Some aspects of welding mechanisation in Bharat Heavy Electricals Ltd. Bhopal

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Mechanisation increases productivity. The statement is equally valid in almost all productive fields. The added advantages are consistency in quality of production, economics and less fatigue. However, mechanising the process is always limited and restricted by some other factors in the field of Welding and furthermore limited in tailormade fabrications like Heavy Power Equipment where the geometry, size and design of the fabrication vary widely. That is how mechanisation in the field of heavy power plant fabrication is much behind. However, in BHEL, mechanised welding is penetrating to a greater extent in the heavy fabrication of power plant machinery, like Hydro Turbines, High Pressure Heaters, Nuclear Reactors components, etc. Still the penetration is now effectively mainly at components and sub assembly stage and is still to reach to full degree of mechanisation on the total product.

In our opinion, having more and more sophisticated equipment alone may not be sufficient to have effective mechanised welding ; rather, all round approach, right from the modification in the design to suit specific process machine, fabrication sequence such as splitting the assembly into maximum number of sub-assembly, regular development of fixtures, positioner etc. are a must. Job screening based upon the suitability to particular machine to utilise the optimum available capacity, allied services such as handling facility, back gouging, etc, near the welding machines are a must to get the fullest advantage.

In the present paper, attempts have been made to illustrate some typical examples of successful mechanisation of welding done in our experience.

1. Mechanisation of Spiral Casing Welding

Spiral casings used in Francis type of Hydro Turbines are fabricated out of rolled plates called segments. These segments are welded to each other both at shop as well as at site. Cross sections are reducing, being maximum at inlet side and gradually reducing inside. However, these cross sections at every joint are a part of a circle. Segments are also made by joining two half segments with a longitudinal joint between them. The entire welding between two half segments (Longitudinal Joints) and between segments (Circumferential Joints) was normally done manually after the entire assembly is ready.

In order to take up the job on mechanised welding, the longitudinal joint was considered first. It was not convenient to weld this joint on automatic submerged arc process in the rolled form. A little change in the manufacturing sequence eased the process. The welding was done in the flat condition before rolling the segments to profile. All the automatic processes could thus be conveniently used on this joint. Unlike the easy mechanisation of longitudinal seams, a more elaborate arrangement had to be made for circumferential joints.

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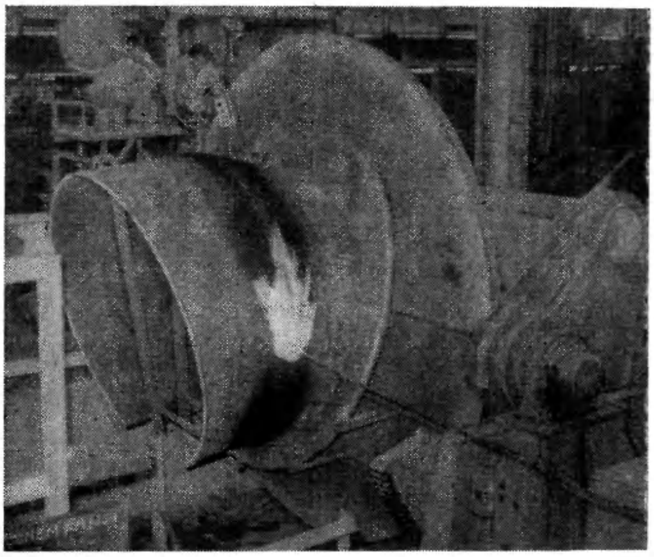

Fig 1. Automatic welding on spiral of Hydroturbines. Use of boom welders and manipulators.

The angular distance between the two ends of the segment is 15⁰. A fixture having a plane inclined at an angle of 15⁰ to the base was specially designed and fabricated.

The base of the fixture was clamped on the platform of the manipulator so that the plane of the fixture becomes 15° inclined to the manipulator plate form. One end of the spiral was mounted on the fixture with its inclined end opposite to the direction of the inclination of the plane. By doing this the other ends of the segment plane of the joint to be welded became perfectly parallel to the manipulator platform.

After properly centering and clamping the job, the platform was tilted by 90° i.e., in vertical direction. The plane of the joint becomes vertical and rotates concentric with the manipulator.

The boom and welding head was set on the top of the joint so that the welding is performed in the down hand position on the whole length of the joint with the rotation of the disc.

Other auxiliary arrangements which had to be made were the expansion of ground pit to accommodate bigger segment and platform for the operators. A complete remote control device had also to be provided at the welding platform for the operation of manipulator and welding machine.

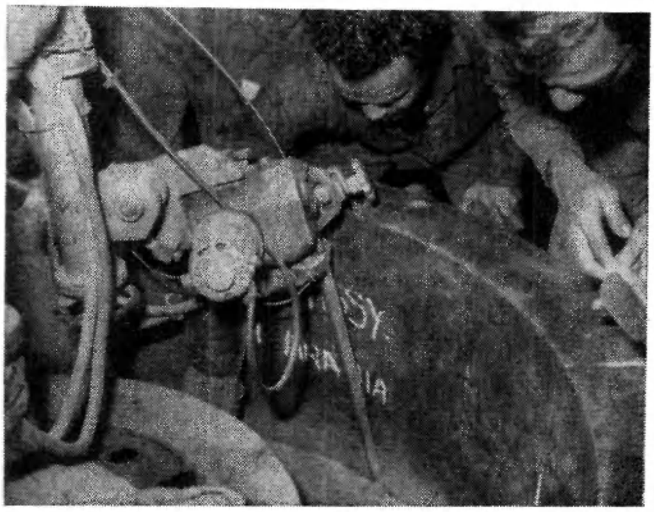

Fig 2. Manual welding of spiral by using manipulator.

The process offered the following advantagse.

(1) The entire welding was completed in 25% of the time.

(2) Handling of the job for the purpose of positioning for other welding processes was completely avoided.

(3) As the welding could be carried out with uniform rate all around, distortion was minimised, hence providing better dimensional accuracy.

(4) The arrangement is universal for all welding processes, manual arc process, CO_2 welding, TIG welding, Semi automatic and automatic submerged arc.

(5) Improved welding quality.

Further development to this system is to use two booms one from outside and another from inside on the same joint for further increasing productivity. Some of the advanced countries have adopted this also.

2. **Automation of Spider Welding**

The fabricated spiders for Saudi Arabia Diesel generating sets, was completely welded on automatic submerged arc welding. 120 mm thick centre plate was welded to full penetration across the whole thickness joining with inner hub forging 140 mm thick wall and outer cell 120 mm.

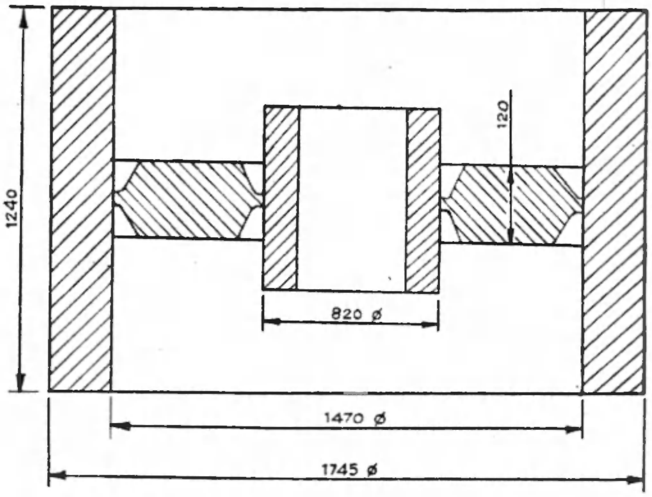

Fig 3. Section of the spider.

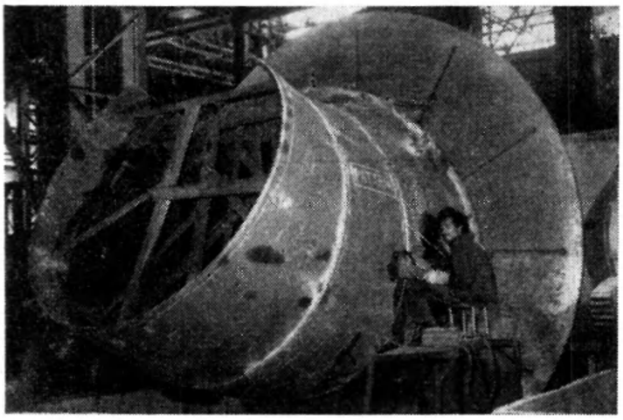

Fig 4. Automatic welding on spider.

100% ultrasonic test followed by magnetic crack detection test was done for the joint.

The disc with hub was welded using a positioner where the job was rotated and a fixed welding nozzle was able to weld around. For welding with the shell, modification in the welding machine was done so as to rotate the welding boom.

The problem of difficult approach to the groove was overcome by using specially designed long nozzles.

The problem was also faced by the operator whether to sit on the hub portion or outer side very close as the job was in a very much heated condition.

Serious lack of fusion defects were observed almost all around the hub in welding with disc in one such spider. However, after correcting the angle of the nozzle and adjusting the parameters, the problem was fully overcome.

The entire work was completed in approximately one fourth the time required for manual welding.

The photographs show the welding in progress towards the outer shell of the spider.

3. Development of Trijunction Welding for Nuclear Shield

Due to limitations and critical requirements of the nuclear designer, the shapes of the components are often very complicated from the manufacturing point of view. Shops are often faced with weld joints which are either very difficult to weld or sometimes altogether inaccessible for welding. In such situations, shops are faced with developing special techniques, processes and equipment for welding such complicated weld joints.

Trijunction weld joint is one such typical weld joint appearing in one nuclear end shield. The tube plate, the baffle plates and tubes are to be joined with a single weld from the tube plate side in a horizontal plane. The joint is so inaccessible that the welder cannot even properly see the joint. In order to take up this welding, we had to develop some reliable automatic process.

A special type of submerged arc nozzle to approach the joint was designed and nozzle movement was mechanised through a motorised turn table. Special flux holding arrangement was developed. After a series of experimentations, the parameters were established and a series of welded mockup were subjected to macro examination till the process was established.

Another development in mechanising the joints was undertaken using TIG welding in the root and pulsed MIG welding in the subsequent phases. A separate set of fixtures, rotating arrangement, etc was to be made. This process is still on trial.

4. Mechanisation in Welding of Hemiheads

Hemi heads used in high pressure heaters are hemi spherical forgings to which 3 main connections are being attached—two feed branches and one manhole facing. Because of the heavy thickness of the heads and full penetration joint, the amount of welding involved is very high, which is 100% radiographic quality to IBR standards.

The entire welding was earlier done with manual arc process taking longer time.

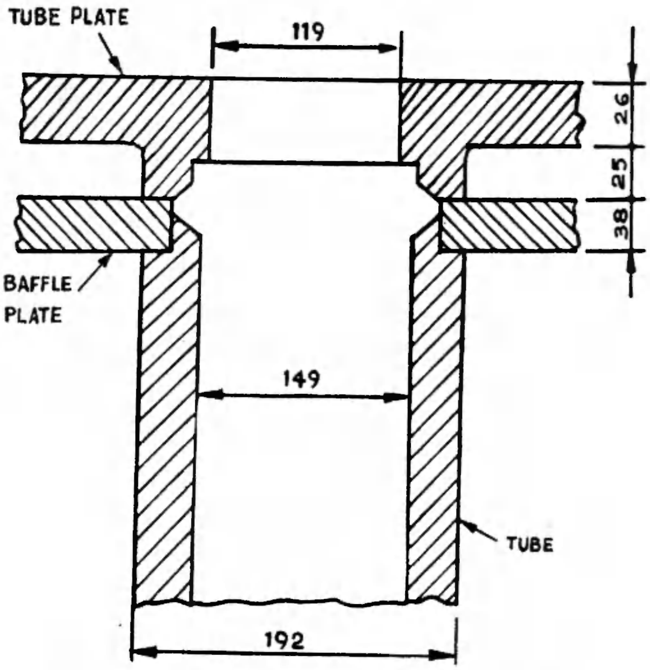

Fig. 5. Section of Trijunction Mock-up joint.

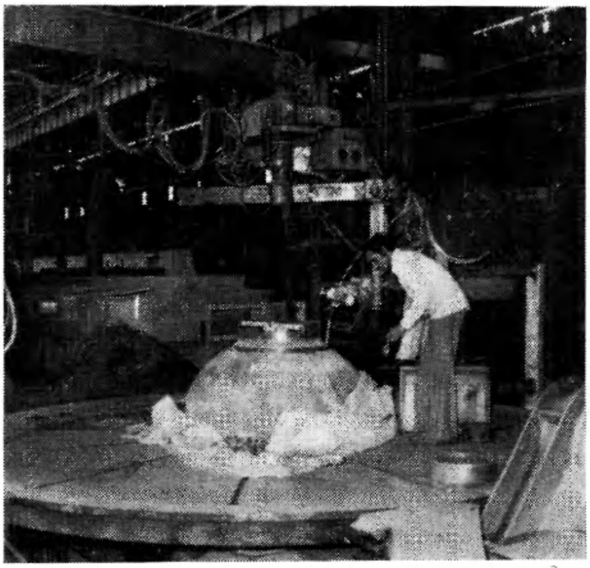

Fig. 6. Automatic SA welding on H.P. heater hemihead.

Successful attempts have been made to weld these joints by automatic submerged arc welding process However, the entire mechanisation has to take places in two phases. In the first phase, the welding of manhole facing which is comparatively simple because of its location on the hemi heads and design of the joints is done. No additional fixture was needed ; however, a little modification in the welding heads was necessary to suit the groove. It was estimated that the welding was completed in 1/3rd the time compared to manual arc welding.

Fig. 7. Automatic welding on hemi head facing— a close view.

The second phase, that is the welding of feed branches is going to be a bit complicated because of the location of the joint and design of joint. A fixture has to be designed so as to keep the branches in horizontal axis and having joint in vertical plane. A tilting type of manipulator has also to be used to hold the whole system in cantilever as the central axis of the branches must pass through the centre of the table and perpendicular to it. A special flux holding device has to be made and modification in the welding equipment may also be necessary.

It is interesting to see in this stage that, with a little change in the design of the weld, the mechanisation systems may change and may reduce a lot of work.

If the joint configuration of all the three attachments are alike, i.e., the feed branches too have the same type of joint design as the manhole facing, the welding of the feed branches also can be done keeping the axis of the branch vertical. In that case, no tilting of manipulator platform will be essential and fixture will be required only to align the base of the hemi head at a certain angle so as to keep the branches vertical and this fixture will be much simpler. Also no additional flux holding device may be needed.

Attempts are being made to effect this welding on submerged arc machine.

5. CO_2 Welding Process

The CO2 process is of great help in welding mechanisation programmes, mainly because of its higher productivity and greater versatility than the submerged arc process. It is no doubt a little unfortunate that the merits of this process were realised very late. It was generally felt that the process cannot produce quality welds, hence its application was limited to structural quality welding. But from the subsequent paragraphs it can be seen how smooth changeover took place in the progress of CO_2 welding process to come to a high standard level. The problems encountered in the use of CO_2 welding can be broadly classified in one of the following categories.

(1) Failure of equipments.
(2) Quality acceptance.
(3) Operational fatigue.

Failure of the equipments : The failure of the equipments in the initial stages was pretty high. The failure was mainly on the torches & wire feed units. A major modification in the torch was done and with proper interaction with the equipment manufacturers modified torches were made available on production level. Though this brought down the torch failure by an appreciable extent, every machine was provided with a spare stand-by torch so that when one torch goes for repair, the machine is kept productive with the help of spare torches.

A separate maintenance cell was formed to attend to torch repairs quickly and put them back on production.

Another problem connected with the failure of equipment was non-availability of spare parts. Small parts such as rollers, used to keep the equipments down. Spare parts frequently required could be judged by experience and advance stock of these parts could be made available in the store. This reduced the breakdown time to a great extent.

Quality Acceptance : CO_2 welded joints in the beginning used to look ugly in appearance. Undercuts and porosities were the most common defects in the welding. A high manganese content filler wire was specially developed with the help of reputed consumable manufacturers. Training of operators was arranged for adopting spray transfer technique. Customers and Inspecting agencies had various doubts about the quality standards and reliability of the process and were reluctant to accept, for which a series of welding procedures were qualified as per ASME Sect. IX Boiler and Pressure Vessel Code and also IBR. This brought in confidence among the inspecting agencies.

A series of refresher courses were arranged for production, design and quality control engineers for their full awareness. That is how the process was brought from structure applications to high quality hydro turbine fabrications, pressure vessels and even on nuclear turbine components to the satisfaction of the customers.

Developments on CO_2 process are not over. The use of flux cored wire and Argon/CO_2 mixed gases has further improved the quality. As the mixed gases are costly it has been planned to use mixing panels to mix the gases at our end.

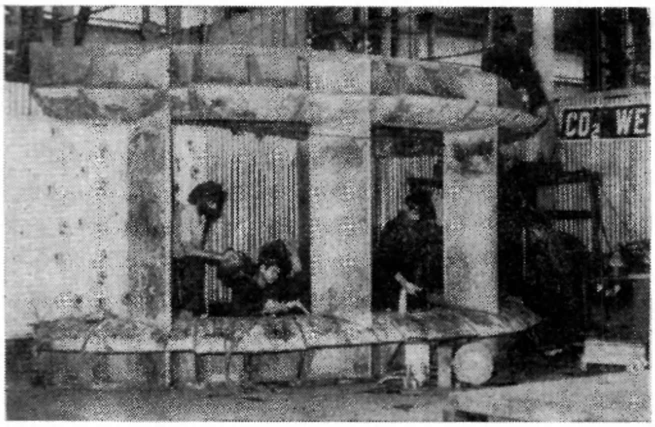

Fig 8. CO_2 welding on contours of large fabricated stay ring.

Operational fatigue : the CO_2 process no doubt causes more fatigue to operators owing to its high arc intensity and spatter. At the time of introduction of the process there was a degree of resistance from the operators. On an analysis, the problem was found to be more of a psychological nature than otherwise.

Courses of training to operators were arranged both in-house and outside. Some rewards and operational allowances were introduced for the operators engaged on CO_2 welding. Operators then started coming forward. High density dark glasses were given to operators to reduce the strain on eyes and flux cored wires introduced to reduce spatter.

Problems pertaining to the CO_2 process can never be completely solved but, with all these now CO_2 is an established welding process in the shops.

6. Conclusion

It may be generally felt that automation in welding is more suited to standard and mass production items having regular geometry. However, present experience shows how a non-symetrical shape and tailormade jobs can also be effectively mechanised. It has also been experienced that all the extra work done for mechanising the process is justified by the net gain. Continuous efforts are, however, a must.

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