubes from tube sheets and also for various cutting jobs where a clean cut edge, such as that left by the oxy-acetylene cutter, is not important.

Most building-up operations are done with 3/16in. dia. electrodes.

For welding tube ends to tube sheets 1/8in. or 5/32in. electrodes give the best results.

Before commencing to weld the bead we found it advantageous to burn off all grease or oil round each bead with the carbon arc, afterwards cleaning off with a stiff wire brush. For best results the work must be well cleaned and the arc used as short as possible, which condition is obtained by using as low a voltage and current as possible.

Our electric welder was placed under the direction of the foreman boilermaker, who, by the way, was trained by the expert during the four months he was with us. The care of the welding plant is under the charge of the shop electrician.

The installation on the Central Railway is located in the central power-house for shops, and heavy cables carried round the round-house and erecting shop. These cables the operator can tap at any point. This is all right for a small shop, but for a large shop the portable equipments would be more satisfactory and would be more economical to instal as it would be only necessary to run comparatively small wires through the shops and round-houses. As instructions for electric welding are issued by all manufacturers of electric welding equipments I will not go into details of operation.

The application of electric welding in railway shops, given a good welding machine and operator, is very extensive, and the savings in time and labour are much greater than one would anticipate.

I am hoping in the near future to instal an electric welding equipment for our marine repair work.

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

FIRST
METHOD

LATER
METHOD
AVOIDS
FLANGING

FIG. 7.

FIG. 5.

FIG. 6.

FIG. 8.

FIG. 9.