Feature Article

Welding Technology for Good Milling Practice: Module 3–Welding Equipments and Welding Defects

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WELDING MACHINES CAN BE CATEGORIES

All welding machines are designed to step-down voltage - low voltage, high current and also taking safety factor into consideration. The secondary voltage, open circuit voltage (OCV) is in the range of 50 - 100 V with the current ratings varying from 5 A - 800 A.

Selection of Welding Machines

In shielded metal arc welding (SMAW) process, a suitable welding machine is required. It can be an AC transformer or a DC rectifier.

The power source selection depends on the following:

- job thickness;
- size of electrodes;
- type of supply;
- maintenance; and
- cost.

The welding power sources are:

- AC power sources;
- transformer;
- DC power sources;
- rectifiers;
- diode-based;
- thyristor-based; and
- inverter-based.

AC welding transformer is referred to as a welding machine in which the input voltage is AC 230 V/415 V and the output voltage is AC 50V-80 V. It is termed as Open Circuit Voltage (OCV). AC transformers are not suitable for non-ferrous metal welding commonly used for general purpose like in the palm oil industry. A 0.5% fluctuation in voltage will immediately cause a 7% fluctuation in the welding current, which can contribute in welding defects especially on overhead and vertical welds. When the power factor is as low as 0.45%, capacitor banks will be required to increase it to 0.9% as required by power supply authorities.

DC welding rectifier is referred to as a welding machine, which consists of a step-down voltage transformer with means to rectify AC to DC voltage in which the input voltage is 230 V/415 V and the output voltage is DC50 V/80V. DC the welding rectifier is much preferred due to its ability to weld a wide range of base metals with good striking arc, arc stability for smooth welding and radiographic quality weld.

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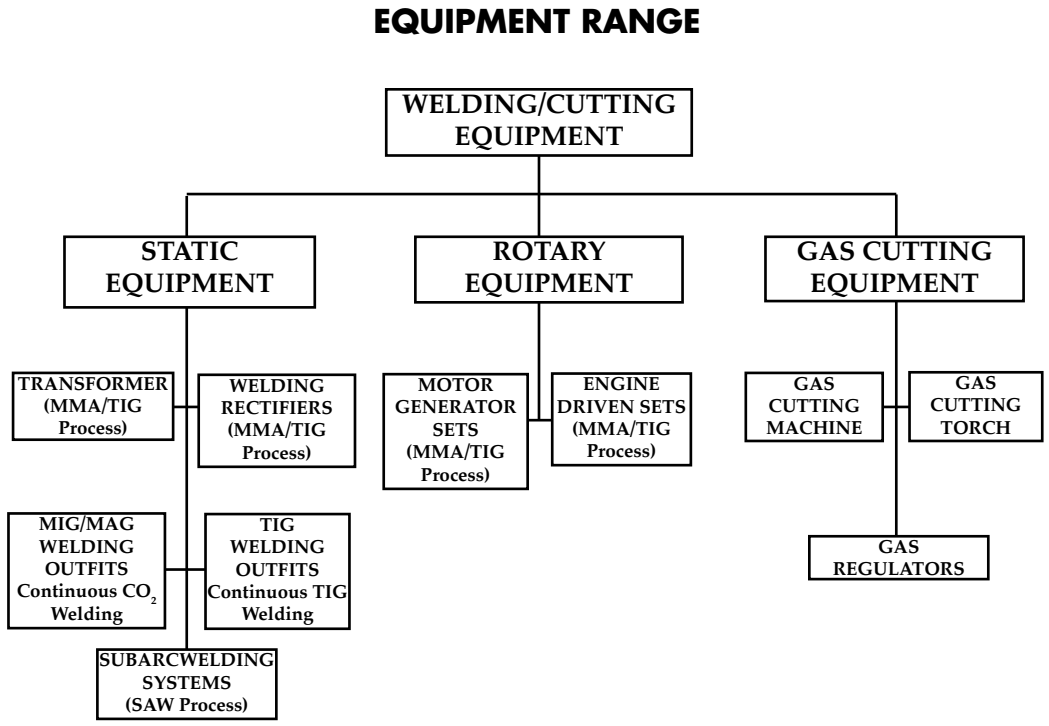


Figure 1.

In an AC transformer since there is no polarity the heat input is 50% on both output terminals. There is no changes in weld performance if the holder is connected on either one of the terminal. In DC rectifier the heat input on the negative terminal is 66% and on the positive terminal is 33%. For DCRP – direct current reverse polarity (or DC +), the electrode holder is connected to the positive terminal and for DCSP – direct current straight polarity (or DC -), the holder is connected to the negative terminal. DC + is applied for good penetration and DC – for hard facing. Usually the polarity is selected as per welding procedure requirement (WPS). Please note that the flow of electron is from negative to positive and the earth termination is very important for proper performance of the welding equipment. The earth cable dimension or current carrying capacity should be the same as the welding cable.

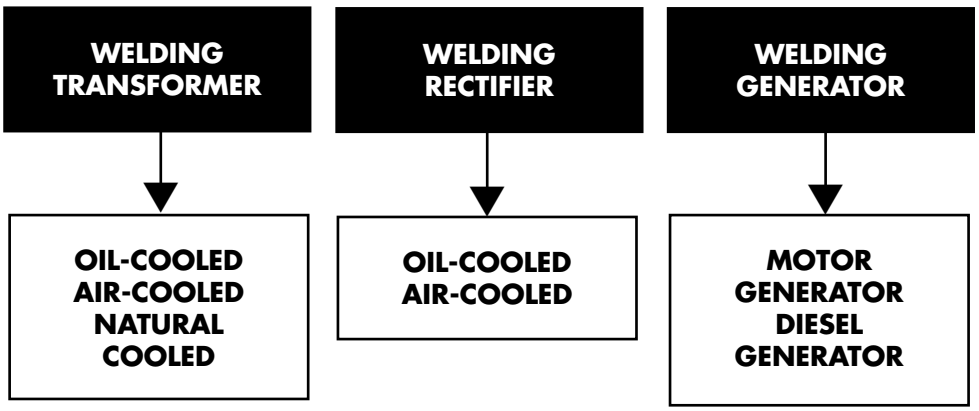


Figure 2.

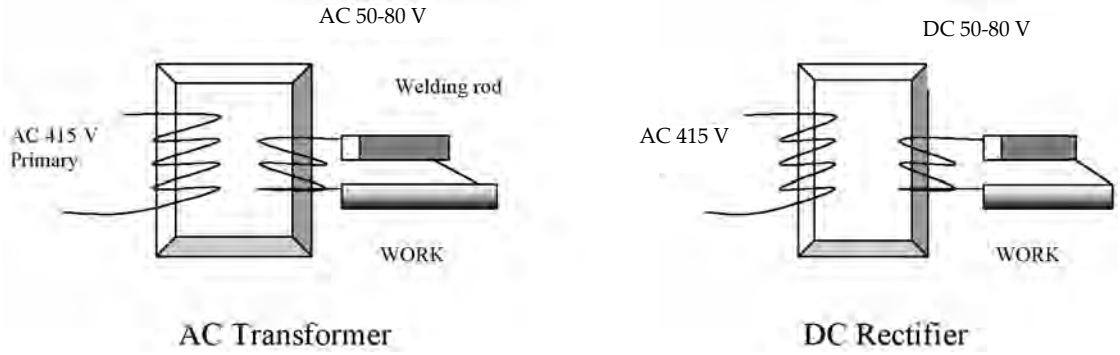


Figure 3.

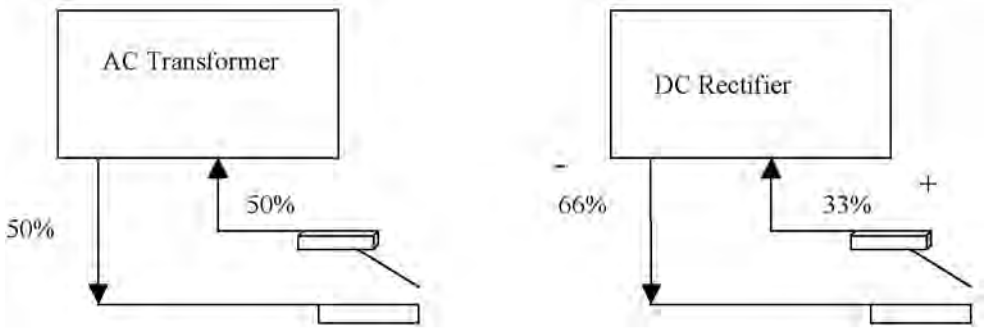


Figure 4.

INVERTERS

Inverters are well suited for good welding.

The advantages are:

- excellent welding characteristics and performance over the entire range;
- smooth and stable arc with minimum spatter;
- very fast response;
- lightweight – one-eight of conventional machine;
- compact size – one-seventh of conventional machine makes it easy to handle, ergonomic and portable;
- constant current characteristics - (within ±1%) irrespective of arc length variation;
- step less current variation;
- excellent welding characteristics and performance over a wide range;
- smooth and stable arc with minimum spatter;
- higher efficiency and power rector. Efficiency greater than 80% against conventional machine's efficiency of 60%;
- power factor correction capacitor banks are not required as power factor remains above 0.8;
- low power consumption. No load power < 100 W. Saves power bills by 33%;
- large I/P voltage range-immune to input voltage fluctuations (355-455 V);
- higher OCV. Easy arc strike/re-strike;

- excellent welding performance even with long welding cables above 50 m;
- input protection - a miniature circuit breaker (MCB) provided at the input;
- overload, thermal, under/over voltage and single phasing protection - protects equipment against over current, high temperature and under/over voltages/ single phasing;
- welding current can be varied either locally or by using remote control;
- provision of a cooling fan; and
- current depending on diameter of electrode.

Basic requirement for MIG/MAG welding process:

- constant potential power source;
- wire feeder unit;
- torch - fast/water cooled; and
- shielding gas used are metal inert gas (MIG). Argon and helium are inert gas used for aluminium, stainless steel special alloy. Metal active gas (MAG) uses carbon dioxide and argon carbon dioxide being the active gas for welding carbon steels and alloy steels.

Advantages of MIG/MAG welding:

- all position welding possibility;
- higher weld metal deposition rates;
- high welding speeds;
- low distortion;
- good and consistent weld quality with low hydrogen content;

Figure 5. MIG/MAG welding equipment.

- no stub end losses as with stick electrodes;
- higher productivity as electrode is continuous. No time is wasted in changing electrode;
- low inventory of consumables as each wire size is suitable for a large range of currents; and
- suitable for a wide range of metals, *e.g.* carbon steels, stainless steels, aluminium and its alloys, *etc.* with appropriate consumables.

Open Circuit Voltage

Open circuit voltage (OCV) is the voltage across the output terminals of the power source, under no-load condition; hence, the term no-load voltage. In constant current (CC) type machine for both AC and DC, OCV plays a very important role in ensuring easy arc striking and good arc stability. The higher the OCV the better the arc stability. However, OCV is limited to 100 V due to the danger of electric shock to the welder. For heavy duty application, OCV should be 60-70 V. On some low duty cycle welding transformer, the OCV can be below 50 V, which results in the welder not being able to strike the arc for certain low hydrogen electrodes.

DUTY CYCLE

Duty cycle is based on 10 min interval:

- 6 min - arc in action;
- 4 min - no – load operation.

Typical example of low duty cycle machine commonly used in palm oil industry welding transformer - rated 250 A.

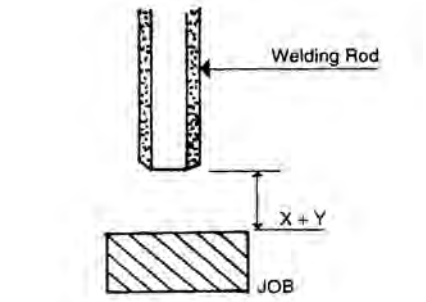
Duty Cycle - What it Means

The 40%-250 A. It means 4 min arc in action; 6 min no-load operation. This machine can be operated at full load of 250 A only for 4 min and 6 min should be idle for cooling. The 60%-190 A means 6 min arc in action; 4 min no-load operation. The above 250 A machine can be only operated continuously at 90 A. Most of the welding machines in palm oil industry are overheated or overloaded for they are low duty cycle machine. For heavy duty operation, 60% duty cycle machine is taken as the standard.

Overloading the machine will burn the coil or cause constant trip if there is a built-in thermostat. Low duty cycle machine are built with aluminium insulation for low cost. Heavy duty machines are built with class H insulation that can withstand high temperatures and can operate continuously without burning the coil but the cost is much higher.

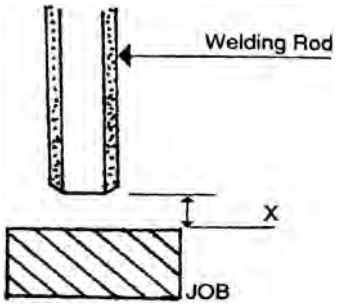
ARC GAP IN ARC WELDING

The gap between the base metal and the tip of welding electrode is called the arc gap. Depending upon the type of welding electrode, skill of the welder, the arc gap can be manipulated and good welding deposit can be obtained. It is advisable to weld with shortest arc gap to minimize the heat input into the base metal and also to minimize its ill effects. Certain electrodes are designed to weld with frigid arc, which is shorter than the short arc.

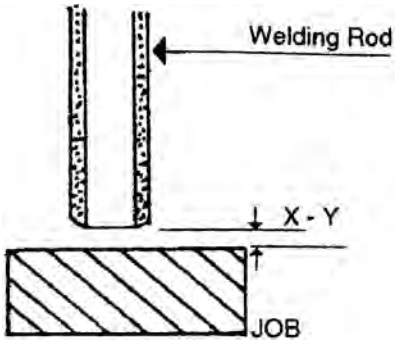


Used for melting and cutting applications

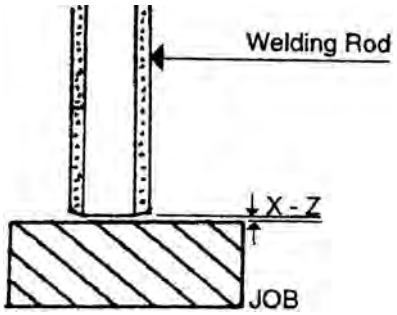
Long Arc



Medium Arc



Short Arc



Frigid Arc

Figure 6.

Long arcs are used for cutting and melting. Medium arcs are for welding low hydrogen electrodes, short arcs are for welding stainless steel and maintenance welding Frigid arcs are only for maintenance welding. With experience, a welder will be able to acquire the values of x, y and z.

Maintaining Arc Length

Minimum voltage is required to maintain the arc. In DC machines, it is easy to maintain the arc. In AC machines, the arc is extinguished at zero current point twice in every cycle. For the arc to re-ignite, a voltage is required. The arc length is an important factor in welding because it controls the arc voltage.

Shorter arc means less voltage and increased current that results in increased weld deposition rate and welding speed.

Longer arc means higher arc voltage and lower current, which leads to lower welding productivity. When the arc is too long, heat is lost to the atmosphere, spatter increases, weld metals picks up nitrogen causing porosity that causes a reduction in toughness.

In DC arc, the shortest possible arc must be used to minimize arc blow and contamination by air. DC machines have the advantage for starting and maintaining arc.

In AC machines, the electrode must have enough arc stabilizers to reignite the arc immediately (arc breaking).

Vertical and overhead welding on thick section is easier with DC because it can maintain stable arc at low currents.