Seminar on Welding in Steel Plants

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It gives me great pleasure to be here with you today at this Seminar on Welding in Steel Plants, specially organised by the Indian Institute of Welding, as a part of its Silver Jubilee Celebrations. I am thankful for the opportunity to share some of my thoughts with you all. At the outset I would like to place on record my appreciation of the dedicated and sustained good work that has been done by the Indian Institute of welding and wish this Institute more achievements and contributions in this field, which is assuming greater importance and offers new challenges as 'Technologies' are developing and 'Customer Demands' are getting more rigorous. The topic selected is quite appropriate as the Steel Industry is a basic one and today Welding has a key role in almost every facet of steel plant operations.

Welding is extensively employed in an integrated iron and steel plant for the fabrication of new equipments and reconditioning of existing ones. In either application, the basic objective is to conserve the two main resources - money and material. Today, welding is playing an ever increasing role in Maintenance Management.

While sharing my thoughts with you, I shall be confining myself to essentially the role of welding in integrated steel plants and give typical examples from Tata Steel's experience. Such case studies, encompassing a wide spectrum, will effectively underscore how welding could be an effective technological tool in steel plant maintenance. These case studies will detail the methods and materials employed and results achieved. Examples of manufacture of equipment by welding will be given. Finally a reference will be made to the methods of inspection and some suggestions on future needs.

WELDING FOR REPAIR OF TG TURBINE CASING

A 27.5 MW Turbine Generator manufactured by British Thompson Houston, U.K., and installed in 1944 in our Power House No.3 developed leakages in the high pressure steam chest from three locations. The turbine is designed for steam conditions of 420 psig and 740 F and was manufactured during Second World War with a stamp "WAR TIME FINISH". It was a risky proposition to keep the turbine in operation with such leakages and so in 1976-77 this job was taken in hand. At that time when welding technology was not as advanced as it is today, a very crucial decision was taken to weld repair the casing. Any failure in this attempt would have rendered the turbine unserviceable resulting in loss of vital power generating capacity.

On closer inspection, it was noticed that the casing had porosity in four regions and through these regions, steam was leaking out. Analysis of the turbine casing material indicated the steel to be of a composition C : 0.32%, Mn : 0.95%.

When the porous portions were removed and edge preparation was done, we had four 'V' grooves of approximately the following dimensions - 100 mm width at the top, 30 mm width at the bottom and about 250-300mm length. As the V' grooves had gone through the 3.1/2 "thick casing, copper backing plates were used for welding which were removed later. Pre-heating by electrical means to 150 C, proper selection of electrodes, well engineered technique for depositing overlapping layers of weld metal, etc were done to avoid base metal cracking due to shrinkage and to get a sound weld. Welding was done continuously for 40 hours.

A special induction heating arrangement was developed in our Electrical Dev. & Maint. Shop for stress relieving the casing. Post welding inspection by radiography and hydraulic test at working pressure indicated that the weld repair was satisfactory. There was no deformation of the turbine casing which was one of our essential requirements, as no machining of the casing could be done to remove deformity.

The turbine is running satisfactory since 1977 after the repair. The cost of a new turbine casing at the time of repair was Rs. 103 lakhs in foreign exchange. The cost of weld repair was just Rs. 1.8 lakhs.

REPAIR OF VAD WATER COOLED BASE PLATE

Tata Steel has at its LD Shop a 130 ton capacity VAD unit in operation, the second largest in the world. The water cooled base plate of this unit developed cracks. The base plate is made of stainless steel (Werk Stoff 1.4541) similar to AISI 321. It was noticed that several cracks had developed due to carbide precipitation (sensitized) and cracks used to propagate further during every repair. By suitable selection of welding electrode and proper sequencing the base plate was repaired satisfactorily and put into operation. The repaired heat base plate thereafter gave desired life and enabled Tata Steel to continue the VAD operations without having to wait for imported replacements.

WELDING OF BLAST FURNACE SHELL PLATE AT SITE

Under our Modernisation Programme we are erecting a new blast furnace. The structure incorporates about 800 metres of welding of plates of varying thicknesses. With increase in the thickness of plates to be welded, there is a progressive increase in the number of layers to be deposited in the Manual metal Arc Welding process. This severely restricts welding productivity, increases costs, distortion becomes unavoidable and the quality of welds in general is uncertain. In contrast to this, Electroslag and CO_2 welding processes are suitable for welding of thicker plates due to their high weld deposition rates, lower distortion and superior weld quality.

Electroslag Welding was selected for vertical joints and CO2 welding was employed for circumferential joints. Since filler wires and fluxes play an important role on the quality of weld deposits, weld procedural tests were conducted at site for the selection of filler wires, fluxes and welding parameters for joining various plate thicknesses.

Preheating temperature of 200 C was maintained and adequate precautions were taken during welding at site for obtaining defect-free welds.

The weld joint following both ESW and CO_2 welding processes were subjected to ultrasonic and x-ray tests for revealing weld defects, if any. The weldments were found to be of satisfactory quality in both the cases.

At Tata Steel's Growth Shop, welding is adopted extensively for fabrication and manufacture of steel plant equipment. Two typical examples are :

HOT METAL POURING LADLES

90-t ladles were fabricated from plate thickness varying between 28 to 40 mm by manual metal arc welding using basic coated low hydrogen electrodes. Welding was performed with thicker electrodes and minimum number of deposition layers and proper sequencing for reducing distortions. These precautions have helped in obtaining dimensional and shape accuracy needed for proper alignments and in minimising stresses and strains even without stress-relieving treatment.

HOT METAL MIXERS

In the past these were being fabricated by employing laborious and time consuming riveting techniques. However, now-a-days welding is being adopted during fabrication. The main fabrication in a mixer is the shell assembly consisting of a shell, two tyres and two end-covers. A 1100 t. hot metal mixer for Tisco's LD Shop was designed and manufactured at our Growth Shop. The shell diameter is 7.64 metres and length is 10.7 metres. The mixer shell thickness is 32mm and thickness of plates for the tyre and track girders are 50 to 80 metres. The mixer was fabricated by submerged arc welding in the manufacturing plant and manual metal arc welding was employed for joining at site. The welded joints were tested by x-ray and were found to be of satisfactory quality. Total weight of the shell, tyres and track girders is 205 t.

HARDFACING : INNOVATIVE APPLICATIONS AT TATA STEEL

The process of hardfacing makes valuable contribution towards reducing lcsses resulting from wearing of components and reduces equipment down-time. Although iron and steel making industries have made sufficient progress in adoption of weld surfacing techniques there is still much scope for enlarging this area of application for reclaiming worn out or damaged components. The hard surfaced components are in no way inferior to the original ones and at times their performance can be dramatically superior. Typical examples include : Sinter Plant suction fan impellers, sinter breaker bars and tips, hot sinter screens, blast furnace hoppers and bells, coke oven hammers, hot shear blades, etc.

Although any welding process can be used for hardfacing it is important to take into account composition, shape and size of the base material and end application of the item to be hardfaced. These considerations help in deciding the most suitable and economical hardfacing material and welding process.

COSTOLINE SPRAYING ON MILD STEEL PIPES FOR RUNOUT ROLLER TABLE OF HOT STRIP MILL

Hitherto centrifugally cast alloy cast iron pipes with hardness of 250 to 300 BHN were being used for the runout roller table rolls of HSM. Now mild steel pipes are being spray coated with costoline powder to a thickness of about 1 mm which can give hardness upto 425 BHN. The spray coating gives a very smooth finish to the rolls without any further grinding. The coated rolls are expected to give a life of 10 million tons rolling of strips as against 2.5 to 3.0 million tons for alloy cast rolls ! We have equipped our Repair Shops with the capability to carry out such spray coating tasks.

RECLAIMING MILL HOUSING AND TABLE ROLLS

During operation the rolling mill housings and table rolls wear out. These castings/forgings are very heavy and costly. These are periodically being reconditioned by weld depositing and remachining.

HOT SHEAR BLADES FOR BLOOMS SLABS AND BILLETS

Hot shear blades are subjected to impact and wear at elevated temperatures in service. At Tata Steel, hot shearing is carried out for a wide product range from 600mm x 200mm slabs, 355mm blooms to 100mm x 100mm billets and 305mm x 13mm sheet bars. The blade size ranges from 45mm thk x 600mm long upto 90mm thk x 1500 long.

Material of the blades used to be either Ni Cr Mo or Hot Die Steels. The ingots were cast, forged, heat treated and machined to the final blade size with in-house facilities. However, use of high carbon Ni Cr Mo alloy steels posed manufacturing problems as well as inconsistent behaviour in service. Work on development of suitable substitute for alloy steel blades started in 1975 and after a serious of trials, use of welded shear blades has been accepted. The base metal selected is 42CrMo4 with welded cutting edge of hot die steel type deposit. The weld metal is totally compatible with the base metal and offers considerable manufacturing ease. In applications like Concast shear, where billets are being sheared, Hastalloy C type weld metal is used at the cutting edge which gives improved machinability.

It has been established that build up type hot shear blades offer 200% to 300% life improvement over alloy steel blades at about 30% of the original cost.

FLYING SHEAR MAIN CYLINDER

The Flying Shear at S.B.B.M. No. 1 is a pneumatically operated shear used for on-line cutting of red hot billets or skelp bars. The operating air pressure is 6 atm. the main cylinder is the operating cylinder for the top and bottom blades. The physical dimensions of the cylinder is 800mm nominal bore and 1054mm length. The cylinder is made of C.I. grade GG 22 with St 60 Piston Rings. The cylinder is well lubricated through a central lubrication system and a drain is provided for draining condensate water. No liner is provided on the cylinder which has wall thickness of 55mm.

The bore wear of the main cylinder measured in 1973 after 10 years of service was 3mm. the cylinder was then replaced with another cylinder at that stage. In the year 1978 the second cylinder was replaced with the first one after reboring the first cylinder to +5mm oversize the wear in the second cylinder at that time was 7 mm in the bore which is on the higher side. Reconditioning of this cylinder by sleeving the bore was ruled out due to low residual wall thickness after sleeving. Hence reconditioning by welding was resorted to, to provide for a spare cylinder before the one in service went out of service.

After reconditioning the cylinder was put into operation in the year 1983 and is still in service. In the meantime the other cylinder has also been reconditioned and kept as spare. The campaign life of the first reconditioned cylinder is almost reaching the life obtained from the new component. Estimated savings from the reconditioning is about Rs. 18.00 lakhs towards replacement purchase in foreign exchange.

WELDING OF LD LANCE PIPE FLANGES

LD Lance pipe flanges are made of cupronickel (90% Cu, 10% Ni) plates of 50 mm thickness, which are to be welded to the pipe of same material. Initially, the foreign collaborator .pa tried several methods to do the welding but could not succeed. Our engineers have done the job successfully by selecting proper electrodes and sequencing. The welding method employed was Tungsten Inert Gas (TIG) welding. The selection of preheating as well as post heating temperatures and cooling rate after post heating were found to be critical for ensuring satisfactory weld joints.

WELD INSPECTION METHODS

Welding is a process which can, and does produce defects within or near the weld deposits. It is therefore essential to inspect the weldments, particularly for critical applications. The weldments on boiler tube-ends and high pressure water lines are regularly tested and certified on the basis of radiographic test results. The welders for critical welding applications like blast furnace shell and other items are selected on the basis of their ability to produce radiographically sound quality welds.

INSPECTION TECHNIQUES

The most common weld inspection techniques are : visual examination, ultrasonic tests and radiography. All three these techniques have their relative strengths and weaknesses.

VISUAL INSPECTION

Visual inspection is the most basic approach to NDT but, left to itself the visual identification of cracks is a chancy technique. To make the potentially serious surface opening crack stand out more readily and consistently, two techniques are common, the use of dye penetrants and magnetic particle inspection.

The main disadvantage of dye-penetration technique is that it relies on the ability of the penetrants to enter the crack and this will be affected by the crack conditions. Shallow surface features such as scratches may allow some ingress of penetrants and show up.

The magnetic particle inspection technique has the advantage that the ink is positively attracted by the stray magnetic field. However, it is limited to application on ferromagnetic materials. This technique is suitable for only surface and open cracks.

ULTRASONICS

This approach relies on the interaction of elastic waves with flaws, leading to reflected or scattered energy which can be detected and provides an indication of both the presence and size of the flaw.

The most common approach to flaw detection by ultrasonics is pulse echo. These techniques rely on the amplitude of the echo to define the flaw size, which will be estimated from the maximum amplitude.

Crack-like flaws, which would include lack of fusion are good ultrasonic reflectors and are thus readily detected if near normal incidence can be arranged. Flaws of a volumetric nature such as pores and regions of slag, will be reasonable reflectors of ultrasound regardless of angle of incidence and are likely to be more reliably detected than cracks. Long stringers of slag can give the appearance of more serious crack-like flaws : this highlights the need for better characterisation of flaws by NDT.

RADIOGRAPHY

Radiography is the oldest, most consistently used NDT technique and has the special feature of providing documentary evidence of weld quality. The specimen is used partially to block the radiation. Any flaw will pass more or less radiation than the specimen and will thus reveal itself on film through the use of suitable radiation detectors. There are several types of radiography, but only x-ray and Gamma-ray techniques are widely used.

For crack detection with radiography, it is essential that the crack is aligned fairly closely with the beam.

Radiography is a good method for locating regions of extra or missing mass. Thus the detection of volumetric flaws with an equivalent of 1% change in section thickness is fairly routine. Weld flaws such as slag and porosity show up well by this technique.

FUTURE NEEDS

1. In our country the share of manual metal arc welding employing coated stick electrodes seems to be as high as about 90% of the total weld metal deposits. It seems essential to adopt appropriate strategy for popularising high productivity and high speed welding processes such as Submerged Arc, flux Cored Arc Welding, CO_2 welding and Electroslag Welding processes. There is also a need for attaining self sufficiency in regard to the availability of filler wires and fluxes. special technologies have been developed to apply ESR to Roll Reclamation. (BHP-Clyde Carruthers Technology) and such areas should receive the attention of the Indian Institute of Welding.
2. There is a need for indigenising Pulsed Arc MIG welding method for advantages like superior and spatter free weld deposits, ease of control over welding conditions, lower risk of lack of fusion due to higher heat input/metal deposition ratio and for covering a larger range of welding parameters even by employing only one size of electrode wire.
3. Adoption of robots for welding in advanced countries has opened up new operational fields for the welding industry. The work piece. which had not been previously handled by automatic welding are now being welded profitably by using robots. It would be appropriate to intensify R&D work in this area.

I have attempted to give a bird's eye view of what appropriate welding technology could mean to a major steel plant. The deliberations at this Silver Jubilee Seminar, I am sure, will be covering the subject in greater detail, and arrive at worthwhile conclusions. I wish the seminar all success.

Thank you for your attention. □