LATEST TRENDS IN WELDING EQUIPMENTS & CONSUMABLES

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INTRODUCTION

Welding today, has become one of the most important tools for efficient maintenance of plants and quality fabrication in industry. It has come to play a vital role in the growth and development of a variety of important sectors of the economy such as thermal, hydro, nuclear power generation, petrochemicals, off-shore drilling, steel plants, industrial machinery, heavy engineering, shipbuilding, transportation, fertilisers, oil & water pipelines, etc.

Traditionally, welding was looked upon as a means of fabrication only. However, with the passage of time and development of welding technologies, industry is using various forms of welding as a maintenance aid and for reclaiming worn out machinery and equipment. Welding Technology today is not merely a joining method but it is effectively used for cladding, hard-surfacing, cutting and for variety of other applications.

Most of the time welding engineers or inspectors think that weld metal quality depends largely on either skill of the welder or on the quality of welding consumables used for depositing weld metal. However, there is a third important variable factor which does contribute to the quality of deposited weld metal and that important variable/factor is quality or type of power source used, while depositing the weld metal.

The arc welding, although invented around 100 years ago, still remains the main means of fabrication for both structures and pressure components made of steel and other metallic materials. There are several Arc Welding processes and a large number of welding consumables and equipments (power sources) available. The aim should be to optimise the welding operation, coupled with proper mechanisation, to obtain a high level of flexibility and quality of deposited weld metal.

During last two decades, our fabricators have realised the importance of productivity and therefore, trend is to switch over from MMAW (SMAW) process to semi-automatic (or mechanised) MIG/ MAG welding process. However, often because of inadequate training to the welders, selection of improper welding equipments or consumables, the fabricators don't achieve the intended benefits and hence, the MIG/MAG equipments procured remain unutilised in the shopfloor.

In order to derive maximum benefits in terms of productivity and quality, welding engineers/ supervisors should study the latest trends in welding equipments and consumables available for various arc welding processes, so that they can derive maximum benefits and can become globally competitive.

TRENDS IN WELDING EQUIPMENTS

The power source must be suitable for the type of welding process i.e.,

a) MMAW (SMAW)
b) Tungsten Inert Gas (TIG)
c) Metal Inert Gas/Active Gas (MIG-MAG)
d) Submerged Arc Welding

TYPES OF POWER SOURCES

Five types of power sources exist. They are :

a) AC Transformer
b) DC Rectifier

c) AC/DC Transformer-Rectifier
d) DC Generator
e) Inverter

TYPES OF CONTROL IN WELDING EQUIPMENTS :

There are three types of controls, which are :

a) Primary tapped saturable reactor control
b) Thyristor controlled equipments
c) Inverter based welding equipments.

REVIEW OF PRESENT PRACTICE

Over 70 percent of welding consumables manufactured in the country for MMAW process are of rutile type, conforming to E6013 classification and almost all fabricators use conventional type power source, i.e. transformers operating at 50 Hz. Transformer is the largest, heaviest and most inefficient power source but at the same time, it is the cheapest available power source for E6013 type electrode.

While using conventional transformer or rectifier or motor generator for welding, the power consumption in comparison to inverter type is quite high and at the same time, no load losses of electrical energy are quite substantial.

ENERGY EFFICIENCY

Inverters are more energy efficient than conventional power sources. Table 1, shows the input KVA, and efficiency for conventional power sources and inverters at the same welding output.

Input KVA determines the amount of primary line current required. Higher the primary line current, the large is size of the line. Here the inverter has a significant advantage. At 200 Amps output, the inverter uses approximately one-half the input KVA. This saving of energy permits more units to be placed on an already installed primary line. Thus, use of inverter reduces the welding energy cost.

The above energy consumption figures indicate that for 3.15 mm size, E7018 electrode, when inverter power source is used, power consumption is about 3.0 KW/Hr against 8.5 KW/Hr when motor generator is used as power source. In other words, consumption of power, for 3.15 mm size, E7018 electrode is about 280 percent higher. Thus, use of inverter can save substantial amount of power.

PERFORMANCE OF POWER SOURCE

The major benefit of inverters is a significant increase in arc performance, stability and control.

In case of 3 phase rectifier, the sensing and control feedback operates at 50 cycles per second whereas in case of inverter, the sensing and control feedback operates at 20,000 cycles per second. Thus, inverter power source gives enhanced performance in terms of arc stability and control.

MULTIPLE CAPABILITIES

Power sources of conventional designs that could be used for several arc welding processes, such as MMAW, GTAW, GMAW-P, etc., are not usually available.

With inverter design, multiple processes are built into a single unit with maximum performance characteristics and full range of each process, without compromising any process. A simple switch allows process selection and the same output control sets the output of MMAW, GTAW and GMAW-P The modular concept enables the users to update the simple inverter, suitable for Pulse Tig or Pulse Mig and Synergic Mig.

ADVANTAGES OF USING INVERTER FOR MMAW

The very fast response of an inverter with MMAW allows benefits to be incorporated which are of definite advantage to the Operators. These include built in hot start and arc force control.

Hot Start : The hot start is a very short time high pulse of current which passes through the electrode, when the electrode touches the work. This gives easier starts and restarts.

Arc Force : Inverter improves arc force feature. By using "Arc Force", the trained Operator can adjust the arc from soft with minimum penetration to forcible and digging arc for enhanced penetration.

Table 1

Sr. No.	Output Welding Current	Input, KVA Required		Efficiency %	
		Conventional	Inverter	Conventional	Inverter
A	200 A	15.59	<8.40	75.70	85
B	300 A	20.98	<9.90	80.0	88
C	400 A	26.00	<14.60	81.45	88.9
D	500 A	30.80	<20.20	82.3	89.3

Table 2 Gives information about no load losses

Sr. No.	Output Welding Current	No load loss (Watt)	
		Conventional	Inverter
A	200 A	> 200 W	< 10 W
B	300 A	> 200 W	< 10 W
C	400 A	> 200 W	< 10 W
D	500 A	> 200 W	<10 W

The above data given in Table 2, shows that no load losses of power in case of conventional power source is quite substantial.

Table 3 Gives Information about Power Consumption for Different Power Sources. But same dia of E7018 Electrode

Sr. No.	Electrode dia (E7018 type)	Power Consumption Units / Hours	
		Motor Generator	IGBT Inverter
1	2.5 mm	6.5	2.5
2	3.15 mm	8.5	3
3	4.00 mm	10.5	4

TIG WELDING WITH INVERTER

When inverter power source is used for GTAW, it gives a very good arc stability at lower current setting. The main salient features are :

1) Excellent arc stability even at lower current setting
2) Lift start capability
3) More precise current control (heat input)
4) Very stable arc with changes in tungsten-to-work distance.
5) High current pulse rate capability.

With inverter power source, it is possible to obtain a hand held stable arc at approximately 1.0 amp current.

Lift start is the ability to start the arc by touching the tungsten electrode to the work piece and lifting it up. The tungsten electrode is touched at one point instead of being wiped (scratched) over the work. The lift start facility with inverter power source eliminates tungsten contamination in the weld.

MIG/MAG WELDING WITH INVERTER

With an inverter, arc characteristics of GMAW can be designed into the power source and adjusted by the Operator. This technique overcomes many of the perceived dis-advantages of short-circuit transfer.

The development of inverter power source is one of the main reasons that GMAW-P use continues to grow. Inverter power sources allow the type of control required for effective GMAW-P welding.

Synergic pulsed MIG power sources, which are advanced transistor controlled power sources are pre-programmed so that the correct pulse parameters are delivered automatically as the wire feed speed is varied. The power source can have pre-programmed pulse parameters for specific material.

Inverters generally conform to 1 P-23 specifications and are CE & S marked. Hence, these equipments are suitable for outdoor as well as shop floor usage, despite their compact size and light weight.

POWER SOURCE FOR SAW WELDING

Thyristor type power source improves overall performance of the

process and therefore, the trend is to use thyristorised power sources for Submerged Arc Welding Process.

CONCLUSION

Welding engineers have realised that for improving quality and output of weld metal, improved types of power sources are necessary. The trend is to substitute conventional power sources with either thyristorised type or with inverter type. Ultimate choice depends upon the welding process, material to be welded, etc.

Inverter based power sources give higher efficiency, negligible no load losses and lower power consumption. By using inverter power sources, the cost of welding can be brought down with significant improvement in Weld Ouality. Moreover, inverter power sources are much compact in size, are portable, and use much smaller floor space.

TRENDS IN WELDING CONSUMABLES

Last year i.e. in the year 1999-2000, steel production in our country was about 27.0 million tons, which has registered growth of about 13 percent.

However, consumption pattern of the steel shows that growth is confined to long products, which are mainly used for construction activities. As far as welding is concerned, there is hardly any growth in the consumption of welding consumables during the year 1999-2000.

Last few years have seen distinct change towards MIG/MAG welding from SMAW (MMAW) process. However, the change is confined to large and medium fabricators. The consumption figures of welding consumables available from the industries are tabulated in Table 4.

During 1999-2000, in our country, about 77.5 percent of weld metal was deposited by using MMAW process whereas about 13.80 percent weld metal was deposited by using MIG/MAG process. The trend is obviously to use more and more MIG/MAG process, using solid or flux cored wires for increasing overall productivity in the shopfloor.

TRENDS IN MMAW WELDING CONSUMABLES

With the global competition, our fabricators have become more quality conscious. Many of them have received ISO-9000 certification and/or ASTM U Stamp. The welding engineers stipulate their requirements of welding consumables by preparing specifications, which are usually based on ASME Section II Part 'C' specification. The latest trends of welding consumables observed are as under :

CELLULOSIC ELECTRODES FOR PIPE LINE WELDING

Even today for laying cross-country pipelines, cellulosic electrodes are preferred. These consumables help to increase the productivity and are now supplied in tin containers, which are hermetically sealed.

Such containers retain moisture in the flux coating of electrodes, which is an essential feature for obtaining desired penetration and performance while welding. For welding of cross-country pipelines, the pipe line designers have started specifying following cellulosic electrodes for welding :

a) E7010-P1

b) E9010-P1

E8010-P1 (pipeline) electrodes have been designed primarily for welding typical high strength, pipe butt joints

Table 4 (IN MT)

Sr. No.		Manual Metal Arc Welding	MIG/MAG Welding	Submerged Arc Welding	TIG Welding	Total
1.	Deposited weld metal (1999-2000)	101,000	18,000	10,000	1400	1,30,400
2.	Electrodes / Wire (1999-2000)	1,60,000	20,000	11,000	1500	1,92,500

in the vertical welding position with downward or upward progression. These specially formulated cellulosic electrodes are best suited for achieving full penetration and radiographic quality. Usually E7010-P1 is recommended for welding of API-5L-X52 and API-5L-X65 piping assemblies respectively. Even today, few fabricators use cellulosic electrodes, type E7010-G and E8010-G for similar applications.

HYDROGEN CONTROLLED, MOISTURE RESISTANCE ELECTRODES

With the revision of AWS/SFA 5.1 and AWS/SFA 5.5 specifications, now welding engineers could be more specific while writing their requirements of welding consumables. The revised specifications allow users to mention what type of hydrogen controlled electrodes are required and whether they are looking for moisture resistant type basic coated electrodes.

Table 5 gives information on how welding engineers could stipulate their requirements, depending on the job specification/critical application.

Welding consumables manufacturers usually supply moisture resistant electrodes in hermetically sealed tin containers or in vacuum pouches. These electrodes have been developed with special binder system and can be exposed to the atmosphere for the period of upto 9 hours at 80F and at 80 percent Rh. The use of moisture resistance electrodes eliminates expensive drying before use and eliminates or reduces post weld heat treatment for many applications.

Table 5

Type of basic coated electrode	Same type with requirements of diffusible hydrogen in the weld metal	Same type with requirements of diffusible hydrogen in the weld metal and moisture resistant coating specification
E 7018	E 7018-H4 E 7018-H8 E 7018-H16	E 7018-H4R E 7018-H8R E7018-HI6R
E 7016-1	E 7016-1 H4 E 7016-1H8 E 7016-1 H16	E 7016-1 H4R E 7016-1 H8R E 7016-1 HI6R
E 8018-B2	E 8018-B2 H4 E 8018-B2 H8	E 8018-B2H4R E 8018-B2H8R
E 11018M	E 11018M H4	E 11018M H4R

NACE specification for such special types of E7018/E7018-1 electrodes is given in Table No.6:

Table 6

Type of electrode	Max 'Mn' Content (%)	Max. 'S' content (%)	Max. 'P' Content (%)
E7016 E7016-1 E7018 E7018-1	1.40	0.010	0.012

E7018/E7018-1 ELECTRODES FOR OFF-SHORE FABRICATION - PROCESS PLATFORMS INVOLVING WELDING OF NACE STEEL

Special types of E7018 and E7018-1 electrodes have been developed for welding NACE steel used in offshore process platforms and other installations. The weld metal of these electrodes are tested in accordance with TM-01-77 and TM-02-84 for sulphide stress corrosion cracking test and for hydrogen induced cracking test. The deposited weld metal for such requirements has much lower limit of impurities such as 'S' and 'P' with maximum limit for Mn content. The Normal E7016-1 or E7018-1 electrodes seldom deposit weld metal with such high impact strength. Therefore, designers of the welding consumables make suitable changes in the flux coating which could deposit weld metal with very low level of impurities with controlled carbon, manganese & silicon content. Such electrodes now fulfil the requirements of designers i.e. minimum impact strength of 100 Joules at minus 46C or minus 50C.

Designers are of the opinion that the weld metal deposited from such high quality electrodes, has unique property of 'resistance to ageing' and thus under severe service conditions, the weld metal does not fail and thus helps to achieve continuous desired productivity year after year.

E7018 / E7018-1 ELECTRODES WITH HIGH IMPACT VALUES AT SUBZERO TEMPERATURES :

For specific applications such as critical parts of steel plants, off-shore platforms, few designers stipulate very high impact requirements at sub-zero temperatures. These requirements are given in Table 7 :

Table 7

Type of Electrodes	Impact requirements at sub-zero temperature
E 7016-1 E 7018-1	100 Joules at minus 46°C 100 Joules at minus 46°C

WELDING ELECTRODES FOR SPECIFIC APPLICATIONS

Chemical, power, offshore, fertilisers, petrochemical and refineries, LNG terminal and transportation, are some of the industries wherein new materials are being used by designers for increasing yield and efficiency. For welding these new materials, depending on their physical, chemical and metallurgical properties with intended end applications, new welding consumables have been developed. Few examples of newly developed consumables are given in Tabfe 8.

WELDING CONSUMABLES FOR MIG / MAG WELDING

Last year approx. 18,000 MT of weld metal was deposited using MIG/ MAG welding process. By and large users of MIG/MAG welding process prefer to use solid, copper coated wires conforming to AWS/SFA ER 70S-6 specification, because of much lower cost of the wire and easy availability, as compared to flux cored wires.

Mix gas for shielding such as 80 percent argon plus 20 percent CO_2 or 80 percent argon plus 18 percent CO_2 and 1 to 2 percent oxygen, are still not readily available to the fabricators. Moreover these gas mixtures are still quite expensive.

From the manufacturers of gases. it is understood that in the near future, gas mixtures wili be available in the increased quantity and cost will be substantially lower. Use of above gas mixtures improve arc characteristics, reduce spatter level and deposit more uniform weld metal with radiographic quality. Once fabricators start using gas mixtures such as 80 percent argon plus 20 percent CO_2 then the wire specification will change to ER 70S-3/ER 70S-4 from ER 70S-6. ER 70S-3 and ER 70S-4 wires have reduced level of manganese and silicon. as deoxidisers because of about 80 percent argon present in the gas mixtures.

FLUXCORED WIRES FOR MIG/ MAG WELDING

Designers of flux cored welding wires, design special wires for 100 percent CO_2 shielding gas and special flux cored wires for gas

Table 8

Sr.No.	Type of Industry	Material	Welding Consumable
1.	Power	P91/T91	E9018-B9/ E9016-B9
2.	Power	A387 Gr. 22 C1.1 & 2	E9015-B3 (Weld metal insensitive to in - service temper embrittlement)
3.	Nuclear Power plant	20 MnMoNi55 22NiMoCr37 13MnNiMo54	E9018-G Deposited weld metal has high metallurgical purity
4.	Offshore Chemical	Duplex St.Steel 1.4462	E2209-16
5.	Cryogenic (at minus 196°C)	1.4404 1.4406 etc	E20.16.3.MnLKB2O+ (As per DIN 8556 spec.)

mixture such as 80 percent argon plus 20 percent CO_2. There are broadiy two types ot flux cored wires which are manufactured, depending upon the technique of manufacturing. These types are :

a) Folded Flux Cored Wires
b) Seamless, Copper Coated, Flux Cored Wires

Recently seamless rutile type E71-T1 all-position flux cored wire has been introduced for welding C-Mn steel. The wire with seamless type deposits weld metal having extremely low level of diffusible hydrogen i.e. less than 3.0 ml./100 grams of weld metal. Use of such wires totally eliminate risk of cracking the weld metal due to diffusibie hydrogen.

In the recent years, depending upon applications, flux cored wires have been developed for welding low-alloy high tensile steels, weathering steels, cryogenic steels, etc. These wires are usually basic type and are available in diameter 1.20 mm or 1.60 mm.

FLUX CORED WIRES FOR HARDFACING APPLICATION OR FOR RECLAMATION WELDING

Variety of flux cored wires either self-shielded or gas shielded are now being used in increasing quantity for hardfacing/reclamation welding. Few examples are reclamation of cement mill rolls, pulleys, caterpillar track rollers, crusher jaws, excavator parts, etc.

The biggest advantage of using alloyed flux cored wires is its availability. A small batch of say 200 to 400 kgs can be manufactured with specific chemical and mechanical properties of the weld metal. Smaller quantity of solid wire with equivalent chemical and mechanical properties will be difficult to manufacture and would be very expensive and will take longer delivery time. Therefore, users prefer to use alloyed flux cored wires for specific applications such as reclamation welding or hardfacing application.

WELDING CONSUMABLES FOR SUBMERGED ARC WELDING - LATEST TRENDS

Submerged Arc Welding Process is mainly used in the country for following applications :

1. Welding LPG/chlorine cylinders
2. Welding pipelines - water/gas/ petroleum products.etc.
3. Welding pressure vessels
4. Welding of storage tanks (horizontal welds)
5. Shipbuilding
6. Offshore platforms
7. Railway wagons/locomotives
8. Cryogenic vessels
9. Automobiles (heavy vehicles)
10. Structural steels
11. Penstocks.

LPG cylinder manufacturers continue to use fused fluxes with EL8 solid wire. For welding pipes, usually agglomerated high speed fluxes with combination of EL8/EMI2K wires are used. The business of manufacturing pipe lines is increasing rapidly in the country. Few of them have set up the plants for exporting the pipes. In fact requirements of welded pipes for transporting water in the country is increasing rapidly, since the State Governments have given priority for supplying potable water to the rural area for drinking purpose.

For welding of pressure vessels, storage tanks for petroleum industries, offshore platforms. locomotives, structures, subjected to dynamic loading, are fabricated using basic agglomerated fluxes with EM 12K/EH 10K wire. The weld metal deposited with such combination gives excellent mechanical properties including impact at sub-zero temperatures.

Specific equipment of power plants, reactors and other parts are fabricated using low-alloy steels. Solid low alloy wires are not manufactured in the country and therefore, flux cored wires are now used with basic agglomerated fluxes. It is necessary to establish WPS and PQR in the shop floor before the welding consumables are used for fabricating the actual jobs.

Deposition rates are highest with Submerged Arc Welding Process. Moreover the process can be mechanised easily by the use of

column, boom and rotators. SAW process is mainly used for downhand welding and for horizontal butt and fillet welding. The process is used in limited scale for welding few grades of stainless steel, 9 percent nickel steel and for overlay applications. In the last one year, the requirement of consumable for SAW has gone up by 50 to 80 percent. However during the year 2000-2001, the expected growth would be about 15 to 20% over the year 1999-2000.

Total requirement of fused flux is met by indigenous manufacturer of fluxes. However agglomerated fluxes for pipe welding are still imported. New types of agglomerated fluxes having moisture resisting absorption properties have been developed recently. Use of such fluxes, specially for welding high tensile steel reduces tendency of cracking the weld metal due to diffusible hydrogen content in the weld metal.

CONCLUSION

1. Welding Industry has realised that quality of deposited weld metal also depends upon the type of power source used during welding operation.
2. Conventional power sources such as transformers,DC rectifiers, DC generators, etc., are quite bulky. These power sources are relatively energy inefficient and consume much larger power while welding. No load losses of power are also quite substantial with these power sources.
3. New generation power sources are either thyristorised or are inverter type. Inverter type power sources are much smaller in size and weight, are portable and occupy much smaller floor space.
4. With inverter design, it is possible to build into a single unit multiple process applications such as MMAW,GTAW,GMAW-P A simple switch allows process selection.
5. With inverter type power source for TIG welding, it is possible to estabiish arc with 1 Amp setting.
6. For MMAW welding, inverter fype power source provides benefits such as hot start and arc force. Hot start benefit facilitates easier striking and re-striking the arc. This facility is especially useful for pipe welding in 5G/6G or 6 GR positions.
7. For GMAW-P and Synergic MIG wetding, it is possible to establish spray type metai transfer at lower setting of the current. This advantage of inverter type power source facilitates welding of relatively thin sheets and outer positional welding.
8. For SAW process, thyristorised power sources give better control on heat-input and thus give better consistency in deposited weld metal.
9. Even though inverter type power sources are expensive, the trend of industry is to use more and more for improving the quality and reduce power losses.
10. During 1999-2000, about 1,30,400 tons of weld metal was deposited against 27.0 million tons of steel produced in the country.
11. For cross country pipe line, new types of cellulosic coated electrodes, types E7010-P1 and E8010-P1 have been developed.
12. Basic coated hydrogen controlled electrodes are now available with moisture resistance coating. These electrodes can be exposed upto 9 hours at 80F and 80% Rh. These electrodes don't require redrying before use.
13. Users of welding consumable now specify their requirements of hydrogen content in the weld metal by specifying revised classification of electrodes such as E7018-H4R/ E7018-H8R or E7018-H16R.
14. For specific applications such as welding of NACE steels E7018/ E7018-1 electrodes are available with much lower impurities.
15. Specialised electrodes have been developed for newly developed low-alloy chrome-moly steels, duplex stainless steel, cryogenic steels, etc.
16. For MIG/MAG welding, now seamless flux cored electrodes are available, which deposit weld metal having less than 3.0 ml of diffusible hydrogen content in 100 grams ot weld metal.
17. For hardfacing/reclamation applications, variety of self-shielded or gas shielded flux cored wires are now available.
18. SAW process is highly productive process. During last year, the growth was in the range of 50 to 80 percent. The growth is mainly due to spurt in requirements of LPG cylinders and water pipe lines. For welding high tensile low alloy steel, fabricators prefer to use flux cored wires in place of solid wires.
19. Moisture resistant type agglomerated fluxes have been introduced recently. These fluxes with suitable wire deposit weld metal with much lower content of diffusible hydrogen.

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