Construction of Special Wagon for Transporting Fuel to Power House

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Introduction

The process of joining metals by fusion welding is now one of the most important links in industries. In the power industry, welding plays a vital role, from the fabrication of steel structures for power houses to boilers, onto transmission towers and again in the construction of transport vehicles for fuel. Welding is found everywhere for joining metals.

Coal, the fuel for thermal power houses, is mostly transported in railway wagons, and most of these wagons are fully welded constructions.

Our factory is one of the largest wagon manufacturer in this country and has been supplying wagons to the Indian Railways and exporting them to several other countries, catering to the diverse range of traffic needs. Special wagons are made to meet specific requirements for transporting minerals, ores and fuel in their many forms. This paper deals with a specific case of design, construction and testing of wagon for merry-go- round railroad system.

Concept of Design

In keeping with the trend of setting up super thermal power plants near the coal mines, the concept of Merry-Go-Round (MGR) Wagon is introduced in the rail-road system of coal transportation from mine to plant.

The concept of coal transportation by rail was mainly to :-

- reduce the transportation time,
- reduce infrastructural requirements vis-a-vis conventional method,
- do away with or reduce dependency on the labyrinthine concept of conveyor system,
- reduce the maintenance cost,
- improve efficiency, and overall reliability and
- reduce burden on already overloaded tracks of the Indian Railways,

A close circuit track (about 400 KM) is laid between the coal loading point at the coal mine and unloading point at the power house. A rake normally of 20-30 wagons hauled by a Diesel Electric Locomotive has to perform 10-12 complete loading/unloading cycles in one day.

Design Factors

Loading of these wagons at the mine is done under an overhead surgebin provided with "Flood Loading" gates, while the rake is in motion at an approximate speed of 0.8 KMPH. And unloading at the power house end, over a 200 M long track hopper (unloading installation) while passing at a controlled speed of upto 8 KMPH. The unloading hopper track is equipped with Line Side Equipment (LSE) for activating wagon doors in groups of upto 15 wagons simultaneously.

The wagons are fitted with spring loaded current collectors at diagonal corners to pick up electrical signals from the LSE which actuates the electro-pneumatic control valves, for opening the bottom discharge doors for discharging coal from wagon to conveyor.

Construction

Welding has now become the principal method of joining materials used on the Indian Railways. Its use is extensive, not only as a repair and maintenance technology but also as the principal joining process in building and construction of rolling stock.

The MGR wagons are fully welded type. Normally three processes of welding, namely Submerged Arc (fully automatic), MAG (semi-automatic) and the Manual Metal

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Arc welding, are utilised. The running weld length, in terms of 5 mm fillet welds, is approx. 1500 M. The material used in the construction of the wagon is generally copper bearing mild steel conforming to IS-226, Fe 410 CUS. Most of the welding is designed for single pass 6 mm fillet. The joints are welded on both sides to reduce stress concentrations at the root of the fillet welds. Most of the welding is done in the down hand position by extensive use of welding positioners and manipulators and special adaptations for MAG machines. At the location of high stress special precautions are taken in the design and procedure. Weld terminations and corner intersections and cross welds, have scallops provided.

Sub-assemblies

It is important to visualise the assembly procedure. The fabricator should break up the weldment down to sub-assemblies, coordinating the following aspects to achieve overall cost savings :

- The sub-assemblies spread the work ; more men can work on the job simultaneously ; more space required ;
- The possibility of distortion or residual stresses in the finished weldment is reduced when the weldment is built up from sub-assemblies.
- Good fitup is obtained ; Poor fitup can be costly.
- A joint can be preset or prebent, to offset expected distortion.
- When possible, it is desirable to break the weldment into natural sections so that the welding of each section can be balanced about its own neutral axis.
- Welding the more flexible sections first, facilitates any straightening that might be required before final assembly.
- In-process inspection (before the job has progressed too far to rectify errors) is facilitated.

Jigs, Fixtures and Positioners

Use of jigs, fixtures and welding positioners facilitate in improving weld quality and decreasing fabrication time. In planning assemblies and sub-assemblies, the fabricator should decide if jigs are simply to aid in assembly and tacking or the entire welding operations are to be done in the jig. The considerations listed below are significant in deciding such issues :

- The jig must provide the rigidity necessary to hold the dimensions of the weldment and stresses due to distortion.
- It must provide easy location points, and be easy to load and unload.
- Camber can be built into the weldment, to control or counteract distortion or provide the desired camber where necessary in the finished job.
- Welding positioners maximise the welding output in the downhand position, allowing use of larger electrodes, and permit use of automatic/semi-automatic welding processes.

Underframe Centre Sill

The back-bone of practically all freight wagon is the under frame centre sill. It consists of two rolled 'Z' section placed toe to toe and welded along the edges of the two upper flanges. Submerged arc process is employed using 5 mm wire, and flux, conforming to AWS F6A2EM12K specification. During welding, the underside of the weld is backed up with either welding flux or a copper bar. The two 'Z' sections are placed in a fixture and manually clamped by a series of wedges, to maintain the inside dimension. A camber of about 20 mm is built in the fixture so that the sections are held at a camber during welding operations, Fig. 1 and Fig. 2.

Underframe

Other than the centre sill & side sills, the members of the underframe are the cross ridges, end ridges, bolsters and hopper arrangements. These items are all pre-fabricated and welded prior to fitment on the underframe to keep distortion to the bare minimum, which is very important, to achieve the stipulated test results of the wagon.

Assembly of the underframe is made on a fixture which is designed to hold the parts in alignment with emphasis on welding accessibility as well as the control of shrinkage and distortion. The sub-assemblies mentioned above are finally assembled on the underframe placed on a fixture, tack welded and the dimensions checked. Welding of the underframe is accomplished in three stages

I. On the fixture itself. Here the underframe is assembled on the fixture, top side in bottom position.

II. On the rotator/positioner. Here welds that normally cannot be done in the downhand position, on the fixtures these are completed in the 1G or 2F position. Positioners for welding the complete underframe assembly has contributed, over other factors, to the speed and quality of weldment.

III. On the Clamp down stage. The underframe is taken off the manupulator and put into the clamp down jig, the top side in top position. The rest of the welding of the underframe is completed.

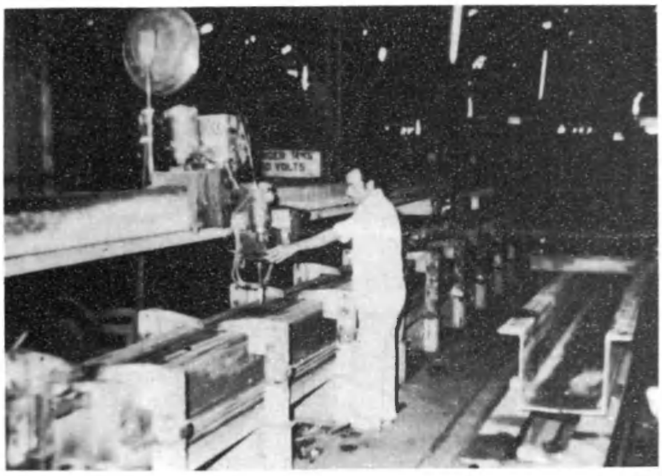

Fig. 1 *Welding of centre sill by submerged arc welding process.*

Fig. 2 *Close up view of welding of centre sill.*

The above stages have been designed so that all welding is accomplished in the downhand position, using E 6013, 4 & 5 mm electrodes, however at critical locations E 7018, low hydrogen electrodes are used. The welding procedure and fixture have been adopted to minimise distortion and residual stresses due to welding thermal cycle, to obtain a fairly true and dimensionally accurate end product. (Fig. 3)

Superstructure

Superstructure consists of body side and body end. Some components of superstructure are pre-fabricated and are assembled on a fixture-cum-minipulator and welded using MAG process. The wire feed unit of the MAG set are mounted on an overhead monorail and moves along as per

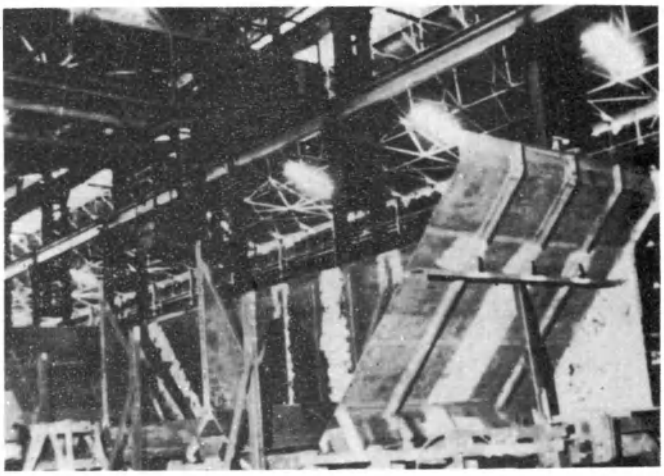

Fig. 3 *Assembly of cross ridges, ridges and ridge support on the underframe.*

Fig. 4 *Assembly of bodyside and bodyend on the underframe.*

the welders requirements. The general parameters for welding are - spray transfer mode; 200-300 amps current and 34-36 Volts; 20 mm Stickout; Arc travel speed of about 45 to 55 cm/min.; Gas mixture used is 80% Argon, 20% CO_2; Solid wire 1.2 mm diameter conforming to AWS ER 70-S6 specification is used. (Fig. 4).

The hopper doors, hopper arrangements are also fabricated as sub-assemblies on separate sub-assembly jigs.

The mojor sub-assemblies are, normally, assembled on a fixture. For convenience, one body side is assembled first and tack welded to the underframe. Then the two body ends are assembled one by one and tack welded to the

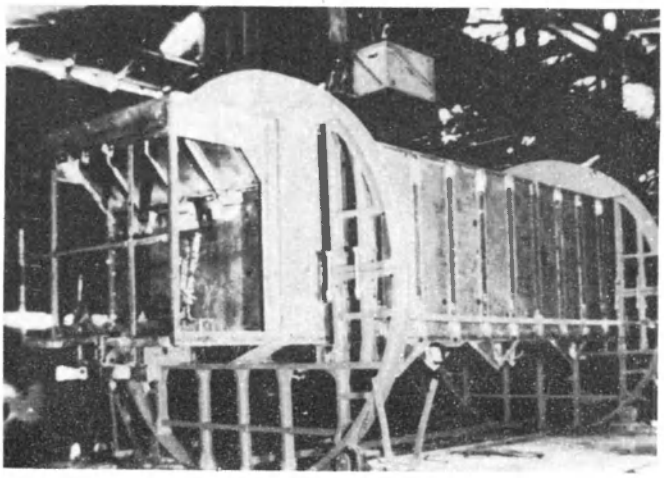

Fig. 5 *Wagon mounted on manipulator for welding after complete assembly.*

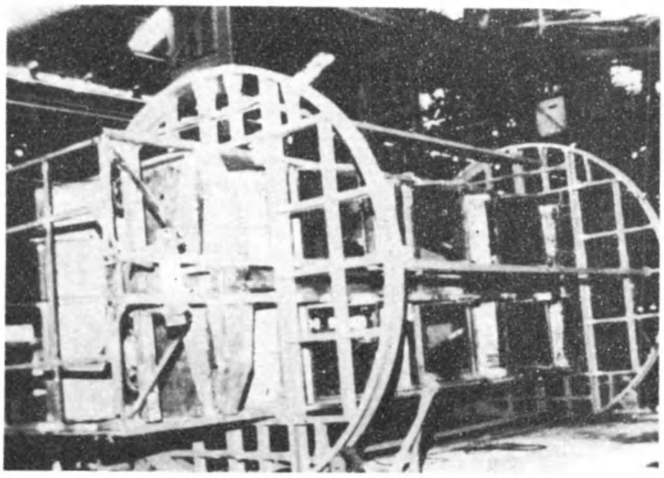

Fig. 6 *Another view of welding in progress on a manipulator.*

underframe and other corresponding members, finally the second body side is placed in position and tack welded to adjecent members (Fig. 5)

The assembled wagon, in tack welded condition, is mounted on rotator/manipulator, which is so designed as to act as a clamp down arrangement and prevents distortion while accommodating the shrinkage also. (Fig. 6).

Weld quality control

While welding, particular care is taken to maintain the proper sequence and the correct welding technique. Almost all the welding is done in the downhand position.

Welding specifications are followed to check continuously the conformity of all requirements on weldments. Production joint qualities are tested periodically. Visual examination and applicable instrumental tests are also carried out, e.g. tong test to control welding currents used by welders and keep check on the overall apparent weld quality. All critical dimensions are checked and documented after stage inspections and clearance accorded by the client nominated Inspectors.

The welding personnel and procedures are qualified and certified in accordance to applicable codes.

Some Salient Data

Height - 3.735 M : Length - 13.43 M : Hopper slope - 46^o, Pay load 60 + 2 tons ; Haulage capacity-85 tons ; Volumetric capacity-75 m^3 ; Normal speed-60 KMPH : Max. speed-75 KMPH ; Energising voltage-24-32 Volt ; DC(+) for door opening and DC(-) for door closing.

The wagon is fitted with graduable release air brake system conforming to the technical requirements as laid down in UIC : 540 and also with hand brake equipment.

Some of the special features are

- Complete discharge of wagon is to be achieved in less than 20 seconds ;
- Wagon superstructure and underframe shall be capable of holding loads upto 150% of the designed payload.
- Micro wave barrier plate are fitted on the wagon to indicate the exact position of the wagon at the unloading station.
- Visual indicators are also provided to indicate that doors are fully closed and securely locked.

Tests

Of the number of prescribed tests only a few are being mentioned, hereunder

1. *Deflection test*

The structural members are checked for deflection under static load during loading and unloading at cycles of 50%, 100%, 125% and 150% of the designed payload, without any permanent set. No permanent set or undue deflection was observed in these wagons.

2. *Door opening reliability test*

Doors are opened and closed 2000 times and should register no failure. This was achieved commendably.

3. *Load discharge test*

This is to be carried out under sta·ic condition for complete and quick discharge in less than 20 seconds. Build up of residual coal in successive loading and unloading must not exceed 500 Kgs.

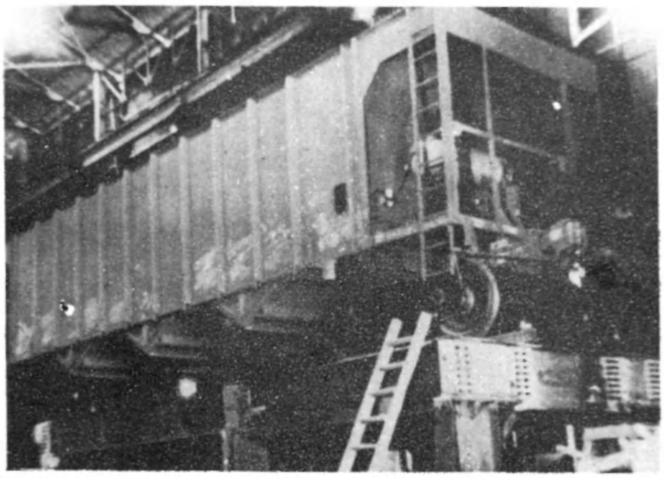

Fig. 7 *Wagon ready for Load Discharge Test.*

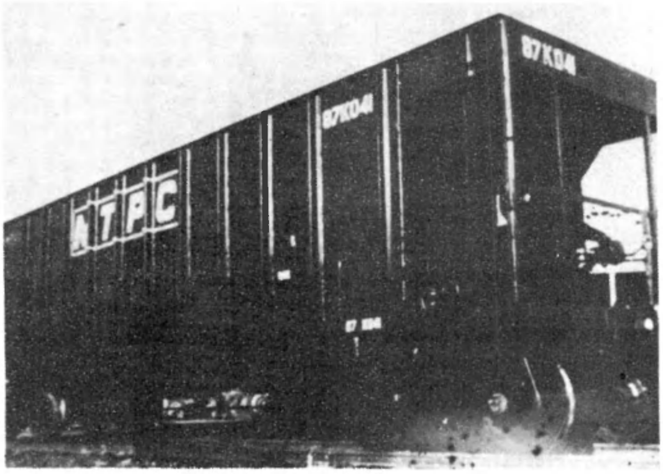

Fig. 8 *A complete wagon - ready for rolling out.*

Discharge time recorded during shop test were between 8 to 10 seconds. i.e. 60 to 80 tons of coal was discharged in less than 10 seconds.

Residual coal build up : This is the residue of coal inside the wagon not discharged during the normal course of discharge operation. The build up may be caused by, all or any of the following : improper slope, mismatch of components, unevenness of the side and end members, distortion of members due to incorrect welding sequence, and faulty welding technique.

During test the built up, registered was nil to negligible in all but one wagon which had a residual coal of 100 kgs. as against the 500 kgs. acceptable limit. Total coal in each wagon takes about 60 Tons. (Fig. 7).

4. *Speed control test*

The speed control was set on creep with a speed of 4 KMPH during test. Speed registered was almost constant with a maximum variation of 3.8 to 4.3 KMPH which is within acceptable limits.

Conclusion

This project was a challenging one in the sense that right from the concept of design and actual designing to fully welded fabrication maintaining the design dimensions and functional requirements, the MGR wagons were to stand certain specific guarantees against liquidated damages. Given below are a few examples . In actual service conditions, the performance of the wagons was found to be even better than the shop test observations and resulted in awarding a repeat order of 165 nos. of MGR wagons. worth Rs. 12 crores. (Fig 8).

Specific Guarantees	*Liquidated Damages*
Time for complete discharge including the time lag in actuating the door openning mechanism, shall not exceed 30 seconds under adverse coal flowsituations.	For every increase of 10 seconds or part thereof over 30 seconds - Rs. 1,72,000/-
Failure to operate door operating mechanism, shall not exceed 0.3%	For every increase of 0.10% of part thereof over 0.3%- Rs. 70,000/-
Coal residue or residue build up after discharge at any time under continuous operation shall not exceed 500 kgs.	For every 100 kgs. or part thereof over 500 kgs. - Rs. 34,000/-

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Editor.

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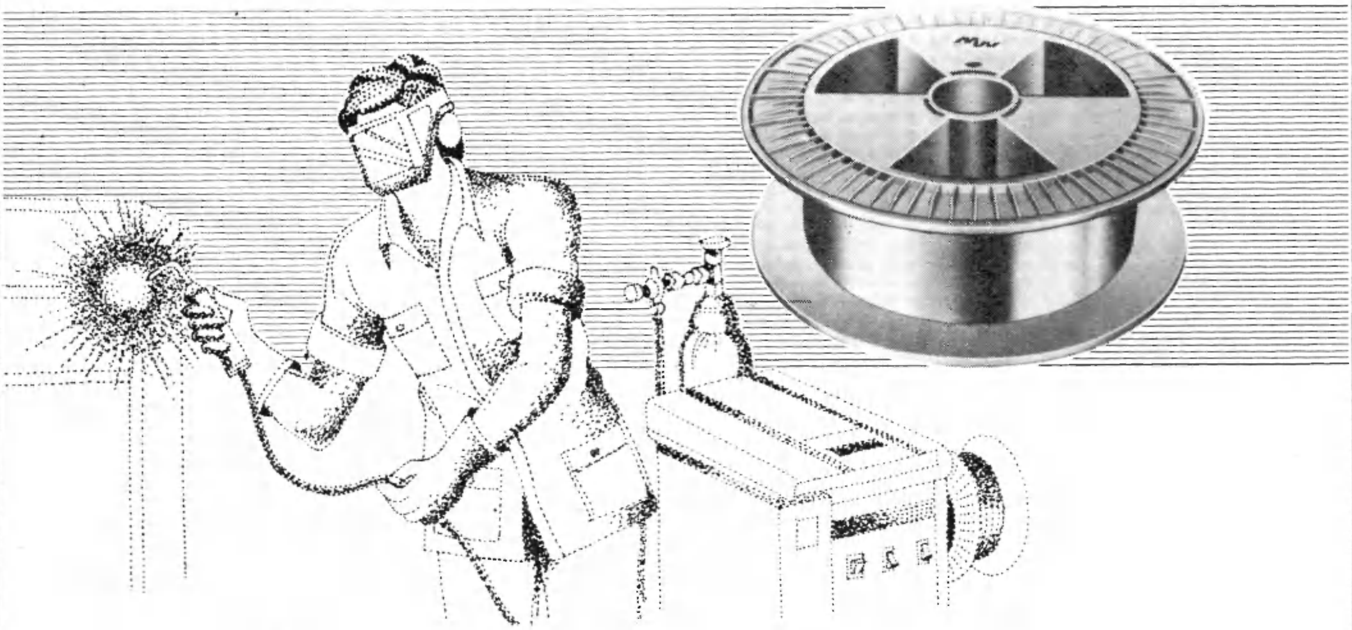

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