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RESISTANCE WELDING IN STEEL MILLS

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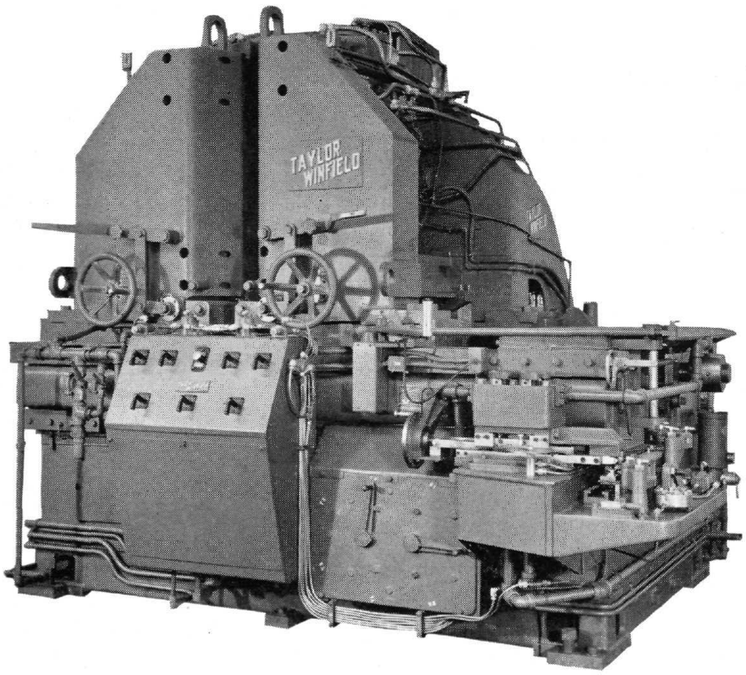
ONE of the modern demands on steel mills is the increasing application for larger coils of rolled strip steel, in addition to the continuous demand for cheaper steel. In meeting these demands, steel mill operators apply resistance welding in two general applications. These are briefly as follows:

First: In continuous pickle lines it is necessary to join either temporarily or permanently the finishing end of one coil to the entering end of the oncoming coil, this joint must be sufficiently strong to hold the ends together throughout the pickle unit and during the uncoiling and recoiling operations. The welds thus made are in some instances, later cut out, and in other instances, are allowed to remain in the coil and in the finished material.

Second: This application does not involve continuous pickle lines, but merely involves the welding of two or more coils together to form a resulting coil larger than can be rolled from a single billet. These welds are not cut out, but remain in the finished material.

A typical welding machine of late design. This particular machine is entirely automatic and is hydraulically operated.



Since somewhat different results are to be obtained from the two applications, they may be separately considered. In the application of the pickle lines, one type of joint mentioned is a series of spot welds placed sufficiently close together to provide the strength necessary for the handling operation through the pickle line, this weld is later cut out at the other end of the line. An adaptation of this type of joint is a roller seam weld in which the spot welds are replaced by either a continuous seam or an intermittent seam. This method has some advantage over single spot welding in that more strength is provided than is generally possible with spot welding.

The other type of weld employed for this application is the butt-flash weld in which case the weld is not cut out, but is trimmed immediately after welding, and then recoiled and subjected to all additional rolling or finishing operations necessary. In either type of weld, pickle lines travel at a speed of around 250 feet per minute, and anywhere from 1 to 2 minutes must be provided for the welding operations. It is, therefore, necessary to provide looping pits following the welder so that when the stock is stopped in the welding operation, the strip continues to move through the pickle line without interruption. Since by far the most important type of welding is the butt-flash method, further consideration will be given this.

A typical line consists of an uncoiler followed by pinch rolls, squaring shears, welder, flash trimmer, looping pit, pickle line, and recoiler. Starting with the coil of steel delivered to the uncoiler, the end is fed into the pinch rolls which drive the strip through the first series of operations. This puts the strip through the welder, trimmer, pickle line and into the recoiler. The strip is fed through the welder and trimmer at a speed considerably greater than that of the pickle line, resulting in the formation of the bank in the looping pit. When the end of this strip is reached, it is sheared off square and properly placed in the dies of the welding machine. The following coil then has its leading end fed through the shear, where it is cropped off square and put into the welding machine, then its end is clamped and the flash weld is made. Immediately following the welding operation, the welded strip is moved forward a few feet into the trimming machine and the burr caused by the upset is sheared off flush with the stock.

By this time the bank of stock in the looping pit has been consumed and another bank is started. Thus, in this manner, a strip of steel of any length whatever can be rolled, the only limiting feature being the size of finished coil which can be handled.

One of the practical advantages for large coils lies in the economy of cold rolling operations, if the stock is later cold rolled. Modern cold rolling mills operate at such high speeds that if large coils are not used, the cold mill hardly gets under way before the coil is run out. Since the gauge being rolled depends to a certain extent on the speed of rolling, it is very desirable to roll coils as long as possible. In the rolling operations, welds which have been made (if they have been properly made), will satisfactorily take any operation that the parent steel will take. The weld is completely rolled out and aside from a very slight variation in color and grain structure, it is impossible to locate the weld after cold rolling.

A typical welding machine of late design is shown in the accompanying illustration. This particular machine is entirely automatic and hydraulically operated. While the underlying principle of making the weld is relatively simple, the addition of full automatic controls and arrangements whereby all controls and adjustments are placed convenient to the operator and consist entirely of the manipulation of levers and dials, the machine takes on a complicated appearance. It consists essentially of two clamping members which clamp the ends to be welded, butting them together, but without pressure exerted between these two ends. As soon as the ends are clamped, an electric alternating current of about 8 to 10 volts, is applied through the dies to these ends. This creates in effect an electric arc between the two ends and as the arc is established, the contacting particles of steel are blown out. This causes an extensive sheet of sparks or flash, hence the term "flash welding".

As soon as this welding current starts flowing, a movement is imparted to one of the abutting pieces which feeds additional material into this weld zone, causing a maintenance of the flash. This movement is very carefully predetermined for, if it is too fast, the flash will be quenched by "freezing" and if not fast enough, the arc will be too slow and cold. The actual rate of feed is generated on a curve of constant acceleration. This rate of feed also determines to a very large extent the quality of the finished weld, especially the hardness of the weld, itself. The principal purpose of this flashing operation is to generate and transmit heat into the ends being welded.

By this method a uniform and very accurately controlled heat is transmitted back into the stock for a fraction of an inch on each side and when this has progressed long enough, the current is cut off and the metal given a very sudden upset. This corresponds exactly to the forge method of welding in which the two pieces to be welded are heated in a furnace to the proper welding temperature, then removed and forge welded with hammer blows. With this type of weld, qualities of the weld itself are obtained which are impossible to secure with any other method.

This upset throws a ridge of molten and semi-molten metal completely across the strip on each side. The size of this ridge or burr depends on the thickness of the stock, the amount of upset, and to a lesser extent, on the speed of the upset. It is essential that the speed of upset be made as great as possible in order to exclude all oxides from the weld proper. It is desirable to keep the burr as small as possible, but since it is necessary to upset and throw out all of the oxides in the weld zone, there is a low limit to its size.

Immediately after the welding operation, the welded strips are transferred into the trimmer in which clamping plates above and below, actuated either hydraulically or mechanically, have merely to hold the welded strip in place while the trimming operation is carried out. Rams, which carry a series of cutters, are then drawn across the surface of the strip, the arrangement being very analagous to that of a broach. The cutters are gauged from the surface of the strip and, therefore, are independent of the size of the burr or the thickness of the strip, the first cutter being set to cut to within about .025″ of the strip surface; the second cutter to within about .015″; the third cutter about .007″ and the 4th, flush with the strip. The cutters are set in the same manner both top and bottom. After one pass of the cutter across the weld, the clamps are released and the strip is then ready to be fed into the looping pit, after which it will be drawn through the pickle line and recoiled.

It is interesting to note that in macrographic study of the weld zone, there is a hard zone which is not over .025″ to .030″ in overall width and which is centered at exact point of weld. By control of the flashing time and upset, and also current densities, it is possible to control this hard zone so that it does not exceed but a few points the hardness of the parent metal.

Another application for butt-flash welding is in recoiling lines wherein no pickle line is used. The purpose of this operation lies solely in making larger coils than can be rolled from a single billet. When small coils are used, such as in the automotive industry for feeding into continuous blanking or dieing machines, but more especially in channelling or continuous forming machines, the cost of frequent handling of the coils and threading stock-ends into these machines, is quite a considerable item. Therefore, from an economy standpoint, it is very desirable to have coils of steel as large as possible delivered to the fabricator.