Developments in the design of AC Welding Plant

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1 INTRODUCTION

The construction of the conventional manual-arc (MMA) welding transformer has remained almost unchanged for many years. However, as AC welding has some special features there is a need to study alternative possibilities for further development of AC welding equipments. The following article considers various control principles and the use of semi-conductors and special circuits to produce square-wave welding current for improved welding characteristics and improved satety.

2 CONTROL OF MAGNETIC LEAKAGE FIELD

The control of a conventional welding transformer is based on the adjustment of the magnetic leakage field flowing in the air-gap and the iron core. The magnetic interaction can be adjusted by changing the mutual position of the transformer windings or by moving an iron core between the primary and secondary windings. The mutual position of the windings can be changed either by using transformer tappings (Fig la) or by moving the windings mechanically (Fig 1b).

Transformers of these types give an almost sinusoidal current waveform as in Fig 2a. The unlinear character of the magnetic circuit very often results in a harmonic distortion of the welding current, producing a waveform as in Fig 2b.

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The current waveform has great importance in AC welding. With supply frequency of 50 Hz the welding current will be at zero one hundred times in every second. At these points the arc is extinguished. The momentary open-circuit voltage appearing between the electrode and the work piece maintains the arc ionisation and results in re-ignition of the arc. Arc re-ignition and the stability of the arc depend on the value of the OCV and also on the distortion of the welding voltage and current.

By using the optimum design parameters for the magnetic circuit, the distortion can be eliminated but the basic design, for quality welding, still has several disadvantages. It requires an OCV of 70 volts to make it suitable for all types of electrodes ; the output varies with changes in the supply voltage ; the mechanical control can be noisy and presents difficulties for remote operation. When used for high quality TIG welding, the conventional AC plant is far from ideal.

3 CONTROL WITH MAGNETIC COMPONENTS

To achieve the necessary volt amp characteristic as shown at Fig 3, various magnetic components can be connected in the welding circuit. Fig 4a shows a welding transformer with a reactor of which the magnetic state can be modified with a DC magnetizing current. The application of a magnetic amplifier for the same purpose is shown in Fig 4b. The magnetic control can also be designed to operate in conjunction with the welding transformer.

By using magnetic control, the advantages of the modern electronics can be utilised. However, the unlinear

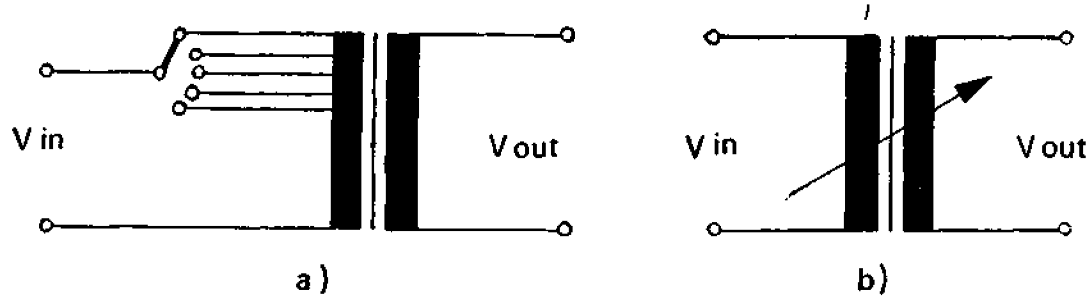

Fig 1

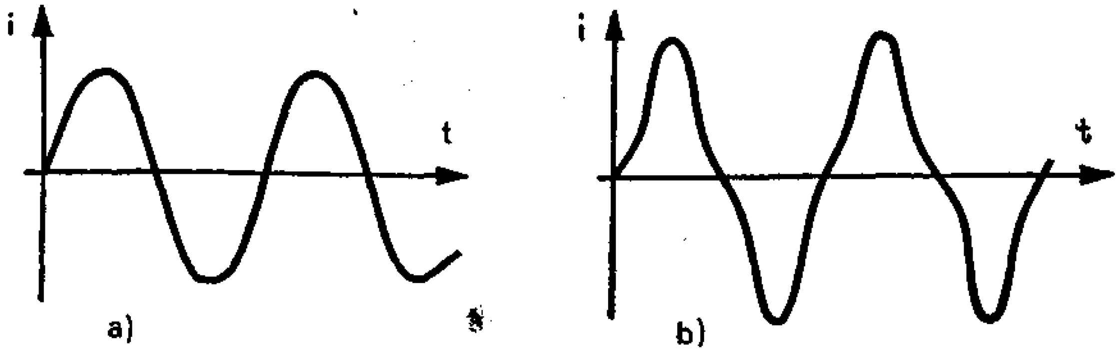

Fig 2

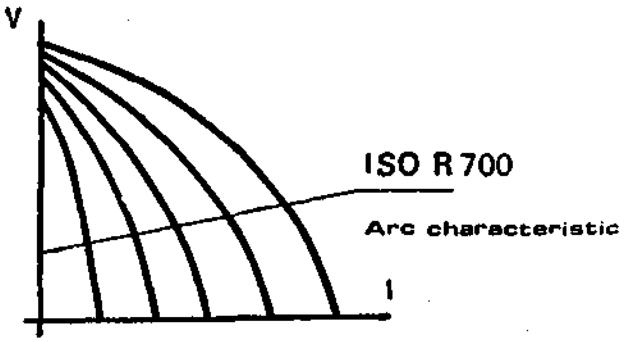

Fig. 3

characteristic of the magnetic components can cause a harmful distortion in the welding output and this design has not been a practical success.

4 CONTROL WITH SEMICONDUCTOR DEVICES

During recent years, thyristors have been increasingly used in DC welding plant design. Some applications have also been introduced for AC welding. Fig. 5 shows the basic circuit for AC welding. The wave form of the load current is shown in Fig. 6.

This simple curcuit is not directly suitable for welding purposes because the welding current is cut off during the non-conductive state of the thyristor. Some alterna, tive solutions to achieve better current waveform are shown in Figs 7 and 8.

These circuits have the same disadvantage as the magnetic control circuits. They lead to distortion of the welding current. So they are not generally accepted as practical solutions.

4.1 Square Wave Technique

It was observed above that the behaviour of the AC welding current at zero points is an important criteria in determining the welding characteristics.

Of all possible current waveforms the square-wave is the most ideal for AC welding as re-ignition of the arc at current zero occurs most readily.

There has been a tendency to develop practical semiconductor circuits to achieve square-wave current for welding purposes. Figures 9 and 10 show two alternative thyristor circuits giving square-wave current waveform as shown in Fig. 11.

An ideal square waveform of current can also be achieved by using a switching technique. Fig 12 shows a principal block diagram, with a semiconductor switch connecting positive and negative polarity of a DC power supply to the welding circuit. Transistor or thyristor circuits can be used for switching.

The design makes it possible to control both the frequency and the duration of the half cycles. In addition,

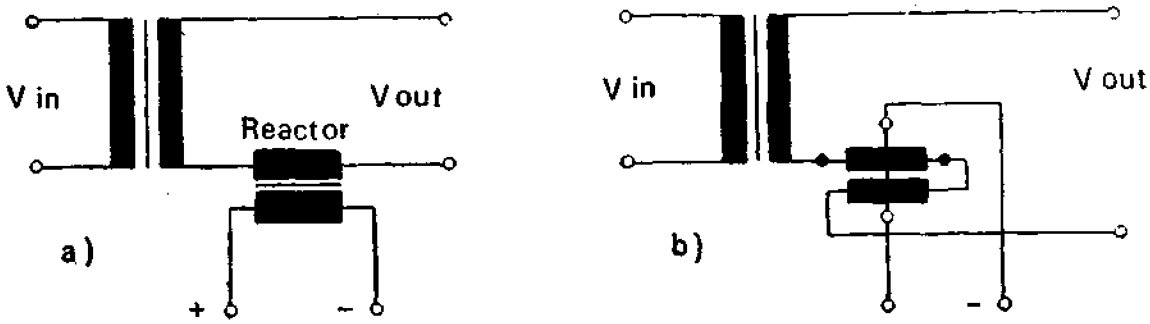

Fig 4

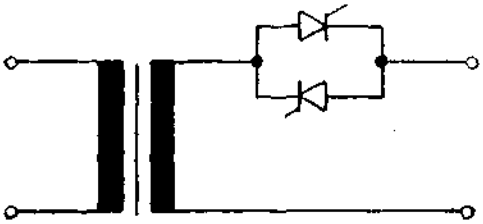

Fig 5

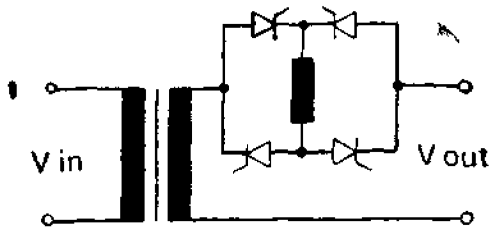

Fig 9

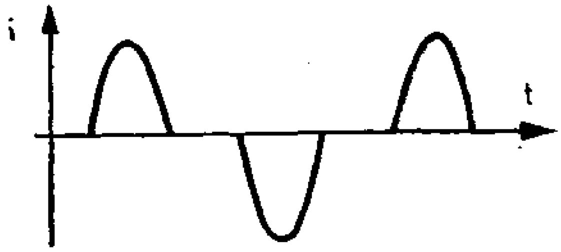

Fig 6

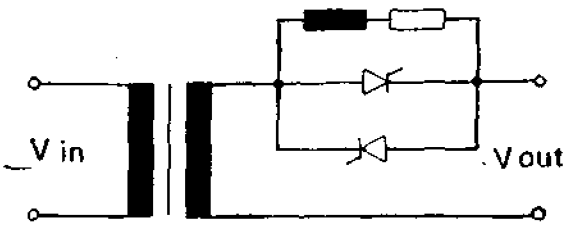

Fig 7

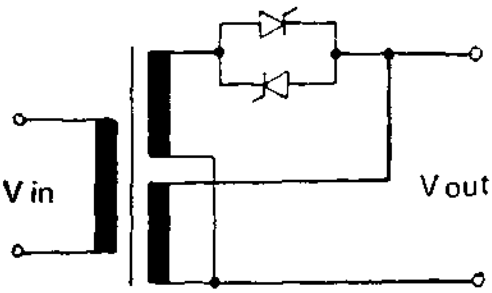

Fig 8

and by comparison with the use of the conventional sinusoidal waveform, the square waveform offers other advantages, for example :

- The most difficult basic electrodes can be used with AC.
- Arc striking and the arc stability of all types of electrodes are better even on the wider current range. Excellent arc striking is normal even with a lower open circuit voltage.
- Weld spatter is reduced because the current peaks are lower. For the same reason, the current capability of electrodes will be better.
  The penetration will be increased.[1]
- When used for TIG welding, the current capability of the tungsten electrode will be increased and the wear on the electrode is reduced.[1]
- On TIG welding aluminium, the asymmetry of the welding current caused by the rectification phenomena is avoided. Capacitor (DC suppressor) units are unnecessary, even for the highest standard of welding.

By using electronic control, it is possible to achieve the desired static and dynamic characteristics, to employ AC pulse welding and to maintain the output characteristics independent of supply voltage variations. Remote control of the welding current is also very simple and in expensive.

5 ELECTRICAL SAFETY IN AC WELDING

In some circumstances, the resistance of the human body may be significantly low, for instance if the current

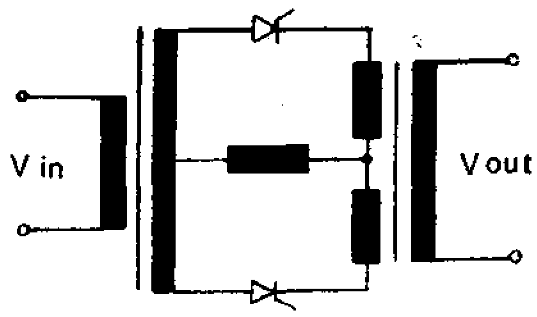

Fig 10

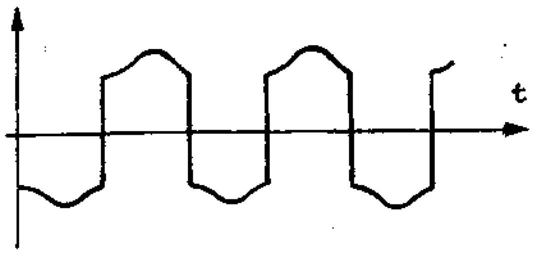

Fig 11

path goes from the elbow to the neck. Thus AC current with a frequency of 50 or 60 Hz through the heart zone may cause complications irrespective of the fact that the open-circuit voltage is within official safety standards. It is necessary therefore that every effort should be made to develop modern AC welding machines which eliminate electrical risks. At the moment there is increased activity on this aspect in several international organisations such as IEC and Cenelec.

According to Cenelec[2] the maximum open-circuit voltage for AC welding in normal conditions is 80 V (RMS). For welding in surroundings of increased electrical risks, there are many national regulations, e.g. the German VDE[3] which defines a maximum open-circuit voltage of 42 V in these circumstances. In Denmark, the corresponding voltage of 12 V comes into force from the beginning of 1979.

Most conventional designs of good quality welding transformers can be fitted with additional equipment to reduce the open-circuit voltage to a safer level but significant technical problems may arise in arc striking and in maintaining a stable arc.

The design of the AC welding machine previously described makes it possible to reduce by electronic means the open-circuit voltage to any desirable level. The AC welding machine shown in Fig. 12 has an open-circuit voltage below 12 V. An additional safety circuit disconnects the machine from the mains if the safety voltage level is accidentally exceeded. In spite of the very low open-circuit voltage the performance of the plant on arc striking and weld stability is excellent.

6 SUMMARY

The conventional welding transformer has held its position and challenged the development of new designs for many years. The development of semiconductor devices and electronic technology in the field of welding has now made it possible to achieve a very practical design of square waveform for the welding current. This opens new horzons for AC welding in the future. By taking advantage of the new technique, it is possible to produce better AC welding characteristics and, at the same time, reduce the open-circuit voltage to a very safe level.

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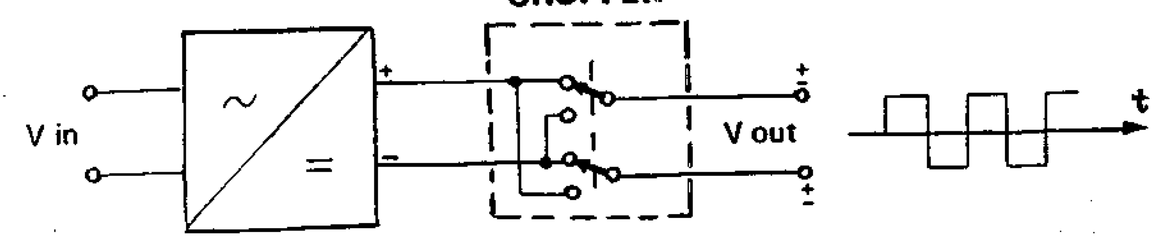

Fig. 12