Generator Technologies

Application Guidance Notes: Technical Information from Cummins Generator Technologies

AGN 079 - Alternators for Welders

MANUAL ARC WELDERS.

Traditional welding plant will consist of a transformer that steps down the input supply to a low welding voltage [typically 60 to 90V open circuit] at high current. This simple welding plant, however; is becoming superseded by the availability of the modern high frequency welders that incorporate power electronics.

Considering the conventional / traditional unit.

The transformer input supply maybe single phase and maybe supplied at 240V from a L - N supply. If welding current is over 160A, however; then it is more likely to be supplied at 415V input from two phases of a three phase supply. With either of these situations, there is a distinct possibility that the alternator will be supplying the welder as an unbalanced load across its three-phase output.

The secondary of the transformer is configured to allow a variable 'striking voltage' - typically 60 to 90V. This transformer output is then connected in series with a choke, which has been designed to allow close control over the welding output current.

Considering the latest technology units with power electronics.

Considering the latest technology high frequency units – sometimes called Suitcase Welders as a description of their shape and size. These incorporate power electronics, which convert the input to a higher frequency ac supply in order to allow the use of physically small components, such as chokes etc, These are used to provide easy control of the 'striking voltage' and then a stable level of welding current. As this system incorporates power electronics, the input current waveform will contain harmonic distortion, which in turn will generate harmonic distortion to the supply voltage waveform.

Common points.

When sizing an alternator for a welder application, the most important factor is to get the 'source Impedance of the supply' correct. This means that the alternator must be big enough to allow virtually instantaneous – unrestricted – flow of current into the welder as demanded by the welding activity. Perhaps the most difficult stage is when the welding electrode is first touched onto 'the job'. When the welding Arc is 'struck' and the operator then adjusts the arc length to maintain the required welding characteristics.

If the alternator's source impedance is too high, because the alternator is too small, and / or the alternator does not have the correct excitation system – one that cannot support high levels of alternator overload – then the act of trying to 'strike' the arc will result in the alternator's voltage into the welder being reduced. The reduction will be to a point that the welding arc will not strike, because the welding electrode simply 'sticks' to the job to be welded and insufficient current flows to melt it free and strike an arc.

When supporting high frequency [suitcase] welders - remember these are Non Linear Loads - the effects of the harmonic distortion caused by this type of welder will place an even greater demand for an alternator with a low source impedance. Low source impedance being related to a low value of sub-transient reactance (X"d) at the alternator's rated output kVA.

<u>SIZING THE ALTERNATOR</u>

Firstly consider the information supplied about the welder, which often is only the output welding current. There is a standard formula, which allows the simple calculation of the voltage required across the welding arc, which in turn allows the output power of the welder to be calculated:

> The voltage across the arc = 20 + [the welding current x 0.04].
>
> Example of 'welding power' for a 300A Welder will have some 32V across the arc.
>
> Therefore: 300A x 32V = 9.6kW of power at the point of welding.
>
> Having established the output of the welder, the next stage is to attempt to establish the input kVA to the welder. Now considerations of the welders working power factor and efficiency are required.

<u>Types of welders</u>.

The conventional / traditional transformer type.

These units can operate at 240V single phase for low welding currents typically up to 180A, and then for higher welding currents say up to 400A, they would be based on two phase supply from a 415V three phase system.

Large Welders.

Typically this type of welder will run at a power factor of some 0.7, with an efficiency of some 65%, although more modern versions using special designs of arc stability chokes in conjunction with special transformer designs can operate at a higher efficiency and power factor.

Example: A large welder that is able to provide a 300A welding current, and so based on the calculation made in the example above, has actual welding arc power of 9.6kW.

Therefore: 9.6kW / [0.7pf x 65% efficiency] = 21kVA.

If the input to this welder is across only two phases of a three phase supply, this is considered to be the L – L voltage as a single phase voltage. For example; 415V single phase. Under these load conditions, the alternator will need to be at capable of supplying a line current of 21kVA / 0.415 = 51A, which is being taken from the alternator from only two phases. Therefore this is an unbalanced load condition. A de-rate factor of some 15% must be introduced and this 15% factor is a low value, because also taken into account is the fact that a welding load is not [normally] a continuous load, and therefore a diversity factor exists.

Therefore, the required alternator rating should be based on:

[51A x 1.15] x 0.415 x 1.732 = 42kVA.

'Rule of Thumb': double the welders input kVA [21kVA] and choose a three phase alternator of this rating [42kVA].

To be able to cope with an unbalanced load – only two of the three phases being loaded – an alternator must be chosen to have a continuous rating of twice the welder's input kVA. The 'Rule of Thumb' offering the 2:1 ratio, then nominates an alternator with a low source impedance. However, it is still most important to choose the correct excitation system to enable the welding plant to have a good characteristic during the striking, and then establish good welding arc stability. The correct excitation system is with a PMG and MX type AVR or digital AVR.

Small Single Phase Welders.

For a small single phase welder of say 180A welding current, based on a 240V single phase supply:

The voltage across the arc = 20 + [the welding current x 0.04].

Example of 'welding power' for a 180A Welder will have some 27V across the arc.

Therefore: 180A x 27V = 4.8kW of power at the point of welding.

Typically this type of welder will run at a power factor of some 0.8, with an efficiency of some 80%.

Therefore: 4.8kW / [0.8pf x 80% efficiency] = 7.5kVA.

The alternator powering such a welder would need to be rated to supply a steady state load of some 7.5kVA, but must be able to tolerate the impact kVA associated with the initial welder output 'short-circuit' as the welding arc 'strike' takes place.

Using a Series 5 type transformer excitation control alternator, rated at some 10kVA as single-phase output, offers the ideal low source impedance [low X"d] alternator.

Alternatively, a conventional single phase alternator with PMG and MX type AVR would be suitable; or a similar 3-phase alternator reconnected in Double Delta for a single phase output.

These alternative options would need to be continuously rated for at least 12.5kVA single phase.

MIG and TIG welders.

These single phase welding plants, operating with an ac output at rated frequency [50 or 60Hz], are often used in MIG and TIG welders. The guidance and factors for alternator sizing remain the same.

Many modern MIG and TIG welders use high frequency technology, and so the following guidance for ‘suitcase’ welders should be followed for modern technology MIG and TIG welders. Some TIG welders have a special ‘arc-striking’ circuit that doesn’t involve touching the electrode onto the work-piece, but still nominate an alternator with a short circuit current capability, and use the same level of ‘over-sizing’ as outlined above.

Modern ‘Suitcase’ welders,

These welders often require a 3-phase supply and usually operate at some 0.9pf and 85% efficiency. Therefore for the above example of a 300A welding current will result the 9.6kW of welding power requiring an input power supply of [0.9 x 0.65] = 16.4kVA.

These modern welders, however; use a high frequency system generated by power electronics to achieve the required welding characteristic, and so present their power source [the alternator] with a Non Linear Load.

This type of welder will be a balanced three-phase load, but as a Non Linear Load. The alternator must be selected to be compatible with the input harmonic current distortion, which should always be identified. The current distortion is likely to be typical of an unfiltered 6-pulse bridge characteristic and so some 30% THD of I.dist.

The expectations of the welder’s power electronics will be that the ‘source impedance of the supply’ [the alternator] must be kept low, as is the case for any Non Linear Load. In fact the welding equipment will expect the harmonic voltage distortion to be kept as low as possible, and this may mean it must not exceed 15%.

Achieving this will result in our example alternator being 30 to 35 kVA, if the fitted with transformer control or a conventional single phase alternator with PMG and MX type AVR.