Energy Conservation in Welding

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ABSTRACT

Energy costs have often been disregarded as being a minor part of the total welding cost. It is discussed here that an inefficient power source consumes unnecessary extra energy which can be avoided by the right design and choice of the equipment.

There are also big differences in energy consumption between the welding methods & processes. Besides the energy costs, heat input also plays a major role with great significance for the metallurgical effects and thermal distortion.

On the macrolevel one has to also consider the enormous savings in installation of new power stations apart from the adverse environmental effects of unnecessary power consumption. The problems with electromagnetic compatibility and the possible harmful effects from the electromagnetic fields on human beings is another issue.

POWER SOURCES

SMAW Power sources are designed to transform high voltage input supply to a low voltage high current supply - output being either AC or DC. They are constructed to withstand high short circuit current. The open circuit voltages are usually high ranging from 60V to 100V. The power factors under normal working conditions are very low ranging from 0.35 to 0.6. The windings can be made of either copper or aluminium. By the very nature of the process requirements, the power sources for SMAW have drooping or constant current output characteristics.

Typical efficiency values for arc welding sources are 75-85%. This means that for a load of 500 A/ 40 V the losses can be in the range of 3-6 KW. The value depends on the type of power source used. Inverters are smaller and they also have less power losses than traditional machines, see Fig. 1.

Normal welding is not continuous and you have to take into account the arc time factor when calculating the energy costs. During the time when switched on but not in use, the equipment has open circuit losses. The old rotating welding converter (Motor Generators) could have open circuit losses of more than 1 KW, large **MMA** welding machines varying between 300 to 1000 W while the modern inverter power sources perhaps have no more than 50 W.

If the power source is designed in a proper way, all losses are dissipated without too high temperature rise in the sensitive parts, i.e. insulation material or semiconductors. If the internal cooling surfaces are clogged up with dust and dirt, the temperature increases and shortens the lifetime of the equipment. It is also important from a safety point of view to avoid overheating. A breakdown of the insulation between the primary and secondary windings in the transformer may admit the mains voltage to reach the welding circuit. If the secondary circuit is not connected to earth, this would be bazardous to the welder.

ENERGY CONSIDERATIONS

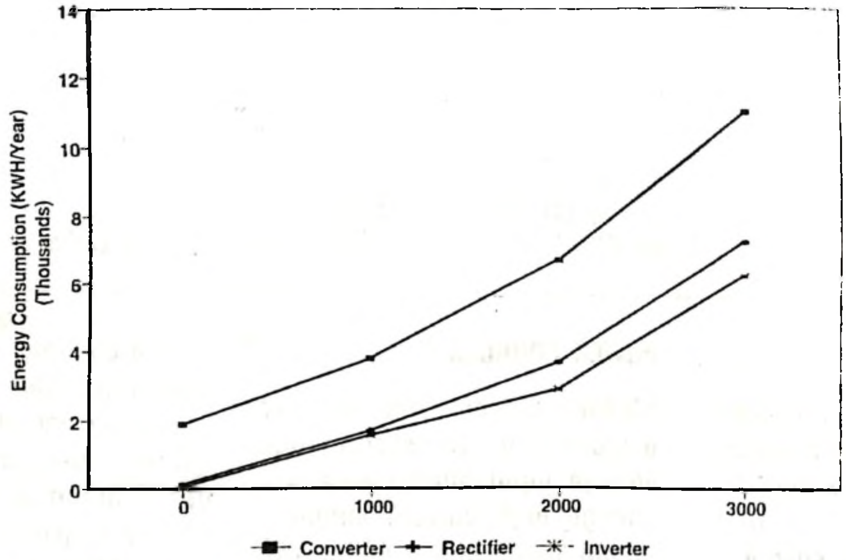

Fig. 1 : Energy consumption for different types of welding power sources

When choosing a power source for industrial welding high efficiency is obviously an important economic factor. Even if the energy cost is just a part of the total welding cost, it can be high enough to motivate the extra investment cost needed for energy saving equipment. The losses from several machines in a workshop also contribute with an extra rise in temperature in an environment that is perhaps already warm enough.

The dimensioning of the electrical installation depends on the total need for power but also on the power factor. The power factor is important for the calculation of the apparent power and size of the fuses. Inverter power sources that have many good properties, not necessarily have a high power factor. If they are equipped with a Power Factor Correction (PFC) circuit, the power factor is increased and the necessary fuse size can be reduced.

If the welding transformer has a bad power factor this implies a phase shift that can be improved by phase compensating capacitors. The power factor of inverters mainly depends on a distortion of the shape of the current, a deviation from the sine wave. The above mentioned PFC-circuit is here a possible help to improve the power factor.

If the necessary welding energy is used in short intervals, as for example in resistance welding, the mains must be able to deliver high electric power. This is comparable with the effect of a low power factor - the size of the fuses and the total cost for the electrical installation increases and can be high in comparison with the real need for electric energy as measured in kWh.

Thus the evolution process of Arc Welding Power Sources can be serialised as Transformers to Converters (Motor Generators) to Rectifiers to Solid State Rectifiers to Inverters in that order. In conventional transformers and

ESTIMATION OF ENERGY SAVING

Let us consider the following data in Indian context :

No of transformers in use	–	50,000 .
No of working days in a year	–	250
Working hours in a day	–	8
Arcing factor	–	25%

rectifiers, a good amount of magnetic materials are used which result in huge losses both in no-load and on-load conditions. In India the situation is far more worse, since transformers/ rectifiers are very inefficiently built by large number of scattered manufacturers using inferior grade laminations leading to very high energy losses. Solid State Rectifiers (thyristorised) somewhat improve the situation, in that control is effected by electronic devices like thyristers, thus obviating the need for saturable reactors eliminating one major source of power source losses. Inverters, of course, have changed the entire scenario not only from weld improvement point of view, but also on energy considerations.

Hence, idle hours (when the transformer is in no-load situation) work out to 6 hours.

If the target of achieving no-load loss to 500 W (Transformers internationally available are 400W or less) from the present average level of 750W (a reduction of 250W per transformer)

Power Savings per day

$= \frac{50{,}000 \times 6 \times 250}{1000}$ kWh

= 75000 kWh or units

Hence annual savings

= 75000 x 250 kWh or units

= 18,750,000 kWh or units

This is a staggering figure and needs everybody's attention and should be addressed on priority basis. The responsibility would lie on the manufacturers, users, industry associations, standardistion bodies and the government. One can imagine, if India goes one step further by introducing Inverters on a large scale, a step which China has already taken, a tremendous amount of energy and resource conservation can be achieved.

CHOICE OF WELDING METHOD

An interesting point is to study the welding methods with regard to their need for energy. Besides the cost of energy the heat input is an important welding parameter. Too much heat input to the joint will reduce the impact strength and introduce thermal stress and distortion in the work piece. Newer welding methods can achieve high welding speed

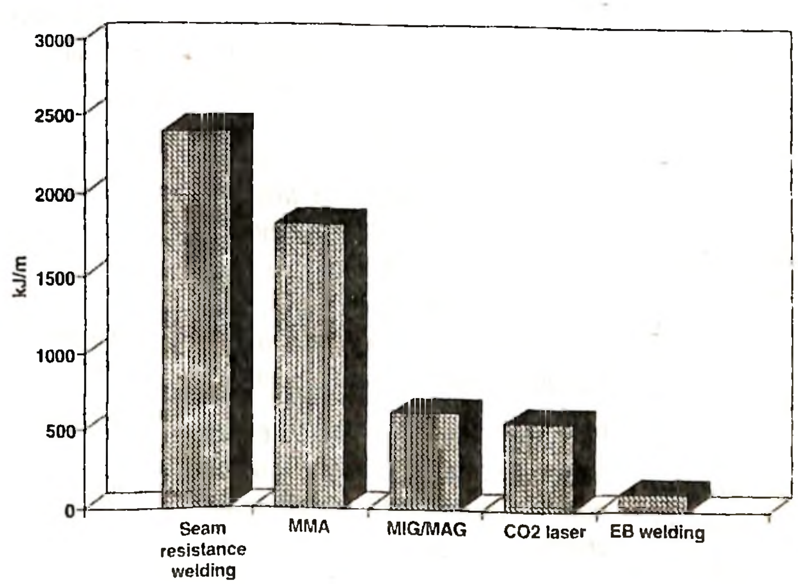

Fig. 2 : Total energy per meter need of some different welding methods. (4 mm steel plate). Power losses from the equipment is included in the calculation.

and low heat input. The diagram in fig. 2 shows a comparison between different welding methods. The total energy for a one meter long weld is calculated. It is interesting to see that in spite of the low efficiency of lasers, laser welding can compete well with the traditional methods like MMA and resistance seam welding. As a rule of thumb, the welding methods with the highest energy density usually have the lowest heat input.

ELECTROMAGNETIC FIELDS

The question of the health hazards associated with electromagnetic fields has still not been fully clarified. Even so, straightforward action may well be justified if it can reduce the level of exposure for people working in high electromagnetic fields and do so at a reasonable cost.

A low-frequency electromagnetic field is a combintion of electrical and magnetic fields but, in a given situation, one of them can be dominant.

Electrical fields originate from the voltage. They occur between live cables or surfaces. Fortunately, it is easy to do something about these fields using an earthed sheath or screen.

Magnetic fields occur around conductors through which current flows. The magnetic flux density is measured in tesla(T). In air or other non-magnetic objects, the flux density is so low that the unit μT is normally used. A low value for the magnetic flux density of low-frequency fields is 0.2 μT and it is unusual for this value to exceed 1 μT in a normal office environment.

The frequency of the field is important when it comes to its ability to transfer energy to its surroundings. So, in this way, heat or electric currents can be generated in surrounding objects.

The welder's situation

Welders belong to one of the occupational groups which are exposed to the highest field strengths. Arc welding requires high welding currents.

The welding equipment may be near the welder and the welding cables are often in direct contact with the body. In the area close to the welding cable, the magnetic field exceeds 200 μT.

A great deal of welding is performed with direct current. This applies, for example, to MIG/MAG welding, which is currently the most frequently-used welding method in industrial applications. Pure direct current probably has no effect on the health risks, but a normal welding current often has pulsations of some kind.

Perhaps the most powerful magnetic fields are found in conjunction with resistane welding. People with a pacemaker should be especially careful. It is unsuitable for them to be in the vicinity when resistance welding is in progress and, in some cases even when some other type of welding with high currents is being performed. Consult an expert physician.

Measures to improve the welder's working situation

A great deal can very definitely be achieved by passing on factual information about the health risks associated with welding. If there is a risk of injuries caused by the magnetic fields, it is probably far lower than associated with many other situations during welding.

The mechanisation of the welding process, perhaps using robots, improves the welder's working environment in a number of ways.

The following simple measures are recommended.

★ Ensure that welding cables and return cables are together whenever this is parctically feasible.

★ The best way to protect oneself from magnetic fields from a power source is to have the power source several metres away. The magnetic field decreases rapidly as the distance from the power source increases.

★ Welding with direct current is preferable to welding with alternating current.

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