Utilisation of welding technology in the erection of electro mechanical equipment in hydroelectric projects

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ABSTRACT

India's major Hydro potential is situated in deep Himalayas. The accessibility of these hydro sites is very tough. Before the start of actual construction of the project, it necessitates construction of roads and other infrastructure in the hilty terrain, which has its own limitations. Since the hydroelectric projects are tailor made suiting to the site conditions and head available for power generation, the size of equipment to be installed is to be decided on roads, bridge conditions and actual accessibility to the site in addition to water availability. This involves decision on fabrication of the various components into small segments and requires them to be welded at site and thus involves huge welding work during erection of E&M equipment at project site.

The Himalayan rivers carry huge amount of silt in the water as it is of the order of approximately 15,000 ppm in rainy season. More than 80% of silt consists of quartz particles which have the hardness of the order of seven on Mohr's scale and it causes enormous damage to the underwater parts which require to be rehabilitated every year by way of welding, grinding etc. This paper outlines the salient features of hydroelectric projects, utilization of welding technology during erection and operation, maintenance of E&M equipment in hydro-electric projects.

Key words : *normal features of hydroelectric project, E&M equipment, welding techniques/procedure & testing, utilization of welding during erection, utilization of welding techniques during O&M.*

NORMAL FEATURES OF HYDROELECTRIC PROJECTS

Generally hydroelectric projects are either reservoir or run-off the river type and consist of the following :

- Dam or Barrage
- Hydro mechanical equipment
- Intake structure
- Head race Tunnel or open channel.
- Penstocks
- Main Inlet Valves
- Power House including Turbine Generators etc.
- Tailrace channel/Tunnel

E&M equipment

Hydro Turbine Generator Sets and its auxiliaries are generally despatched to the site in very large number of parts. The size and number of parts of E&M equipments are decided on the basis of road conditions, capacity of bridges and culverts and size of the tunnels enroute, if any. Details of the major equipments of hydro Generator sets are given below :

- Peir Nose - It is erected at the outlet of the draft tube for channelizing the flow into the concreted portion of D/T
- Draft Tube - It is made of various segments fabricated out of steel plates exactly matching to the profile of the water and to give an access to the inspection and maintenance of the turbine.
- Draft Tube Cone - It is made of either in single or two halves and made of steel plates.
- Conjugating Belt
- Foundation Ring
- Speed Ring
- Spiral Casing including inlet and transition piece

- ❑ Lower ring
- ❑ Guide Vanes
- ❑ Top Cover
- ❑ Regulating Mechanism of Guide Apparatus
- ❑ Runner
- ❑ Main Inlet Valve
- ❑ Turbine Shaft
- ❑ Generator Shaft
- ❑ Rotor
- ❑ Stator (core and winding)
- ❑ Guide bearing parts
- ❑ Lower and Upper Brackets
- ❑ Thrust Bearing
- ❑ Dewatering and drainage, cooling water, oil lubrication, air system, instrumentation, and piping etc.
- ❑ EOT crane
- ❑ Generator Transformer
- ❑ Switchyard structure

Welding techniques/procedure & testing

Welding

- ❑ Grinding and cleaning of the joint
- ❑ Pre-heating of the surface
- ❑ Baking of the electrodes
- ❑ Full penetration welding
- ❑ Cleaning and removal of slag from each and every layer
- ❑ Filling of full "V" or double 'V' and grinding in between
- ❑ Back gouzing through carbon electrodes
- ❑ Cleaning by grinding
- ❑ Filling/sealing of the joints
- ❑ Finishing

Testing

NDT of welded joints is done in respect of all important major components as per details below :

❑ Visual inspection of the workmanship is done through chipping hammer, magnifying glass etc. for surface flaws, cracks, slag inclusions under/over welding and in proper fit up as a primary inspection.

❑ Radiographic testing is done on all joints through X-Rays and films are developed for ascertaining any cracks, porosity, blow holes, non metallic inclusions, undercuts, and incomplete root penetration etc. as per code and specifications for welding of spiral casing and high pressure joints.

❑ Liquid dye penetration using penetrants and developers for visualisation of surface cracks and blow holes etc. during the course of welding and thereafter.

❑ Ultrasonic testing through ultrasonic eqipment for surface and sub-surface flaws including those which are too small to be detected by other method as a very sensitive testing. It is being done in respect of specified areas of spiral casing and speed ring joints and in case of all of the brazed ferrules of stator winding.

Utilisation of welding during erection

Out of the equipments mentioned above at 2.0, many equipment viz. Draft Tube, D/T cone, Speed ring, spiral casing, Foundation ring etc. involves huge welding. The description of welding work in brief is given component wise as under.

Draft tube & draft tube cone

❑ These are made of steel plates in various segments which are required to be properly matched and welded together through full penetration welding at the site of installation.

❑ Spiral Casing is generally received in number of pieces and every segment is in two or three parts which are required to be matched and welded at site. This is required to be done by pressure vessel quality welders; this has to undergo extensive NDT.

Special example of Salal H.E. Project (3 x 115 MW) is shown at Fig 1. There were 26 segments in total, 50% out of the above consisted of 3 pieces and balance at least two. All of the pieces were matched and welded together to form the segment and all of the segments were matched and welded with speed ring and with adjoining segments exactly as per the theoretical drawing of the flow of the water. The welding consisted of 36mm to 36mm, 36mm to 40mm and 40mm to 65mm. This was full penetration (V or double V) welding duly sealed after gouging. It is to highlight that welding was run approx. in 500 mm and it consumed approx 2.65 lac low hydrogen electrodes per spiral casing.

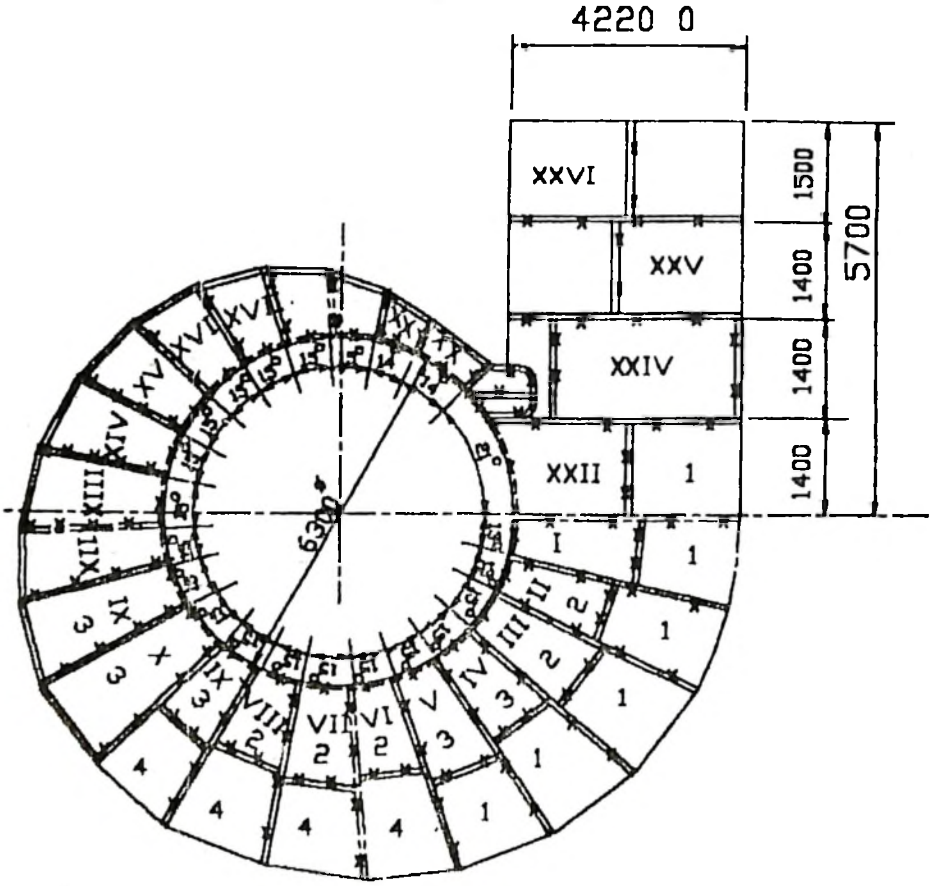

Fig 1 : Spiral Casing of Salal (3 X 115MW) in XXVI Segments

❑ Other turbine parts such as lower-ring, speed ring, Top cover, Pit liner etc. are being matched and welded at site and undergo extensive testing.

❑ Other areas, where welding during erection is necessarily required, are as under

- During core building of rotor and stator and locking of all hardwares.
- Welding and filling all of the erection elevation gaps through conjugating belt and welding.
- Welding and locking all of the fasteners of all major components.
- Special stainless steel welding of the coupling elongated bolts of runner and turbine-generator shaft.
- Various welding works of erection of Upper bracket, Lower bracket and associated equipment.
- Providing various jacks and their welding during embedments.
- Laying & welding of embedded pipe lines.
- Brazing and NDT of all the ferrules of stator winding.
- Welding during erection of various high pressure pipe line pertaining to cooling and drainage water, oil, instrumentation and air.
- In one of the project of NHPC i.e. Chamera Stage-I (3 X 180MW), there is a network of approximately 12 kms. of piping which required a lot of quality welding works as 80% of the above piping comes in high pressure range.

Fig 2 : Damages on Runner (Salal H.E. Project)

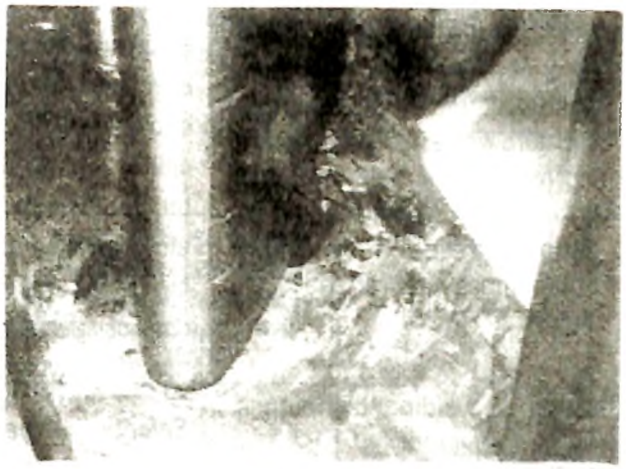

Fig 3 : Damages on Lower Ring & Runner inlet (Salal H.E. Project)

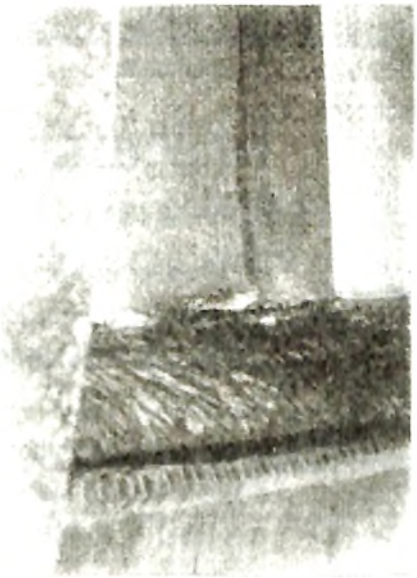

Fig 4 : Damages on Lower Ring Guide vane (outlet) of Salal H.E. Project

Fig 5 : 42 Tubular Structure Erected at Chamera H.E. Project

- Quality welding works are required in erection of structures & equipments of switchyard also. Special example of such an exemplary work is Chamera H.E. Project (3 X 180 MW) of NHPC where instead of lattice type of switchyard structure, nearly 42 meter high tubular structure was erected after welding (without any hardware) and successfully commissioned in the potyard area. A photograph of the structure/tower has been shown at Fig. 5.

Utilization of welding techniques during O & M

As highlighted above, Himalayan rivers carry huge amount of silt in water and when suspended silt particles pass through the turbine, it is subjected to the cavitation and turbulence etc. Combination of these forces makes the movement of silt, under varying pressure gradient and velocity profile, very complex which due to above and its own abrasive action (approx. 80% quantity is quartz.), causes enormous damage to the under water parts resulting in heavy loss of material. It causes a great challenge to the maintenance engineer as O&M personnel need to concentrate on operation of equipment with minimum damage. It is necessary to use material in turbine having high resistance to silt erosion thereby ensuring decrease in down time/less maintenance cost and high reliability of operation of the plant. Though some factors are to be taken care of during design and construction stage itself while selecting the proper material for the critical turbine components yet extensive use of welding technology can not be avoided.

Extensive use of welding technology is a must for maintenance and rehabilitation of parts of hydro machines. In addition to the welding techniques/procedure and testing etc. explained at Sr. No. 3.0, following issues are required to be taken care of specially in case of maintenance of hydro-machines.

Selection of welding electrodes

- ❑ Based upon chemical composition of base/parent surface to be welded/rehabilitated.
- ❑ Keeping in view the resistance to silt or any other factors which are specially required for a particular machine.
- ❑ Arrangements of pre-heating and post heating at site are to be kept in view. The electrodes which require post heating for heat treatment etc. cannot be selected for in-situ repairs etc.
- ❑ Grindability of the welded surface for in-situ repairs.
- ❑ Machinability of the welded surfaces, wherever necessary.
- ❑ Distortion of the welding (Many components viz. Labyrinths etc. operate in very close clearances and no distortion/ ovality etc. can be afforded). Hence, welding in controlled fashion and also use of stifeners during the welding is required to be ensured.

A series of welding trials were conducted by NHPC at one of its project i.e. Baira Siul H.E. Project, 3 x 60 MW where enormous damages on underwater parts were noticed due to silt erosion etc.

- ❑ Two guide vanes were repaired with Microloy 812 electrode of Diffusion.
- ❑ One guide vane was repaired with application of sweat-on-paste (M/s. Wall Colomonoy Ltd.) fused with Carbon electrodes.
- ❑ Three Guide vanes of 13 Cr. 4 Ni composition with different hardness were installed.
- ❑ Final welding coat with 375-Ni (Phillips) and 444L of D&H was applied on localised area for experimentation.
- ❑ Xuper Turbotec - 5300 electrodes of L&T were used on guide vanes.
- ❑ Regular use of 309-MO-15 S.S electrodes in building up on all underwater parts.

Based upon the above experience, 309-MO-15 stainless steel electrodes are extensively being used for rebuilding of stainless steel parts of turbine in-situ.

Such specialised use of welding both quality and quantity - wise is a must during O&M stage. Table I & II show approx. yearly consumption of electrodes used on maintenance in Salal H.E. Project (6 X 115 MW) of NHPC and it is increasing in quantity every year with respect to silt content in the water. The above clearly underlines the extensive utilization of welding during O&M of hydropower stations in India. Various photographs showing the damages on underwater parts of Salal H.E. Project are exhibited in Fig. 2 to 4.

CONCLUSIONS

Welding Technology is extensively used during erection of E&M equipments of H.E. Projects as well as during the maintenance stage. The maintenance personnel dealing with welding operation should be updated with latest available Modern welding technology.

Table 1 : Yearly consumption of welding electrodes (all sizes) Salal stage-1

S. No	YEAR	CONSUMPTION	REMARKS
1	1990-91	33,902 Nos	In-Situ repairs
2	1991-92	39,801 Nos	-do-
3	1992-93	65,336 Nos	-do-
4	1993-94	84,645 Nos	-do-
5	1994-95	91,340 Nos	Excludes repairs of runner

Table 2 :

S.No	Description	Approx. Average Yearly consumption of Electrodes per machine of Salal Stage-I (Commmissioning of Stage-I m/c. - Nov'87)	Remarks
1.	1988-89 to 1990-91	5000 Nos	Silt level in the reservoir very less
2.	1991-92 to 1991-93	18000 Nos	Silt level is very less in the reservoir
3.	1993-94 to 1995-96	29000 Nos (does not include major repair of one runner)	Silt level is very high in the reservoir

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