ROLE OF WELDING IN HYDROELECTRIC POWER GENERATION

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Welding plays a vital role in fabrication, erection, maintenance and repair of core equipment associated with hydro power generation. In hydro power sector, welding is extensively used in :

- Hydraulic Control Equipment
- Water Conductor System like Penstocks and Liners
- Hydro Turbines
- Earth Moving and Construction Equipment.

Today hydro stations are facing daunting problem of massive erosion of vital components of hydro turblines like stainless steel runners, guide vanes, top and bottom rings etc. This calls for extensive repair work consuming tonnes of best available welding electrodes which are deposited over the worn-out parts. Search for the better welding technology to overcome the above problems, has to be done indigenously. With more and more use of high tensile steel plates for penstocks and hydraulic gates located in the interior hills where the temperatures are low and humid conditions prevail, it is necessary that a variety of extra low hydrogen type electrodes are developed in the country to avoid hydrogen induced cracking.

NHPC PROJECTS

The total installed capacity of various hydroelectric power stations having 22 generating units under the control of NHPC is 2089 MW and the annual generation from these stations is about 8000 MU. Since commissioning of the first unit in 1980 till today, there has been a number of problems which were encountered for keeping the machines fit for generation, of which erosion damage to the underwater parts of some of the power stations was the major problem that is bothering us even today. Welding process has come to our rescue for restoring the underwater parts to their original shape and dimensions. I would like to share with you various welding methods and the problems associated with them for repairs of underwater parts.

List of various operating hydroelectric projects of NHPC, their date of commissioning, installed capacity etc, are reproduced below :

Project	Installed Capacity (MW)	Year of Commissioning	Type of units	River
Baira Siul(*)	3x60	1980-81	Vertical Francis	Baira/Siul
Salal(I)*	3x115	1987	-do-	Chenab
Salal(II)*	3x115	1993-95	-do-	Chenab
Loktak*	3x35	1983	-do-	Loktak lake
Chamera	3x180	1994	-do-	Ravi
Tanakpur	3x31.4	1992	Vertical Kaplan	Sharda
Uri	4x120	1997	Vertical Francis	Jhelum

(*) Inflows carry huge amount of silt (Quartzite based) especially in monsoon season.

BAIRA SIUL PROJECT

In the very first year of commissioning. unit 01 of Baira Siul Project had to be stopped as high vibrations were observed at the TGB. Inspection of underwater parts revealed considerable erosion damage on pressure side of guide vanes (stainless steel) and top & bottom clearances had increased to 0.4 to 0.5 mm as against 0.15 mm design values. Top cover, Lower ring. guide vane bushes, and Draft tube cone had also suffered considerable damage. On the first inspection of damaged parts, it was strongly felt that all these parts needed replacement for making the unit fit for generation. However. restoration of all the parts was taken up by building up of damaged portions by welding. grinding. and polishing operations. Till the time the above works were taken up, based on the experience in the hydro field, manpower strength requirement of specialised welders in the operation and maintenance had not been foreseen and only two general type welders were considered sufficient for annual maintenance work of generating plant. Actual deployment of welders. consumption of welding electrodes & other accessories, duration of repairs etc, are summarised in Table - I. Detailed discussions were held with M/s BHEL to finalise the type of SS welding electrodes for proper matching with the composition of material of underwater parts. These repairs were undertaken in 1981.

Since commissioning up to date, two units have been taken up for minor repairs and one unit for major repairs every year. During these years efforts were also made for increasing the life of repairs in order to minimise the frequency of capital repairs. Many innovative ideas like deposition of hard coatings. application of Bellozona compound, Steliting of faces of guide vanes, welding by 4441 welding electrodes, plasma coating ect, have been tried on the guide vanes. All these trials, except plasma coating, were not successful due to problems like surface finish. difficulty in polishing, danger to health of workers engaged etc. Although plasma coating was considered suitable for making the components erosion resistant, there were many practical difficulties e.g. heat treatment. distortion. machining, polishing etc. due to which these have not been used so far on bulky components like Top cover. Lower ring & Runner etc. Hence, specialised welding seems to be the only alternative till today for restoration of these worn-out components.

Based on the experience gained, highly skilled welders (eight in number) were included in the strength of work force required in the operation and maintenance stage of the project.

Erosion damage to all the underwater parts is on the increase each year of operation as it is not possible to restore the components to their original drawing dimensions due to the

Table - I

Name of Item	Consumption of Electrodes[2] (no.)	Skilled manpower utilised (mdays).	Consumption of Grinding Materials
Guide vanes (24 nos.)	3000	72	AG7 - 30, GQ4 - 12, IT2 - 24, HS7 - 96, rotary bur - 4
Top Cover	4000	40	AG7 - 30, GQ4 - 20, HS7 - 150
Lower Ring	2500	28	AG7 - 30, GQ4 - 20, HS7 - 100
Runner (I)	1000	60	Machined for restoration of AG7 - 15, GQ4 - 12 H2 - 24, HS7 - 200 rotary bur - 15

1) Damage on runner blades was not very severe, therefore, patch welding on crowr. skirt and runner vanes was only required to be done.

2) Philips make welding electrodes 309 Mo - 15 of sizes 2.5 mm, 3.25 mm, 4.0 mm were used for deposition of weld metal.

occurrence of worst kind of pitting damage. Consumption of welding electrodes used during the repairs of one unit in 1996-1997 are shown in Table-II.

During the welding of guide vanes, it is seen that upper & lower stems get distorted and are machined to true centre by deposition of weld metal and machining on lathe. Effective heat treatment facilities are not available at site for stress relieving after welding.

There are other practical problems which affect the progress of welding in that the welders always try to bypass the essential processes like heating of welding electrodes, pre-heating and post-heating of the job and welding in correct sequence etc. Although all-out efforts are made to improve the quality of welding process and welds, due to the lack of adequate knowledge in the field it is not possible to adhere to the right type of welding mode, and it is strongly recommended that welding experts need to be included in the corporate O&M manpower where such type of problems are expected.

Further, a group of skilled workmen should be trained in specialised welding techniques, grinding operations, template fabrication and accurate measuring procedures etc. so that downtime of machines can be minimised. Interaction with the manufacturer of welding electrodes and welding accessories is very much desirable to choose the right type of welding equipment and welding electrodes.

Table II

Item	Consumption of electrodes (no.)	Skilled manpower (mandays)	Consumption of grinding materials
Guide vanes (24no.)	4000	100	AG7-30, GQ4-12, ff2-24 HS7-96 rotary bur-4
Top Cover	6000	75	AG7-35, GQ4-50 HS7-150
Lower Ring	4000	60	AG7-30. GQ4-20 HS7-200
Guide Vane Bushes	1500	25	Machined for restoration of shape
Runner	600	160	AG7-25, GQ4-12, ff2-40, HS7-250 rotary bur-15

SALAL H.E. PROJECT

All the six machines each of 115 MW capacity are in operation. Three units of Stage I were commissioned in November '87 and the other three units of Stage II, namely Unit 4, 5 and 6, were commissioned in 1993, 94 and 95 respectively. All the units in first stage were in smooth operation till the occurrence of floods in 1993 when the penstocks got choked due to the heavy amount of silt accumulation in the reservoir. As the silt accumulated in the reservoir could not be removed due to non-availability of under-sluice gates, it passed through the machines.

All the generating units thus continued to accumulate damage. All the underwater parts of Unit #1 were found completely damaged. The damaged runner was sent to M/s BHEL for repair, where it took 12 months for restoration of runner blades by welding, grinding & polishing etc. Large quantity of welding electrodes were consumed in carrying out these repairs. It has been estimated that about 5% of weight of runner (35 T) was required to complete the work of restoration of runner. Other underwater components e.g. lower ring, guide vanes, guide vane upper bushes were restored back to shape by welding. grinding & polishing. It is worthwhile to mention here that it has taken 160 days to complete the major repairs.

We are now planning to take up major repairs of two units every year, for which we are proposing to strengthen the team of skilled workers e.g. welders, grinders & mechanical fitters, etc.

AREAS NEEDING CHANGES IN TECHNOLOGY

Today hydro power stations are facing daunting problem of massive erosion of underwater parts of hydro turbines like Stainless Steel blades and Top and Bottom rings etc. Even after making best efforts to reduce the silt content through desilting arrangement. the turbine blades, guide vanes and liners are subjected to extensive damage due to cavitation, erosion, abrasion and corrosion. pollinated by water carrying in excladable fine silt comprising parts of material of hardness as high as 7 Mho. This calls for massive repair work using tonnes of best available welding electrodes which are deposited over the worn-out parts and then ground to exact shape and size. Such repair work involves lot of expenditure and machine down-time. Under these circumstances lot of research work and innovative application are required to be carried out by the welding technologists in consultation with the field engineers to develop welding materials which can last for longer period. Solution for the problem may not be coming from the advanced countries like Russia, France, Canada, Sweden etc. as they do not have such serious silt problem in their power stations. Their stations operate on lake-fed or clear stream waters carrying hardly any silt. The erosion in their turbines is mainly due to cavitation which is of very insignificant nature. The search for better technology to overcome the above problem has to be done indigenously.

However, with more and more use of high tensile steel plates for penstock & liners and hydraulic gates in hydroelectric power stations which are located in the interior hills where the temperatures are low and humid conditions prevail, it is necessary to avoid hydrogen induced cracking, which plays a vital role in such areas.

A request from the EDITOR

Dear Readers,

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Your article should be neatly typed on **Electronic Typewriter** in **double spacing** in **A4 size** paper. All photographs should be of **140 X 85 mm.** Sketches and Graphs are to be neatly drawn on tracing paper with **25 mm** margin on all sides. Sketches, Graphs, Photographs (black & white) should be serially numbered with appropriate reference in the body of the paper.

Your early response on this matter will be much appreciated.

Regards,

-- **Editor**