Welding of Non Ferrous Metals - Indian Perspective

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ABSTRACT

India's non-ferrous Welding industry, mainly consisting of Aluminium, Copper, Nickel, and Titanium, has travelled a long way from where it was a decade ago. In the next decade i.e. towards the end of 2020, the industry is expected to see a dramatic turnaround with lots of expansion plans running at full capacity. Hence it is a challenge for welding industry to cope up with the demand and technology. Also the consumption of the welding consumables as well as welding equipment will be in line with the demand. This article scope limits to review in general welding of Aluminium, Copper, Titanium, Nickel and its alloys with reference to the present scenario and road map.

INTRODUCTION

Metals and alloys form are the basic raw materials for the development of light and heavy engineering industries in any country. The measure of their growth is a yardstick of the country's general progress in terms of modern civilization. Metals and alloys are broadly classified in two broad groups, viz. ferrous and nonferrous. Among all numerous non-ferrous metals, the few most important are Aluminium (Al), Copper (Cu), Nickel (Ni), Lead (Pb), Zinc (Zn), Tin (Sn), Manganese (Mn) and Magnesium (Mg) to which is now added the wonder metal – Titanium (Ti) [1]. These metals supplemented by their alloys form the chief backbone of non-ferrous metal trade and industry. From the list of above metals Zn, Mn, Sn are used for making alloys and not as a major elements.

WHAT IS NON-FERROUS METAL?

The term non-ferrous is used to indicate metals, other than iron and its alloys, that do not contain an appreciable amount of iron or rather non-ferrous metals are metals that do not contain high amounts of iron, (**Fig.1**). For example Aluminium, Brass, Copper, Magnesium, Nickel, Tin, Zinc and Titanium are Non-Ferrous Metals. One can also get non-ferrous metals as alloys, e.g. Brass is an alloy of copper and zinc.

Nonferrous metals are specified for structural applications requiring reduced weight, higher strength, nonmagnetic properties, or resistance to chemical and atmospheric corrosion. They are also specified for electrical and electronic applications. Copper and its alloys (brasses and bronzes) are available in rod, plate, strip, sheet, tube shapes, forgings, wire, and castings. Zinc, a crystalline metal with moderate strength and ductility, is seldom used alone except as a coating. Zinc is

The Indian metals industry has to main segments

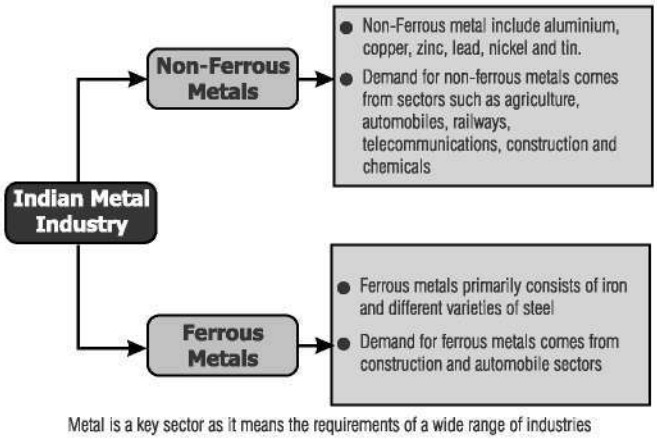

Fig. 1 : Ferrous and Non-ferrous

also used to make brass, bronze, and die-casting alloys in plate, strip, and coil; foundry alloys; super plastic zinc; and activators and stabilizers for plastics.

NON FERROUS METALS- INDIAN PERSPECTIVE:

For welding industry development and growth is depending on the availability of cheaper and quality materials, Consumables, Equipments and Infrastructures. As far as raw material is concerned, our country is heading towards becoming a global player in nonferrous metal industry with most of production plants would be tapping potentials in the foreign markets. Currently, India is exporting huge quantity of Aluminium, while a substantial share of its Copper consumption is being import today. The country not only lacks Copper concentrate reserves but also the existing reserves did not find fit for mineable reserves category. India is considered to be the fifth largest producer of aluminium in the world. Aluminium is one of the few metals that extensively affect the ordinary life of human beings. India has huge deposits of natural resources in the form of minerals and metals like Copper, Chromite, Iron ore, Manganese, Bauxite and gold. The Indian Aluminium industry falls under the category of non-iron-based, which also includes the production of Copper, Tin, Brass, Lead, Zinc, and Manganese.

Aluminium is one of the leading industries in the Indian economy. Its growth can be sustained by the diversification and exploration of new horizons for the industry. Its consumption as on 2005 and in 2030 in Global prospective is being shown in **Fig.2.**

India has to rely on import of Copper concentrates to feed its smelters. Therefore, international prices would hold the key not only to future expansion projects but also sustenance of existing capacity. During the last decade, production capacity for refined metals has increased almost meeting the demand for refined copper. In 2010, India's Copper capacity has touched 9 lakh tpa, thanks to both Brownfield and Greenfield expansions (**Fig.3**).

The domestic zinc industry is now completely under the private sector and is in the midst of a serious expansion programme. By 2015, India is expected to attain complete self sufficiency in meeting its Zinc demand. India would require zinc capacity of 14 lakh tpa by 2020, in order to be self-reliant.

The comparison above shows that share of India in Aluminium consumption will rise from 3% to 8%, in 2030. India also ranks 6th in Copper Consumption globally, (**Fig.4**).

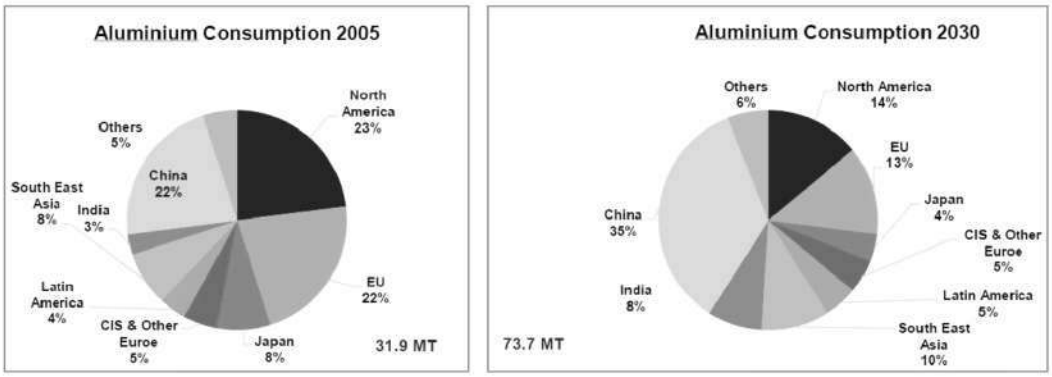

Fig2. : Consumption of Aluminium 2005 & 2030 (2)

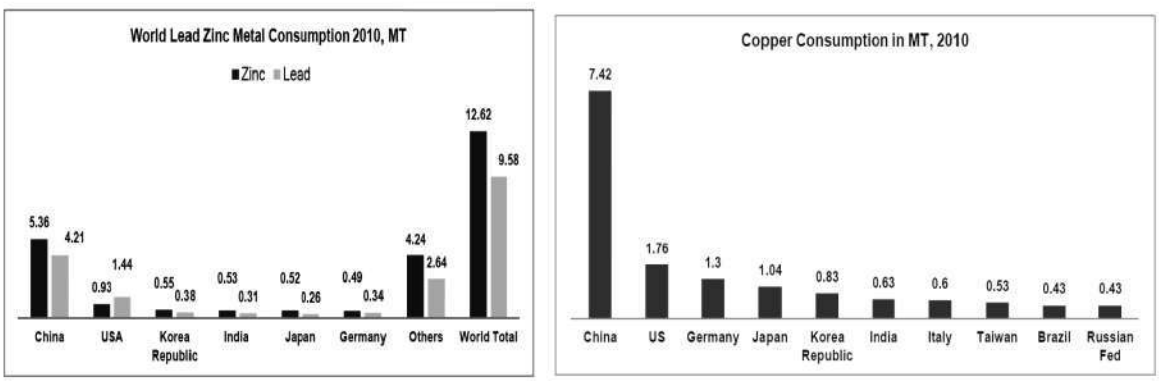

Fig. 3 : Global Copper, Zinc & Lead Consumption 2010 [3]

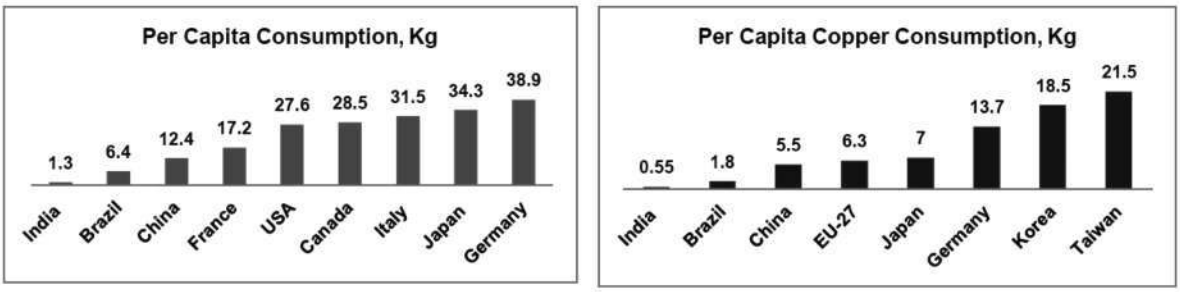

Fig 4. : Per Capita Aluminium & Copper Consumption in Kg

The SWOT analysis of Indian Non-ferrous Metal Industry is given in **Fig 5.**

Strengths	Weakness
• Abundant Bauxite, Zinc Reserves • Low Labaour Cost • Possession of Captive Coal Blocks • Globalized Industry • Modern new plants because of recent capacity addition	• Labour Laws • Land Acquisition and Environmental Issues • Limited known reserves of Copper • High Cost of energy • Technology wise still dependent on technology Imports for Aluminium, Steel
Opportunities	**Threats**
• Rapid Urbanization • Increasing demand for consumer durables • Untapped rural demand • Foreign Metal producers eyeing India for Strategic alliances and Joint Ventures	• Market fluctuations and China's Export possibilities • Global economic slowdown • Environmental concerns • Resource Nationalization • Technology wise still dependent on technology Imports for Aluminium, Steel

Fig.5 : SWOT Analysis of Indian Non Ferrous Metal Industry [4]

Nickel as a metal (90%), Titanium, Magnesium and their alloys not produce in India has to depend on Import.

WELDING FOR NON-FERROUS WELDING METALS/ALLOYS:

The non-ferrous metals and their various alloys today form one of the most important groups of materials available to the discerning engineers. Although the output of iron and steel far exceeds the total tonnage of the non-ferrous metals, their true value can be assessed by reference to the special wide range of properties presented. Their cost most often is more than that of mild steel or cast iron, but their special characteristics make their choice obvious and economic. It is, therefore, quite natural that in the present day, welding of these non-ferrous metals should engage the attention of the engineers. It may be stated at the outset that almost all non -ferrous metals and alloys are weldable by one process or another. The word "Weldability", which is very often used in practice, can be defined as "the capacity of a metal to be welded under fabrication conditions imposed into a specific, suitably designed structure and to perform satisfactorily in the intended servic". Although this definition is quite expressive, it cannot be evaluated quantitatively and can only be expressed as a personal opinion. The process normally used for welding the non-ferrous metals can be broadly divided into two groups - fusion processes and pressure processes. The fusion processes are inert-gas shielded arc welding (TIG & MIG), Laser welding, FCW, Electron Beam Welding, Metallic arc welding, Carbon arc welding and atomic hydrogen welding.

The pressure processes are: Spot, Seam, Butt and Flash

welding (all being resistance welding processes), manual forge welding and pressure welding. Recently the Friction Stir welding is being used extensively for Aluminium welding. However, its usage is now limited to joining of straight plates only. The process is still under development. The essential difference between the fusion and pressure welding is that in the former the weld is made by melting the parent metal with or without the addition of extra metal and allowing the metal to solidify, while in the latter the joining is effected by pressure without fusing the metal, but this desirable aim is not always realized in practice and some melting may take place. It will not be out of place to refer here to brazing processes which are considerably employed in the fabrication of Aluminium and certain of its alloys, Copper and its alloys, Nickel and its alloys, and some precious metals using appropriate brazing filler rods.

The choice of the process and technique of welding non-ferrous metals is governed to a large extent by their physical, mechanical, chemical and metallurgical properties [5]. They are;

1. Physical - Melting point, specific and latent heats, conductivity, coefficient of expansion, change in volume on freezing (effect of alloying constituents on the physical properties).
2. Mechanical – tensile and impact properties and the changes effected by the variation of temperature.
3. Chemical, including physico-chemical properties - Oxidation and gas solubility.
4. Metallurgical properties - Cast metal, wrought products, heat-treated alloys and effect of heat on the parent metal.

In this brief resume it is not possible to detail the procedures of welding all the nonferrous metals and alloys.

The scope of this paper limit to review the welding scenario, the welding process is not touch upon.

ALUMINIUM AND ITS ALLOYS:

Aluminium and its alloys, because of their low specific gravity, high conductivity, good resistance to corrosion and other characteristics as required for various sectors such as transportation, packaging, building / construction and electricity, chemical plants and food processing equipment. Certain aluminium magnesium alloys for marine work, high strength heat-treated alloys for aircrafts, etc. Aluminium is used in, while in India the power sector consumes most followed by automotive and housing sectors. The sector wise consumption break-up as follows: Electrical-64%, Transport-18%, Packaging-4%, Industrial machinery-3%, Consumer durables-3%, and Steel sweetening, Power and Chemicals - 11%. Globally, Automotive, Packaging and Construction sectors are the major end users of Aluminium are being used increasingly for fabrication purposes. Some applications in automotive industry is shown in the **Fig.6**.

Broadly, for welding purposes aluminium and its alloys can be classified into two main groups, i.e. non-heat-treatable and heat treatable. The chief characteristics influencing the weldability of aluminium and its alloys are their (i) low melting point (there is no visible colour change on heating), (ii) high specific heat, (iii) high electrical and thermal conductivity, (iv) hot-shortness, (v) high thermal expansion and contraction, (vi) readily surface oxidation at all temperatures, (vii) capacity to absorb hydrogen in molten and solid state, and lastly (viii) the effect of welding on their properties, especially in the case of heat-treated alloys.

Aluminium alloys are mainly welded using GMAW and GTAW processes [6]. The use of SMAW process is very restricted. For

Fig.6 : Some automotive components in Aluminium that have been repaired by welding

welding Aluminium Alloys a wide range of filler metals exists. Wires and rods for GMAW and GTAW are classified in AWS A5.10 and EN ISO 18273; coated electrodes for SMAW are classified in AWS A5.3. The choice of filler metals depends on the alloy to be welded. The standards give the guidelines; see for example AWS A5.10 Table A1. In AWSA5.10 also requirements for the soundness are given. When welding Aluminium alloys the weld seam is more sensible to failures compared to steel welds. Main used filler metals used to weld aluminium constructions are: ER4043, ER5183 and Er5356.

NICKEL AND ITS ALLOYS:

Nickel and its alloys due their physical and chemical properties have become most versatile materials. They are used for high temperature corrosion resistance. High quality joints are readily produced in Nickel alloys by commonly used welding process. Some of the characteristics of nickel alloys results in somewhat different techniques than used for other materials, but difference is not increasing the difficulty of welding. The choice of welding process depends upon thickness, design of the equipment, joint design and service conditions In India ~30% of Nickel alloy filler metals are used for joining and balance 70% are used for overlay or repair applications, (**Fig.7**). Unfortunately in India these most of these consumables and the materials are not produced and we have to depend on import of the same.

COPPER & ITS ALLOYS:

Copper and its alloys have a face centered lattice structure that accounts for its good formability and malleability. Copper being resistance to oxidation Fresh and Salt water, Alkaline solutions and many Organic chemical. This good corrosion resistance makes Copper alloys ideally suited for Water Tubing, Valves, Fittings, Chemical equipment and bearings **(Fig.8 & 9)** [7 & 8]. Copper and most copper alloys can be joined by welding, brazing and soldering. The most outstanding characteristics governing the weldability of copper are its high thermal conductivity, High thermal expansion, Hot-shortness, High fluidity when molten, Reaction with oxygen at high temperature, and Capacity to dissolve hydrogen at high temperature.

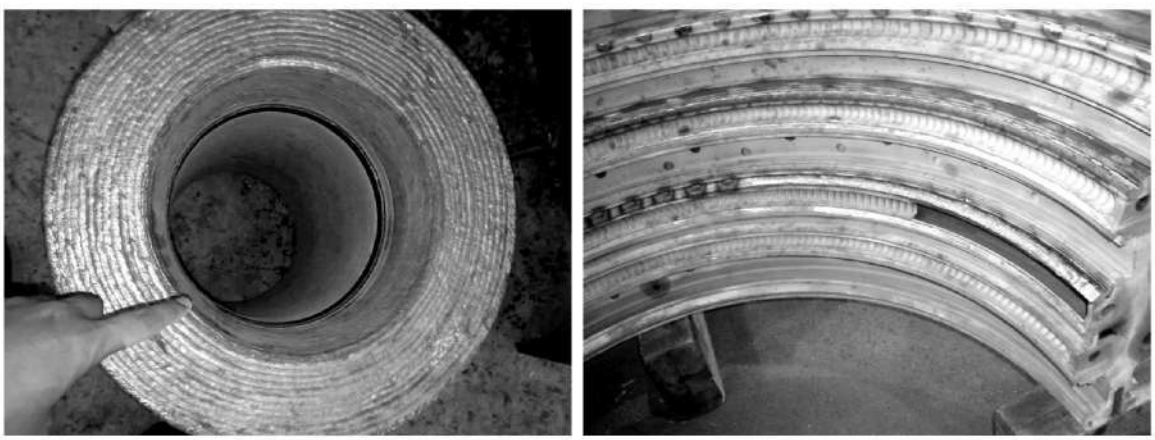

Fig. 7 : Some of the overlay components with Nickel Alloys & Welding of a Gas Turbine part made of Alloy 617

Fig. 8 : Aluminium Bronze Pipe welding

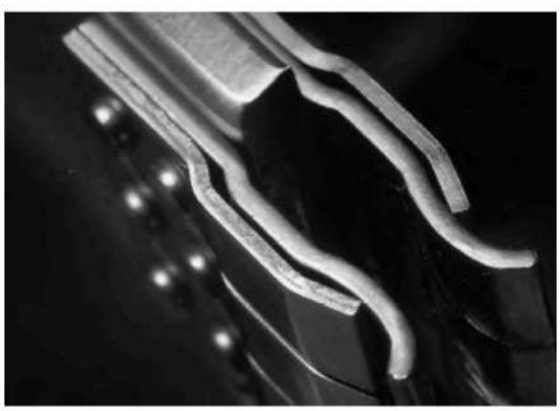

Fig.9 : Brazing of Copper for electrical contacts

MAGNESIUM & ITS ALLOYS:

Magnesium alloys containing small amounts of Aluminium, Manganese, Zinc, Zirconium, etc., have strength similar to that of mild steels. They can be rolled into plate, shapes, and strip. Magnesium can be cast, forged, fabricated, and machined.

As a structural material it is used in aircraft. It is used by the materials-moving industry for parts of machinery and for hand-power tools due to its strength to weight ratio. Magnesium can be welded by many of the arc and resistance welding processes, as well as it can be brazed.

Magnesium like Aluminum is produced with different tempers. These are based on heat treatment and work hardening. The strength of a weld joint is lowered in base metal, in the work-hardened condition, as a result of re-crystalization and grain growth in the heat-affected zone. This effect is minimized with gas metal arc welding because of the higher welding speed utilized. This is not a factor for the base metals that are welded in the soft condition. In India magnesium alloy welding is not being carried out extensively, due to lack of expertise, Consumables and available infrastructure.

TITANIUM & ITS ALLOYS:

The high strength, low weight and out-standing corrosion resistance possessed by Titanium and its alloys have led to a wide diversified range of successful applications in Aerospace, Chemical plant, Power generation, Oil and Gas extraction, Medical, Sports and other industries, [9]. There is a common question which links all of these applications and that is how best to join titanium parts together or to other materials to produce the final component or structure. This demand for versatile selection of joining processes for Titanium. Welding of Titanium by TIG & MIG processes (only till date arc welding process) is widely practiced and service performance of weld is proven with an extensive and continuously exceeding record of achievements. Most titanium alloys be fusion welded and all alloys cab be joined by solid state process. Titanium Welds are substantially immune to many weld metal cracks. Engineers still believe that titanium is difficult to weld. This may be due to gas shielding or handle by specialist fabricators. It is easy to weld by most process. Embrittlement through contamination with air and carbonaceous material pose the biggest threat to successful fusion welding. So area to be welded must be clean and protected by inert gas while hot. Welding consumables are available for the common titanium grades. Big companies such L&T, Alfa Laval, etc are successfully carry out for fabrication of Titanium equipments. Plate heat exchangers are specially made units, cast in titanium to prevent corrosion from the constant exposure to the salt water in most of the tanks **Fig10 & 11**. Though the expertise is being developed by Indian engineers over a period of time, however for raw materials and consumables, India has to depend on import.

Fig.10 : Heat exchanger made out of Titanium Alloy

Fig.11 : Seven plate evaporators made out of Titanium alloys

INDIAN SCENARIO:

The engineering industry is the largest segment of the overall industrial sectors in India, accounting for 3% of India's GDP, offering employment to over 4 mn skilled and semi-skilled workers (direct and indirect). It is diverse with a number of segments and can be broadly categorised into two segments: Non-ferrous metals and its welding are part and partial of these industry, which is further divided into Heavy engineering and Light engineering. Engineering is relatively less fragmented at the top as the competencies required are high and more fragmented at the lower end, in terms of technology and capital investment and are dominated by comparatively smaller players. The major end-user industries for Heavy engineering goods are Power, Infrastructure, Cement, Petrochemicals, Oil and Gas Refineries, Fertilisers, Mining, Railways, Automobiles, and Textiles among others. Light engineering goods are essentially used as inputs by the heavy engineering industry..

Growth in the domestic engineering industry has been fuelled by growth in key end-user industries and many new projects undertaken in various core industries such as Railways, Power and Infrastructure. Capacity creation in sectors such as infrastructure, Oil and Gas, Power, Mining, Automobiles, Auto components, Refinery and Consumer durables has driven growth in this sector. For example, the domestic sales of Automobiles have grown at a CAGR of around 18% over the past four years thereby increasing the demand for engineering goods. This provides an increased number of technically trained human resources each year has been another key factor aiding the engineering industry in India. Further, India is being preferred by global manufacturing companies as an outsourcing destination due to its lower labour cost and better designing capabilities. Our industry caters to a wide variety of process industries like Oil & Gas, Petroleum refining, Petrochemicals, chemicals, fertilizer, Pharmaceuticals, Metal industry, cement, Paper, Sugar, Cryogenics, Distilleries etc. The industry designs and manufactures a very wide range of equipment and systems such as: Pressure vessels, Columns, Towers, Heat exchangers, Multi-tubular reactors, Evaporators, Crystallizers, dryers, Road/Rail Tankers, most modern storage equipment, Loading and Unloading systems, Cooling towers, Cryogenic systems, equipment for Dairy and Food processing, Equipment for Power plants, Equipment for offshore projects, Nuclear, Thermal and Combustion systems etc. An impressive array of equipment for solid-liquid separation, equipment for water and waste water treatment, systems for environmental engineering and pollution control, large material handling equipment, marine equipment and special purpose equipment for critical services such as reformers, multiwall ammonia converters, urea reactors, urea strippers, transfer line exchangers, process gas waste heat boilers, hydrocracker reactors, fired heaters etc. are also being manufactured and exported by the industry, where non-ferrous welding is a part of it.

It is a highly capital as well as labour intensive sector with a strong engineering orientation where the products are mostly custom built. Hence economies of scale have less relevance in this sector except for the machine, or labour utilization factor if work load is not uniform. During the initial phases of India's industrialization (1951-66) Government set up a number of machine building companies. These were set up with appropriate infrastructure and capabilities including technology tie-ups to build and manufacture equipment for the core process industries like Refineries, Petrochemicals, fertilizer plants, aluminium plants etc. Very few private players got licences to manufacture equipment for these sectors. In the first phases of liberalization in the mid 1980s, more and more private players entered the arena initially as sub contractors to the big players. Today, the PSUs are no longer competitive though they still posses the infrastructure. However, the volume of work required to sustain them has tapered off after the core sector industries were set up and no further major investment having taken place during the 1980s and 1990s.

The industry at present is equipped with modern machinery in addition to competent engineers with management skills, skilled technicians and qualified welders. Their experience ranges across a wide spectrum of materials of construction such as various grade titanium and its alloys, aluminium, Nickel, Monel cupronickel etc. Their experience also spans

SWOT Analysis

Strengths	Weakness
• Low Labour Cost • Pool of Talents Recourse • National Ore Reserves • Open Economy	• GOI Policies • Energy Crises • Lack of Indigenous modern technology • Labour Law • Import of R/M, Welding consumables, Equipments • Less Focus on R&D and expenditure • Poor road and infrastructure in Rural Area
Opportunities	**Threats**
• High Captive Consumption • Rural & Urban Modernisation • JV • Infrastructure Development	• Market Volatility • Stringent environment rules • FDI by Global Fabricators • Global Recession

across a wide range of welding processes for welding materials of thickness ranging from 2 mm to 100 mm [10].

CURRENT STATUS IN INDIA:

Today in India there are a few companies who have made a mark in the export arena due to their manufacturing skills and quality. Today the manufacturing facilities are equipped with modern machinery and are producing very sophisticated equipment such as high pressure heat exchangers, spiral heat exchangers, multiwall vessels, air fin coolers, multi-tubular reactors etc. A few large companies have equipped themselves with the best welding facilities like SMAW, MIG/MAG, synergic pulsed MIG & TIG, Friction Stir welding, Laser, EBW, Hybrid process such as laser and TIG , Laser and MIG SAW and Plasma welding with facilities for establishing welding procedures with laboratories having destructive / non-destructive testing and metallographic studies. Hence they can do critical welding of Titanium, Cryogenic materials (9% Nickel Steel welded with Nickel Alloys), Corrosion resistant materials, special grade high strength quenched and tempered steel, corrosion resistant overlays by strip cladding and submerged arc welding.

The modern facilities include hot and cold rolling, metal forming, an impressive array of welding equipment, heat treatment and sophisticated inspection facilities. Most of the manufacturers are also equipped with a basic but modern design and drawing office. This infrastructure coupled with dedicated teamwork they are able to extend total quality assurance. High-dome workshop bays are well equipped with a variety of cranes and material handing equipment. Many of these workshops have been authorized by the American Society of Mechanical Engineers (ASME) for the use of U, U2 and S code symbol stamps. With the pick-up in investments, the growth of the process plant equipment sector in 2004-05 has been very encouraging and far exceeded estimates. On an average, the industry grew at more than 35 percent. For the process plant equipments sector the unprecedented rise in input raw materials prices put pressure on the margins of most companies. It also encouraged companies to look at various cost cutting methods and business process re-engineering.

- The design & engineering sector of the industry has upgraded itself with the latest software and communication methods to international standards but the percentage of companies doing so is very small, and is confined mostly to the bigger companies.
- The Plant equipment manufacturing sector, barring a few exceptions, is still following traditional manufacturing technologies. However, they have upgraded their methodology to the extent that they are now able to produce equipment acceptable to international quality standards.
- Automation in fabrication and welding techniques is not to international standards. Companies are unable to invest in these areas due to high investment requirements.
- Inconsistent performance on delivery and time schedules due to poor infrastructure facilities are some of the drawbacks of the sector.
- Issues of safety, health and environment (SHE) are causes for concern in small and medium sized companies. These companies are often unable to convince foreign buyers that their SHE policies and their implementation within their factories and worksites are at acceptable levels. Often, despite having an acceptable product they fail to pre-qualify for foreign orders.
- State-of-the-art manufacturing capabilities are available only in the medium and big companies.
- India has a world-class pool of talent in engineering and management skills. Since this sector is more engineering and labour intensive, a highly talented pool of skilled manpower at competitive wage rates is an added advantage for India. This sector is globally competent in terms of quality and competitive in engineering man-hour costs.
- World-class competency levels exists in engineering, manufacturing and handling of lump sum turnkey contracts but again these capabilities are restricted to a few of the bigger companies.
- Companies are able to offer customization in products and systems as per customer requirements.
- Since economies of scales, higher technical expertise and experience coupled with manufacturing excellence bring down the production costs, it is foreseen that the industry will witness a process of consolidation with the smaller players acting as sub-suppliers or sub-contractors to the bigger players.

TECHNOLOGY:

The technology of the equipment depends on whether it is static like reactors, columns tanks, heat exchangers etc. or moving like Pumps, Compressors and Rotary equipment or Special unit Operation Packages. In India manufacturers for

the first category and also for equipment manufactured from noble metal are very few since these require very high levels of manufacturing expertise and standards of welding, annealing and heat treatment process design as well as the proprietary component is available with the process licences. Further, the basic and extended basic engineering capabilities are available with the global companies all of whom are already operating in India and working with these companies. The manufacturing technologies pertain to the fabrication of materials of complicated metallurgy. Most of the large Indian companies started with import substitution, followed by technology absorption. Very few companies have the modern techniques of welding and fabrication like plasma welding, automated fabrication machines, Welding consumables, etc., which are used globally. At present the technology requirements are for niche areas and particular types of equipment and unit operation packages and they are not easily available due to many constraints. One of the reasons for lack of technology availability is that for the technology provider hardware supply is more profitable. The certain technology cannot be developed in India due to lack of enough opportunities in the user industries and has to be transferred through collaboration or JVs. In India, user industries are not giving the domestic companies this opportunity of developing new products. They instead prefer to import the equipment directly from the manufacturer associated with the process licensor.

DESIGN AND ENGINEERING:

Some of the bigger companies due to their association with international companies have installed modern computer systems and have incorporated and developed several software programmes in areas such as piping designs and engineering, stress analysis, heat exchanger design, pressure vessel design, process simulation and analysis, structural analysis and design, project management etc. Since the equipment manufacturer has to prepare the detailed manufacturing drawing, design and engineering departments are found in almost all the big and medium companies. 85 percent of the surveyed companies offer design services, however, only 40% of the companies had in-house design and engineering set ups. The rest of the companies sub-contracted the design and engineering. All the companies having design and engineering department used CAD / CAE. Many of the companies who have design and engineering set ups, during the recession phase started diversifying by catering to design and engineering orders from consultants. These companies bagged design and engineering orders worth Rs.4 crores in 2003-04 and many companies are looking at this as another business opportunity. The percentage of engineering hours spent on doing engineering rework was found to be higher on an average at 13 percent with the range being 2% to 20% in some cases.

TECHNOLOGY TRANSFER:

Some companies had technology transfer agreements and another are planning a technology tie-up to upgrade their Products/ Process. This Welding sector is predominantly a manufacturing based on certain fixed design parameters and process technologies which are with only a very few technology providers and hence the scope for technology tie-ups is very limited. Only companies, which have the capabilities of absorbing the extended basic engineering and have the capability of developing the manufacturing technology on their own are interested in technology tie ups. Moreover, there are financial constraints for companies who are looking for technology transfer since the technology providers demand upfront fees which may not be economically viable for these manufacturers. For this reason GOI should have a national technology transfer policy whereby the equipment required by the Government controlled user sector is mandatorily manufactured in India with technology transfer to a suitable company based on their track record. This will help them in gaining expertise to use it in the global market. This is particularly important if India has to expand its export market. All companies who are dependent on collaborations for technology are also restricted in their access to global markets which is not desirable on a long-term basis. Some time companies having technology tie-ups faced problems in retaining foreign trained personnel during and after the technology absorption phase. This is mainly attributed to the booming conditions in the IT sector and comparatively low wages in this sector.

RESEARCH AND DEVELOPMENT:

Very few companies are having in-house R&D, however some companies have invested in R&D with the advent of the liberalization process in the country. The percentage of sales budgeted for R&D ranged from 0.5% to 3%. Out of the companies engaged in R&D only few percent of them are working in collaboration with some educational / research institutes. The prominent ones among them being IITs/ NCL/ IIW/ Heavy Water Board/ VIT Pune, VNIT, Nagpur/ ITI. Half the industry surveyed feels that the Government should create a R&D fund.

MANAGEMENT EFFICIENCIES:

The industry barring the few big players needs stronger marketing abilities. That is the reason why only some companies had a larger chunk of the market share. It was observed that the smaller players had no formal strategy planning or were aware of strategic planning or product development strategy. Some companies have established procedures of strategic planning and Some companies have in-depth strategic planning. Some companies will follow strategy to enhance their market share by achieving high quality and service. The second priority they felt was aggressive marketing. Some companies are working on to reduce costs and lastly they also felt increasing the product range may help them to increase their market share. Companies should use technology for reducing procurement and vendor management costs through e-procurement and other supply chain optimization features like vendor-managed inventories.

Many companies are invested to implement ERP or enterprise resource planning is an industry term for the broad set of activities supported by multi product application software that helps a manufacturer or other businesses manage the important functions of its business including Product planning, Parts purchasing, Maintaining inventories, Interaction with suppliers, Providing customer service and tracking orders. Supply Chain Management (SCM) is the management of the entire value added chain, from the supplier to manufacturer right through to the retailer and the final customer. SCM has the primary goal of reducing inventory, increasing the transaction speed by exchanging data in real time and increasing sales by implementing customer requirements more efficiently.

CRM (Customer Relationship Management) entails all aspects of interaction a company has with its customers, whether be it a sales or service related. CRM is an information industry term for methodologies, software and normally patent capabilities that help an enterprise manage customer relationships in an organized way.

HUMAN RESOURCE DEVELOPMENT:

Companies are realizing that to retain talent, the expenditure on training and HRD needs to be increased and human resources should be the focus since this sector, specially the engineering side, has its competitive edge because of its talented manpower. This sector is unable to retain talent and experienced technical manpower like welders, fitters, machinists and design engineers who are lured by the high wages in the Middle East. Hence HRD has an important role to play to motivate employees and try their best to stop the flight of the trained workforce.

DELIVERY SCHEDULE:

The percentage of shipments before / within the due date is area of concerned. There is no co-relation found between delivery on time and computerization used for production planning and scheduling. The reasons for late deliveries were attributed mainly to delays in customer clearance and design clearance by the small players who either supply to the bigger companies, or EPC companies, or are dependent on design from them. The majority of the companies have however attributed their delays to capacity constraints and delays in procurement of raw materials.

OPERATIONAL EFFICIENCIES:

Only 25% of the companies used CNC or NC machines because most of the manufacturers are small players and did not find it economical to invest in CNC machines. Another reason being this sector is heavily dependent on fabrication. Wherever the smaller manufacturers required machining or castings, they subcontracted it to machine shop vendors and smaller foundries respectively. Since this sector has the capability of enhancing its export share, the companies need to focus more on computerization to increase not only their productivity, but also for easy connectivity with its network of suppliers and customers.

ROAD MAP:

The Welding industry has evolved primarily on the basis of the requirement to set up core process industries in India after Independence. The demand today is also from these process industries being set up but the size of the plants have increased and are at times comparable, or larger than global capacities. Since for the past few years no new investments were made due to the recession, the industry faced a severe downturn and this made them focus on exports and today it is one of the sectors in the capital goods industry to have the highest percentage of exports. The industry being very heterogeneous is also very fragmented with each player operating in a specialized product category. It is also the larger companies who are diversified into many product ranges catering to a larger user segment. The industry is expecting a process of consolidation to take place and this process has already started with the bigger players using the smaller companies as subcontractors. Similar trend in terms of welding consumables

manufacturers, small players have shut down their plants or being take over by bigger manufacturer or by Global player.

Some companies have divested unrelated businesses to focus on their core competencies and some have gone in for acquisitions to consolidate and further their growth. The industry will see tremendous growth since investment in the hydrocarbon sector is likely to increase. Companies who can position themselves in areas of high growth will be benefited in the years to come. Liberalization has helped the sector in allowing it to access the global markets. Ease of imports has helped companies to source raw materials and high technology components easily. With the reduction of customs duties, companies can import high grade or higher thickness raw material easily, which is not available in India.

Non-availability of Indigenous Modern welding equipments, Consumables, Alloys (Nickel, Titanium, etc) required in bulk by the industry is hurting the industry in terms of cost competitiveness and delivery. Almost 60 to 65% of the raw materials required by the industry like Consumables, Base materials and forgings are imported from mainly Western Europe and Japan, as these are not manufactured in India. GOI should reduce the customs duty of all these materials to 5% to help the manufacturers. The domestic Fabricators, manufactures of welding consumables and alloys should be developed indigenously and should try to meet the requirements of the sector in terms of availability and quality.

The industry can help itself by adopting the following measures which are being carried out by some of the big players.

- A few sub-suppliers should be adopted as an extension of the company and help extended to them in terms of training in engineering, welding, planning and quality systems and standards and up-gradation of technology.
- Assistance in terms of finance also can be extended along with assured workload
- Training of a large number of labour/Welder apprentices many of whom find employment in the smaller units who cannot afford such training Manufacturers do not foresee any threat from the FTA / PTA's being signed. Instead they look upon them as opportunities to make inroads into those countries.
- Companies are gearing up to face the increasing international competition by focusing on the latest and high technology areas by enhancing quality and acquiring international standards such as ISO, ASME, CE etc., better productivity thereby reducing cost and improving upon the delivery period.
- Many Indian companies are already positioning themselves as a low cost manufacturing hub by aligning themselves and working together with the leading international consultants. The oil rich countries are investing in refineries and downstream industries which have thrown open vast opportunities.
- The Fabricators, Welding equipment manufacturers or Consumables manufacturers have the right mix of talent, expertise and opportunity to grow at a fast pace if the much-needed investment in the core infrastructure industry takes place and they relook at their operational and management inefficiencies.

Companies need to stress more on HRD since they can leverage more on the human resource expertise especially in the design and engineering field and R&D. Attracting and retaining talents will be a major constraint in this sector. Many of the domestic Fabricators have faced difficulties in increasing capacity both in their supplier base and recruitment of talents owing to the sudden buoyancy in the sector. The average wages per employee is quite low in this sector, which is the reason that companies are not able to attract and retain talent. The smaller companies rarely can afford a qualified engineer in their manufacturing shop and more often than not depend on diploma or ITI trained manpower or even experienced welders, fitters and machinists. The low wage structure of the industry is creating a vacuum in terms of a trained technical workforce which is lost to the Middle East because of their high wage structure. This issue needs to be looked at very seriously by the industry since the competitive advantage of the sector lies in its human resources. The industry needs to focus more on human resources so that the in-house talent and expertise can be harnessed with minimum effort and cost. Multi tasking skills need to be inculcated so that at all times manpower can be utilized to the maximum especially since the industry is dependent on industries which are cyclical in nature like steel, cement, paper etc.

Top-level management both in the private sector companies and the PSUs should be exposed to skill up-gradation programmes regularly on management issues and the international scenario. Companies need to focus more on best practices to reduce their manufacturing costs and improve upon quality standards. Since raw material is a major component in the cost of the equipment, companies need to invest more in IT to integrate their supply chain system, thereby reducing the inventory levels and allow for cost effective methods of procurement. They also need to improve upon their manufacturing technologies and invest more in IT to

enhance their productivity, give shorter delivery through better integration with supply chain systems and better service by integrating with customers' systems through CRM. The quality consciousness of the industry barring a few larger companies is not upto expectation. These are the companies who use poor quality material and do not follow the process or quality standards. However, with the users becoming more conscious of the quality aspects, they do specify procurement from ISO certified companies and hence the non-ISO certified companies end up being subcontractors to the ISO certified companies. The manufacturing companies need to invest into R&D for developing manufacturing capabilities involving different materials in a most cost effective manner. Like other global players, they should invest in R&D to develop market oriented optimal technologies; new technologies and businesses which are likely to see a high growth in the future and at the same time strengthen the production technologies. Most of the companies should take a relook at their business processes and focus on ways and means to improve the productivity and enhance capacity to improve returns on assets and capital employed. ROCE and PBIT as a percentage of sales for the industry is lower than that for non-electrical machinery as reported by CMIE and the industry needs to focus on this aspect. For the fabrication industry, with the enhancement of quality standards and improvement in delivery schedules, India can be a major outsourcing destination due to the availability of highly skilled welders / machinists at a very competitive rate. At present, automation in fabrication, machining and welding techniques and integration of the processes through IT is minimum since high investments are required.

GOI should increase depreciation rate on such equipment to encourage companies to invest. The workloads in the fabrication industry are of a fluctuating nature. Labour reforms should be carried out to enable a flexible system of hiring labour to meet these fluctuations on a contractual basis. Though PSUs in India like HEC, BHEL and BHPV are equipped with the best manufacturing facilities in heavy engineering, they lack the managerial effectiveness because of red tapism. GOI should provide a certain degree of autonomy in terms of marketing and ensure accountability for the performance of the PSUs. Companies should diversify their product range to counter the problem of cyclical downturns. The outstanding as a number of day's sales can be further brought down by the industry to improve its profitability.

The opening up of imports has increased competition for the domestic manufacturers since they do not enjoy a level playing field due to high domestic taxes and duties. A number of recommendations have been given in the first section to counter the disadvantage. To focus more on exports, companies would need to focus more on marketing and sales and build on the India brand image. They should also interact with all the International Consultants based in India / abroad and work in close proximity so that more and more jobs can be outsourced from India for projects being set up abroad. Since the industry has the potential to increase its exports, GOI should provide all help to the industry in the following ways:

- Ease of export regulation and formalities and quick reimbursement of export related financial benefits.
- Encourage participation in international trade shows and trade missions to countries with potential demand
- Ensure that equipment are procured from Indian companies when GOI extends the credit
- Improve Infrastructural facilities specially port handling facilities to enable companies to reduce their handling and transportation costs.

Since the future plants that are set up will have global scales and therefore the equipment will be heavier and larger. There are tremendous opportunities in the Aerospace, Defence, Oil and gas In case of Oil and Gas sector, Oil companies worldwide are expected to make significant investments in the field fuelled by continuing Oil price increases and the rise in energy demand. It would be prudent for the fabricators/ manufacturers to position themselves in this field both in design and manufacturing to be able to capture the market. Investments in natural gas will also be significant and requirements for gas to liquid (GTL) and liquid natural gas production, plants are going to have a high trajectory growth path. Companies in this sector therefore need vision and strategies to enter a market with future potential by partnering with either high tech companies or related process license holders. Over the next 5 years, most capacity additions are expected in Asia and the Middle East. In the medium term, capacity additions are expected to grow more or less in line with the demand growth rate. In India, there is however an overcapacity in the refinery sector and foreign investors do not find this sector attractive for investment. Major refining modifications needed to be considered to get gasoline/diesel to meet EURO – II/III standards. Additional capital will be added for these modifications. Planned capacity additions by players like IOC, ONGC, GAIL and Reliance (already initiated for Jamnagar refinery expansion) are expected to add to new capacities. The liberalization of industrial policy and other

initiatives taken by the Government have given a definite impetus for entry, participation and growth of the private sector in the Non Ferrous Industry as well as by diluting their equity to privet. While the existing units are being modernized/ expanded, a large number of new/green field steel plants have also come up in different parts of the country based on modern, cost effective, state of-the-art technologies.

CONCLUSION:

Metals and alloys form the basic raw materials for the development of light and heavy engineering industries in any country. The measure of their growth is a yardstick of the country's general progress in terms of modern civilization. The Welding industry has evolved primarily on the basis of the requirement to set up core process industries in India after Independence. The demand today is also from these process industries being set up with the size of the plant. Growth in the domestic engineering industry has been fuelled by growth in key end-user industries and many new projects undertaken in various core industries such as Railways, Power and Infrastructure. Capacity creation in sectors such as infrastructure, other Industries have driven growth in this sector. This provides an increased number of technically trained human resources each year has been another key factor aiding the engineering industry in India.

The domestic manufactures of welding consumables, Equipments and alloys should developed these consumables required for Non-ferrous metal welding indigenously and should try to meet the requirements of the sector in terms of availability at world class quality standards. Companies need to stress more on HRD since they can leverage more on the human resource expertise especially in the design and engineering field and R&D. India has world-class pool of talent in engineering and management skills Attracting and retaining will be a major constraint in this sector. Top-level management both in the private sector companies and the PSUs should be exposed to skill up-gradation programmes regularly on management issues and the international scenario.

Further, India is being preferred by global manufacturing companies as an outsourcing destination due to its lower labour cost and better designing capabilities. This sector is globally competent in terms of quality and competitive in engineering man-hour costs. Liberalization has helped the sector in allowing it to access the global markets. It would be prudent for the fabricators/manufacturers to position themselves in this field both in design and manufacturing with proper strategy in place, aggressive marketing, keeping delivery schedules and remain cost competitive, this will help to capture the market globally.

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