A CASE STUDY OF STEEP PENSTOCK WELDING AT RAMMAM HYDEL PROJECT

By
Sujit Banerjee

TEXMACO Limited, Calcutta

A project was commissioned in September'95 for supplying much needed 50 MW power to Darjeeling area. But construction of the project appeared to be one of the most difficult of its kind. The site of the project was in a very remote place tucked into the picturesque hills of Darjeeling district which loom majestically on the sides overlooking Sikkim and Nepal. In particular major complexity was involved in the installation of steel Penstock lines. There in the welding of virtually vertical pipelines was a challenging job. The entire assignment of design, fabrication and erection of the penstock system (carried out by Texmaco of Calcutta) under the difficult site conditions, such as climate, location, and the time schedule, presented many interesting problems. This article reflects those problems encountered and similar future projects might benefit from this experience.

The scheduled time of completion of the Project was 8 years and by 1990 it was over due mainly due to various unpredictable reasons. The project authorities(WBSEB) were determined to complete the Penstock work latest by December'94. This virtually left a very tight time schedule. The task continued to be aggravated due to delay in importing of special steel for Penstock, delay in arranging steady power supply for field welding, delay in making access roads along a near-vertical drop of 517 metres in Penstock alignment etc. However, all these problems were handled systematically. The Penstock installation and the related welding were completed in time.

Salient Aspects of Penstock :

As for the brief description of the job, this two-laned Penstock was 1.31 metre diameter approximately, each one kilometer long, including Specials like complex bends, expansion joints, manholes and bifurcations and the total tonnage being 1300 MT.

The Penstock had a whopping hydrostatic drop for 520 metres, ranking as one of the highest in India. It was serving as pressure conduit for the water conductor systems between the turbine scroll case and the first open water from the turbine i.e. the fore bay reservoir. The steel plates were of boiler quality C-Mn-Si Steel, heat treated, used for pressure vessels and designated as plates, American specification ASTM A-537 Cl.I of thickness varying from 8mm to 28mm thick, with Specials having thickness 50mm maximum. Construction and welding of Penstock was done strictly in accordance with the ASME Boiler and Pressure Vessels Code, Section-VIII.

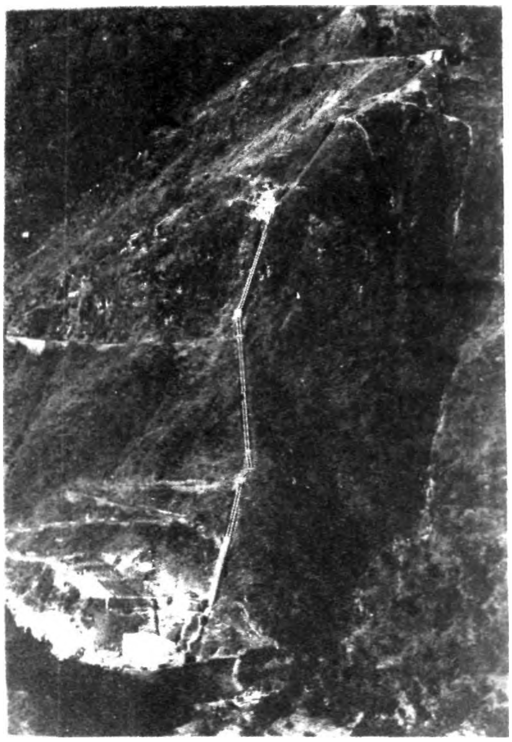

Fig 1 : A Bird's eye view of the profile for Rammam Penstock Lines

Unfired Pressure Vessels by ASME Code (USA) or equivalent IS Code viz. IS:2825.

TYPICAL PROBLEMS & REMEDIES

Hostile Climate for Welding :

Field welding consisted of the circumferential welding of Penstock moudles that were joined, piece by piece, in the aligned profile. The welding itself met many major setbacks due to prolong and frequent rains, landslides and severe cold in winter. Tight time schedule was maintain and the work continued with few recesses. The measures adopted to keep the work going were as follows :

All welding was done by state-of-art welding rectifier machines of multi-operator outlet. This welding system was of new generation high efficiency electronic controlled outfit. The solid state thyristorised circuits gave quality improvement in the face of cold climate. Gadgets for preventing electrode freezing and hot start facility enabled welders to defy adverse weather condition.

Each welder used remote control which was plugged in to the welding machine with 100 metre flexible copper cable for frequent current adjustments. Therefore overall contribution of such welding machines was substantial to the quality and progress of welding as a whole. Careful choice of electrodes was made under AWS Code E-7018-1 of iron powder low hydrogen type. Shielded manual metal arc welding process was used producing deposit metal of UTS 54 kg/sq.mm, YS 46 kg/sq.mm and CVN impact strength 5 kg M at minus 50°C. Products of only reputed manufacturers were used.

Baking of electrodes was given utmost importance to prevent hydrogen cracking in HAZ region of parent material. Apart from Cabinet type oven at site stores, all welders were equiped with portable type safe-voltaged electrode ovens. These kept the electrodes maintained at an oven temperature of 50-60oC before these rods actually struck the joint. The effect was commendable.

Portable steelframe over penstock pipe was provided during welding. This light structure held a canopy fatricated of sheet metal on top and the sides keeping away light rains.

Boosting welding progress in adversity :

In order to improve the Penstock erection time, every effort was made to expedite the major time-consuming cycle of work i.e. welding which was an extremely hard task.

Difficulties :

Firstly, the welding position in the steeply inclined profile itself posed a problem to expedite welding. Secondly, all field welding of seams was subject to 100% Radiographic Test rendering welding itself as of high quality. Originally the sepcification called for 10% test only. But in order to save time for the much time-consuming hydraulic pressure test of all individual pipes at Calcutta workshops, it was decided that random hydraulic test of the pipes for 10% total number would be done. Instead, finally, 100% radiographic test was done for all welded seams, irrespective of whether it was shop joints or field joints. This was done because the project authorities were in a hurry to transport and stack as many fabricated pipes as possible during the dry season in view of the fact that monsoon-damages to the hilly roads and the landslides would pose haz-

Fig 2 : Steep gradient of the Penstock ards. Such decision brought about all field girth joints as of best quality welding which was more time-consuming. It meant requirement of high quality electrodes and highly skilled certified-welders with experience in similar difficult terrain conditions.

Remedies :

Fortunately welding progress could be boosted up to desired speed inspite of the above odds mainly due to the following steps adopted :

i) All welders were hand-picked. They all worked previously in hill topography in North Eastern India in similar surface Penstocks. They were duly tested at Alipore National Test House for their qualification.

ii) Special care was taken to provide adequate scaffolds and access ladders to work freely and as well as to combat the working risk in steep slopes, apart from statutory safety belts. Mobility of welders was maintained unhindered as far as possible, to keep the flow of work going. Meals or even tea for individual welders were served at their work points by a gang of back-up force. Incentive scheme and overtime were implemented tactfully with supervisory vigil on quantity control. Quantity was encouraged but not at the cost of quality.

iii) Considerable welding time was reduced by coupling two pipes on flat position near the installation points and thus doing the welding at faster rate using conventional roller beds. These coupled pipes of double length was launched on rail track and hauled up or slided down to required erection point by power

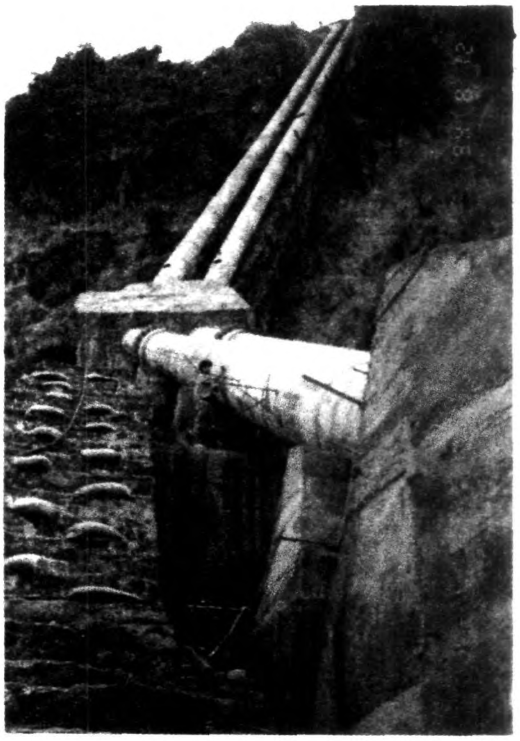

Fig 3 : Work access to Penstock welding

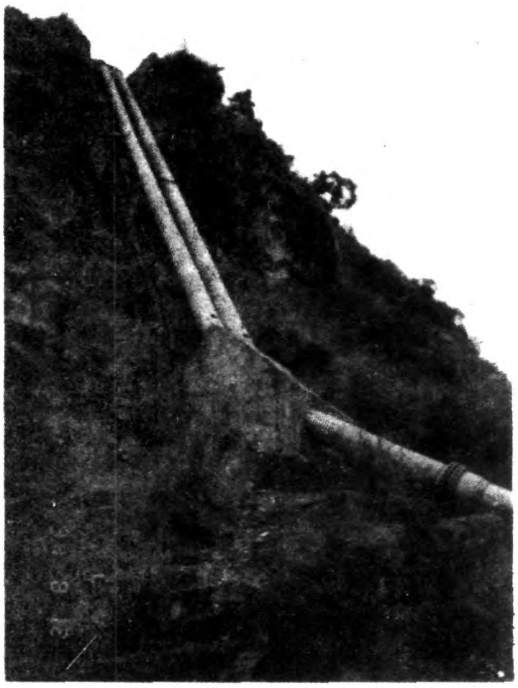

Fig 4 : A close picturesque view of an almost vertical drop of the pipelines

Winch. The combined effect of above measures was treamendous. It made welding completion at second time before the stipulated date enabling the concerned agency to bag a bonus payment from WBSEB under the cover of Crash programme.

Behaviour of Distortion & Control :

Over and above the design of the suitable weld joints, a substantial amount of distortion, during and after welding, came in the way of aligning the pipeline to its true profile. This was felt in major quantum when the penstock was at a steeper angel. The nature of distortion was studied and was found that (a) Transverse shrinkage and (b) Rotational distortion were occuring. Rotational distortion was especially very prominent and difficult to tackle because the gravitational pull of pipeline acted very feebly in steep slope and this made it difficult to restrain the distortion. Above distortion/shrinkages were inevitable during multipass welding. Proper precautions were adopted during welding to minimise above phenomena.

The circumference of welding seam was subdivided into 12 equal sectors and diagonal welding was performed by 2 welders at a time for the uniform distribution of thermal impact.

Joint design of welding grooves was revised from Single Vee to Double Vee type. This reduced the Transverse shrinkage substantially and brought down the amount or rotational distortion to the minimum.

Root opening was maintained strictly as per Drawing and was not allowed to exceed. It was found that the distortion increased where root gap exceeded and hence the trend was set in line with that, during the fitting of circumferencial joints.

Repetition of heat cycle in weld joints was kept at a minimum of that required. This meant that repetition of thermal gauging process or power grinding was discouraged. This called for less defect repairing of welding during radiography test. Fortunately the welding quality was maintained at splendid level and the defect repairing quantum was as low as 1.5%.

Adequate and strong fixtures were provided from all sides to the Penstock pipeline during welding. Upward movement was arrested by welding steel connectors to the reinforcements of then evenly spaced permanent concrete foundations below.