The Role of Welding Technology in the Maintenance of a Steel Plant — Its Management Aspect

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1. INTRODUCTION :

Maintenance in an integrated Steel Plant covers a wide range of complex activities on different technological processes and has multi-dimensional constituents of different disciplines of engineering. Welding technology is considered to be an important constituent. On a very conservative estimate, a steel plant may need approx. 3000 tons of fabricated structure per year for maintenance purpose. Over and above this, it may need 7000 tons of spares/components per annum for maintenance of the equipment in various production units as well as for services departments. This figure may vary with the size of the plant and also on other conditions such as availability of quality spares in time, maintenance system, development of indigenous spares etc. The above tonnage can again be divided into three distinct categories—plain carbon steel, high carbon steel/alloy steel, cast iron and non-ferrous materials. While the welding on plain carbon steel which covers mostly fabrication of structures, calls for mild steel electrodes, the requirement of weldments needed for the high carbon/alloy steel, cast iron and non-ferrous materials calls for special varieties of electrodes of varying specifications and matching orientation. Both the latter categories are required mostly for manufacture or reconditioning of critical spares and sub-assemblies. The following table shows the requirement of various electrodes for a particular steel plant.

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Table 1—Consumption pattern of welding rod.

Type	*Consumption in Kg.* 1975-76	1976-77	1977-78
Mild steel	56095	60595	64861
Special steel	3384	3676	3824
C.I. & Non-ferrous	945	1057	1126

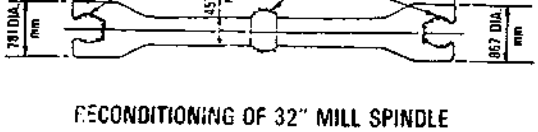
The above figures would enable one to assess the volume of consumption pattern of weldments as well as the multiplicity of the activities necessitated in the maintenance tasks of a steel plant. As regards variety of requirement one has to take a perspective look on the equipment starting from Coke Oven plant to the finishing end of the Steel Mill. The jobs brought under repair/re-conditioning programme may include—various structural fabrications, Mn-steel hammer, various alloy steel gears, shafts of various dimensions and compositions, furnace skids, pump bodies, mill spindles of various sizes—ranging from 1 tonne to 30 tonnes, fan impellers etc. etc. The above will just highlight the magnitude of welding required in quantity as well as in variety.

Reconditioning of spares is considered to be very important in steel plant maintenance. It may not be economical to throw away all the worn-out spares for disposal as scrap nor can we afford to scrap all these because of limited availability of spares in the country. There are numerous spares which can be reconditioned and recirculated for maintenance of the equipment. In Durgapur Steel Plant, this area has been organised and a saving of more than Rs. 60 lakhs per year has been achieved. More than fifty per cent of the jobs in reconditioning of spares is controlled by welding technology. In this connection, an example may be cited regarding tremendous success in reconditioning. By way of reconditioning of Mn-steel hammers for the Cokeoven Hammer Mill, the plant has achieved an economics of approximately Rs. 40,000 per month and the credit goes entirely to welding technology.

2. WELDING—ITS QUANTIFICATION IN RELATION TO MAINTENANCE ACTIVITY:

Techno-economic consideration is the key-note for deciding the degree of importance with which a particular dimension has to be dealt with by the management. Welding activities in the steel plant is no exception and follows the same principle. In a running equipment, any minor crack, looseness of any moving item or defect in the fastening system is always temporarily managed by tack-welding and this enables to run the equipment for a particular period till the same is available for complete repair or replacement work. Technically, this type of stop-gap arrangement may not be sound practice but if we consider the economic point along with technical activity it is always beneficial because of noninterruption in the production. The decision of taking down the equipment for repair or to run it in the above way is always based on the experience of the maintenance engineer. In this system, some risk is always involved and one should not cross the limit lest it may damage other parts of the equipment or cause accident, thereby involving heavy expenditure and time.

The picture is completely different in the Repair Shop where welding activity is directed to the dismantled parts. Here welding technology can be successfully applied under controlled atmosphere and without any technological violation. Two examples are cited to clarify the technoeconomic concept which has been achieved in a steel plant.



RECONDITIONING OF 32" MILL SPINDLE

Fig. 1

Example-I.

Fig-1 shows a worn-out mill spindle repaired by welding method. The extent of repair has been to build up the wornout surface at palm ends and the spherical seating portion.

Technical & Financial details are as under :—

Carbon equivalent	...	.63%
Thickness of deposition	...	18/20 mm
Thickness of base metal	...	188 mm
Preheat temperature	...	300°C
Electrode required	...	Cr/Ni/Mo (22/11/3) austenitic types

Welding time ... 33 shifts of continuous welding by three welders in relay.

Post weld treatment ... 550° soaked for 8 hrs. and furnace cooled (Heating rate 50°C/hr.)

Machining time ...218 machine hours at 64% activity level (inclusive of preparation).

In the above work the benefits have been obtained which is clear from the following ratio achieved.

$$\text{Ratio of } \frac{\text{Cost of repair}}{\text{Cost of new spindle}} \ldots \ 1:8.6$$

$$\text{Ratio of } \frac{\text{Time reqd. for repair}}{\text{Time reqd. to procure new spindle}} \ldots 1:6$$

Example—II :

In the steel plant, a fleet of special rolling stock is always maintained. This includes the rolling stocks required for movement of ingots and charging boxes. The fleet size may vary from plant to plant. The requirement of wheels for these rolling stocks may be in the range of 1500 nos. or more. Because of continuous use for production work, substantial wear takes place on the wheels resulting in derailment of these cars. It is always necessary to take timely action to replace or repair these wheels by welding technology. Cost factor has to be considered while taking the decision for complete replacement. We have found that the cost of reconditioning the wheels is always economical until there is some major defect in the wheel. The ratio of reconditioning cost to the cost of new wheels is approximately 1 : 9. Considering this aspect, a guideline has been formulated to replace only 10% of the defective wheels which have other major defects than simple wear out and to recondition the rest of the worn-out wheels by welding.

For further understanding of the techno-economic aspect of reconditioning of spares through welding process, if we analyse the available data of some 251 varieties of spares reconditioned through welding technology during 12 months period in Durgapur Steel Plant we get an average value of 1 : 6 towards ratio of reconditioning cost : new cost.

Reconditioning expenditure can again be broken down to different constituents e.g. cost of welding, cost of finishing and the cost of overhead. On proper analysis, it could be seen that the average cost of welding consumables inclusive of electricity cost constitutes approx. one-fourth of the total reconditioning cost.

Table—2 below shows the %age distribution of welding cost in a steel plant between various cost centres and its relation with cost of maintenance.

Table 2 : Distribution of Welding Cost.

Cost Centre	*%age of welding cost over total welding cost*			*%age of welding cost over maint. cost.*
	At site	*In repair shop*	*Total*	
Coke Oven	4.30	12.73	17.63	0.89
Blast Furnace	8.05	11.64	19.69	1.27
SMS	5.88	17.75	23.63	5.32
Rolling Mills	22.50	9.70	32.20	1.38
Services & Misc	3.92	3.53	7.45	0.316

The impact of welding technology on the total activity of maintenance including its financial aspects has been discussed. It is revealed from Table—2 that while 55.35% of welding activity is being carried out in repair shop where facilities do exist, the remaining 44.65% of the activity is being carried out in different areas of plant in different working conditions. One more fact is that a good percentage of the welding work of field activity is being done in odd hours of shifts by shift engineers whose foremost responsibility is to race against time and hand over the equipment to operations departments.

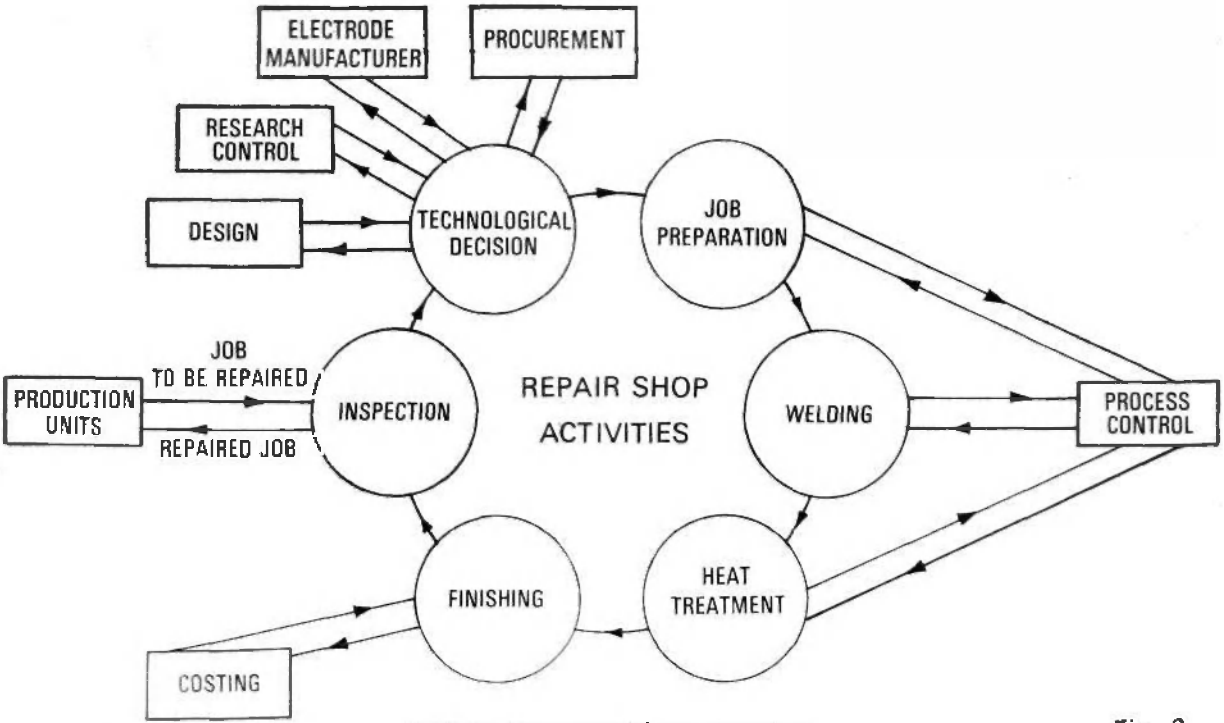
Such is the complex situation in the welding activity of a steel plant for which a manager has to give enough of thought.

3. AREA OF CONCENTRATION :

It is the repair shop of a steel plant which is engaged in carrying out over 50% of the total welding activity and hence this is the area where management is required to put maximum thrust for cultivating the growth of this technology in all its facets. From the flow diagram for all the activity as shown in Fig. 2 it may be seen that, at the technological decision stage, maximum interaction is taking place involving five different agencies including the management of repair shop. Though the objective is common, the way these five agencies would view the job may not necessarily be the same for the simple reason that the "thought sphere" of each of the persons is of varying dimension and is very much influenced by his own sphere of work. Procurement management will have to take care of all the formalities for purchase of materials, electrode manufacturer will naturally be interested to push their electrodes for carrying out the welding jobs, research organisation will try to take all the technical parameters into consideration, design manager will find out the ultimate strength so that there is no failure when the welded job will be put to use whereas the repair shop management will be under heavy pressure from the production unit for early delivery of the job. Difference of opinion crops up and it is the repair shop manager, who is required to act as an active co-ordinator and deliver the finished job by squeezing out the necessary help from all these agencies. This integration of opinions is considered to be a very important management activity in the decision making process.

Having decided the technological steps to be taken in repair of the job, the implementation portion is planned and executed by the repair shop manager. Here also he will have to integrate the actions of different personalities—line supervisor, fitter, electrician, machinist, turner, furnace operator, helper and the most important person, the welder, who may be considered as the real artist for doing the job.

The above are the outlines for doing the welding jobs in the repair shop of a steel plant. Of course, the different processes remaining streamlined, these steps are taken in a routine manner and most of the jobs are executed without any hindrance. Only in cases of critical heavy repair task all the concerned agencies are



ACTIVITY ANALYSIS/FLOW DIAGRAM

Fig. 2

required to be brought together to have their confluent actions on the planning and execution of the welding jobs.

4. CONTROL AND WELD JOINT TESTS :

Defective welds may be caused due to unsatisfactory base metal, improper electrodes, poor workmanship or wrong welding procedure. In the steel plants, welders engaged, by and large, have good experience and have worked in the plant over a period of time. Selection of electrodes are also made on the basis of the experience and in consultation with the electrode manufacturers. The procedures for general purpose welding on the shop floor are more or less streamlined. The major reasons for poor welding have been found to be unsatisfactory preparation of the base metal and sometimes wrong procedure. For example, when welding is being carried out on the shop floor without dismantling the parts to be welded, sufficient precautions are required to be taken. But if the job volume is small this is sometimes left to the less skilled welders and continuous welding is being carried out instead of back step welding or welding is done without proper preparation of the base metal. As a result, failure of such welding does happen.

But when welding is carried out in the repair shop, management becomes easy and all the necessary controls are being exercised under proper supervision. In the repair shop, both manual welding and automatic welding are carried out.

So far as weld-joint tests are concerned, generally visual inspection of the joints after necessary cleaning is being carried out both in the shop floor as well as in the repair shop, until special attention becomes necessary when pressure testing, magnaflux tests or radiographic tests are carried out. The latter two processes are generally conducted on shell welding, mill spindle welding etc. pressure testing of heat exchangers, storage tank and furnace doors after fabrication of the same in the shop has yielded good result.

6. SOME SALIENT MANAGEMENT STEPS :

6.1 Cost Aspect

The costs of individual welding works are generally not assessed in steel plant maintenance. The welding cost is a part and parcel of the total maintenance cost and it is always reflected in the cost sheet for maintenance. This is true both for welding works carried out in different production units as well as for the works executed in the repair shop. This does not mean that this aspect is overlooked. The cost consciousness is generated through the use of correct electrodes and in economic quantity where control on the total consumption is exercised. The steps to economise the total cost in preparation of base metal, in setting up of jigs and fixtures, finishing etc. are of paramount importance and positive steps in this dimension are adopted. On the other hand, while assessing the total cost of welding, the down-time cost of the production unit for breakdown on the equipment must also be taken into consideration. For example, one hour down-time in any mill may cost the management to the tune of Rs. 10,000 - or more. A balance between the two is therefore necessary and the decision-making is always based on all the above factors mentioned.

For heavy and special works done in the repair shop, the cost aspect is throughly checked and all the data generated on the shop floor regarding material, labour etc. may be sent to the Cost Section for having a feed back on the total cost involved in the work. This is necessary for keeping a total control on the welding works vis-a-vis cost of new spare.

6.2 Safety

Safety of men and equipment is one of the management functions. The welding work is definitely a hazardous job and safety measures are required to be taken with respect to electrical connections, equipment, accessories and finally the personnel involved in the work. Proper insulation of the electrical wires, effective earthing system, maintenance of the welding torch (for gas welding), good welding screen, protective appliances for the welders etc. are absolutely necessary to having a safe welding work. Steel plant with all the existing hazards is itself considered to be a dangerous place and the welding work especially on site unless properly supervised is liable to be carried out by following unsafe practices. It is not uncommon that the welding machine is kept far away from the working place, not visible from the welding site and the connections are made with cables which may be in a dilapidated condition. This can result in an accident. Cable connections and earthing system should be checked before operation of the equipment by the welders for execution of the job.

6.3 Training

The object of imparting training to the welders and welding supervisors is to make them conscious about the improved methods for execution and control of welding technology needed for steel plant maintenance. Training has to be planned with definite objective—objective which can contribute to improved working with necessary knowledge in metallurgy required in this technology. The composition of base metal, its preparation, selection of electrodes, necessity for heat treatment and the method of welding should be the major items and, along with these, other related matters can also be taken care of. Classroom activities in identification and implementation must percolate down to the shop floor so that we can achieve the desired success. In the steel plants, these factors are considered and the personnel engaged on the jobs are being sent to attend different training programmes arranged by plants' training Institute or by electrode manufacturers.

6.4 Documentation

The managerial functions of planning, making decision and evaluation of welding technique can only be discharged efficiently if proper documentation or paper work is designed and effective communication system is enforced. An integrated steel plant having welding activities scattered through a varied nature of production and service units needs a well designed communication system to enforce a standard system in welding as well as to select the right electrode for the right job. Documentation or paper work is also necessary to assess the total number of welding equipment required by the plant, to take central action for repair of equipment and accessories and to formulate a replacement policy for these. Until this is done, the total need will be haphazardly controlled resulting in defective equipment or shortage of machines at the time of actual need. It is not uncommon when defective machine remains at site for a considerable period without any proper action taken to repair it or heavy demurrage is incurred due to unnecessary delay in returning empty gas cylinders. This inefficiency can only be averted if recording and communication systems are enforced. Paper work is also necessary to control the consumption of electrodes, to generate the data bank for different welding techniques adopted for special repair works and to have a complete control on the welding works in the plant.

6.5 Standardisation

The vastness of the steel plant and the mutlidimensional maintenance activities involve welding works on variety of equipment and spares of varied composition and in different locations. This may necessitate use of a variety of welding equipment, accessories and protective appliances. To have a proper control on the use and consumption of these, it is absolutely necessary to adopt positive steps in variety reduction so that procurement, storage, ultimate use and finally cost control become effective. This is an area where standardisation can play a vital role. This method may be adopted in the following areas

(i) Standardisation of welding equipment and accessories.
(ii) Standardisation of electrodes.
(iii) Standardisation of welding procedure.
(iv) Standardisation of inspection method.
(iv) Standardisation of inspection method, and
(v) Standardisation of paper work, training etc.

This aspect should be centrally controlled and communicated to various agencies so that no dfficulties are experienced for implementation by the working welding team at various sites of the plant. Before formulating inplant standards, it is necessary that the central agency studies the various aspects of welding technology carried in different maintenance activities. To have complete success in standardisation in all the steel plants, it will be beneficial if actions are taken to form interplant standardisation group for studying and formulating policies to be followed by all steel plants. The infrastructure laid down by Indian Standards Institution may serve as a guideline for this activity. It is needless to emphasize that standardisation of all the constituents involved in welding technology not only facilitates smooth and effective welding operations but also enforces an effective system in cost control.

7. ORGANISATION :

Organisation is the framework within which the responsibility is discharged. Is it possible to design a separate organisational structure in a steel plant for carrying out welding activities? The answer is 'No'. It is an integral part of maintenance management and the job is carried out by the field welders under supervision of maintenance engineer supervisor of the respective units. The welding of plain carbon steel needed in structural works generally does not pose any problem because the experienced welders on the shop-floor are capable enough to do this welding independently and no strict supervision or control may be required. But for specialised welding, provision of a specialist in the total organisation is felt absolutely necessary. The role of this specialist, his functional responsibilities and his relationship with the line supervisors must be well defined. Until this is done, there may be dual control on the same job resulting in confusion, conflict and delay in the work. The specialist, who may be attached to the Engineering Shop of the steel plant, where bulk welding works as well as specialised works are carried out, may not be aware of the practical difficulties in everyday working of different units of the plant. On the other hand, line managers sometimes may have apathy to accept the specialist version either because of the pressure for running the equipment or from psychological complex.

This specialist from the Engineering Shops can help the different maintenance units in carrying out difficult welding work where strict technological control becomes necessary. But even then, occasions do arise where outside help, specially from the electrode manufacturers, becomes necessary. In our plant, we have carried out a number of difficult welding works with the help of specialists from the manufacturers, who have helped us in supplying the detailed procedure to be adopted and also arranged for close supervision round the clock to have a complete control on the performance.

8. CONCLUSION :

We have discussed about the management aspect of welding technology required for the maintenance of a steel plant. There cannot be any second opinion that welding is a complicated science dealing with the intricacies of metal and metallurgy with all its accompanying constituents. But until we assert ourselves for the actual application of the science in the plant, it is not possible to obtain the desired benefit. On the other hand, it is also practically impossible to have the implementation of this technology purely on the scientific recommendations. In the crudest terms of business, a number of field welders engaged in the activity of welding are perhaps not aware of the scientific thought and approach that is needed for these works. Here lies the total crux of the problem. The management task that lies ahead of us is to get the job done in the nearest-to-ideal way through our maintenance crew, that is, the field welder at the shop floor. How shall we go about it? It is not welding technology that comes as a bottleneck—to that extent, a technology perhaps can be prepared in an office with proper support from the back room scientists of the concerned industry and, if needed, with proper inter-action with welding consumables manufacturers—but the important point that remains to be sorted out is the actual interpretation of the technology through shop-floor welding staff. At this point, the most important part has to be played by the maintenance engineer himself, be it manufacture of a product or repair of an equipment by means of welding process with proper amalgamation of technology and management.

Many a time, welding technology is applied in maintenance management as a substitute to good maintenance because of shortfall in quality spares or defect on the part of a subassembly. To cite an example, we may state that it is not uncommon that welding is done to fix a loose nut on the bolt or gas cutting is resorted to enlarge a hole just to manipulate the entry of a bolt. This welding and cutting technology, although not a sound practice, may sometimes become necessary on the shop-floor just to keep the production going and to take care of the shortcomings on the spares or other mechanical conditions of the equipment. However when this practice is indiscriminately done on the shop-floor the 'welding & cutting' manager may become the greatest enemy to maintenance management causing huge loss of money in the way of premature replacement of the parts and sub-assemblies.

As a maintenance engineer responsible for the management of welding technology, one has to take positive steps to see that each individual, that is, the back-room technologist, the shop supervisor, and the welder are baptised in his own sphere through a process of evolution. This is possible through specially prepared training programmes suiting the adaptability of each category of people, through organised seminars, shop-floor talks/demonstration etc. It is not an easy task but we can say that this is neither an impossible one. We know that in the steel plant, all practising engineers are in fact doing all these exercises but things can be improved upon further from the management point of view if a structured approach is adopted through a proper forum.

To conclude,—In an advertisement of an adhesive it has been claimed that "It can join everything except the broken heart." Welding technology if properly managed, can join the broken heart of an equipment, revitalise its nerves and limbs and the heart beat of the equipment may start throbbing again with full vigour and thereby help production to continue. This is the objective we want to achieve.