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ADVANCED CONVERTER OUTPUT CONTROL TO REDUCE SPATTER IN GMAW

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Abstract- The improvement in welding performance is achieved with the adoption of the inverter circuit topology for the welding machine sector. But traditional arc soldering machine converters uses the properties of constant voltage. So, in view of spatter generation, the metal transfer is done under suboptimal condition. Melted metal explosions occur when the arc is restarted during short-circuit metal transfer of the gas metal arc welding (GMAW). This can spread around and on the welding beam in particular when carbon dioxide is the protective gas. After soldering the spatula requires additional cleaning. Many investigations and patents have been carried out to quickly regulate the output current in GMAW to reduce the spatter. This fast output regulation can reduce up to 80% amount of spatter, which highly increases the productivity and reduces the cleaning work. The main objective of this paper is to suggest the efficiency in the proposed GMAW implementation of hybrid control method for the speedy regulation of output voltage and output current.
Index Terms- Gas metal arc welding

I. INTRODUCTION

Arc welding machines have been widely used in the building and automotive industries [1–12]. There are two different types of welding arc, driven by the AC and DC currents, respectively [3]. The heat generated during the arcing period is concentrated mainly in the sold material for the DC straight polarity method (DCSP). The DC reverse polarity (DCRP) is instead approaching Instead, the DC reversed polarity (DCRP) approaches the welding work for longer because heat is concentrated primarily on the electrode end. However, during theDCRP cycle, emissive electron forces exposing clean metal to be sold are releasing the oxides on the surface of the work piece. The AC Arc welding technique combines advantages of both DCSP and DCRP. Due to advantages of high speed and almost all types of metal welding, GMAW is a very common arc welding method for joining metal [1]– [3]. GMAW is also known as MIG (metal inert gas) /welding or MAG (metal active gas) welding, depending on the shielding gas used. One of the most common metal transfer approaches in GMAW is short-circuiting metal transfer. Fig. 1[4] shows the circuit diagram of a traditional GMAW device.

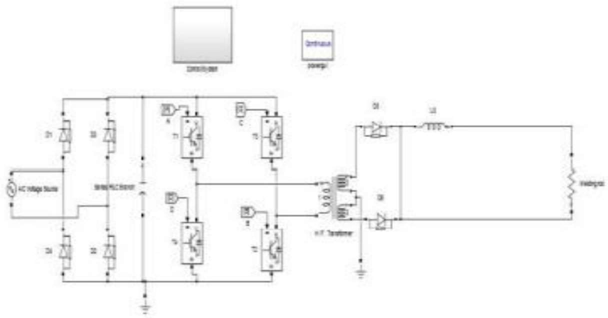
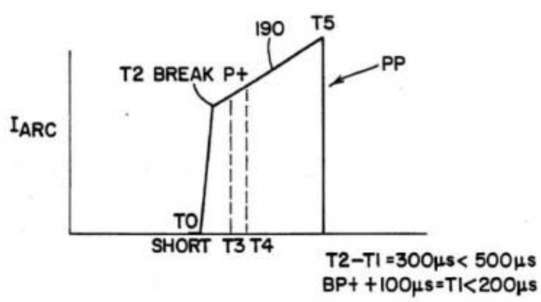
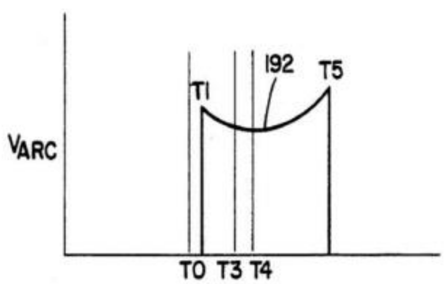


Fig.1 Circuit of conventional GMAW machine

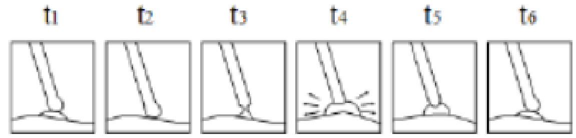
To provide a desired power for welding, an isolated DC/DC converter is used. The machine's output voltage is controlled because GMAW needs a constant voltage source [5], [6]. In contrast to the operation of a traditional DC/DC converter, short circuiting occurs frequently in GMAW. As a result, an additional control circuit is required to enforce the inductance function, which determines the rate at which the output current increases after a short circuit, as well as the slope function, which determines the maximum output current during theGMAW's short circuit process. Furthermore, due to the short circuit operation of GMAW machines, large output capacitors are not used. In a traditional GMAW, the output current and voltage waveforms, as well as the short-circuiting metal transition, are shown in Fig. 2. [7]



(a)



(b)



(c)

Fig 2. Shows a) arcing current b) arcing voltage c) short circuiting metal transition cycle

Generally the metal transfer modes of GMA welding machine are divided into short-circuit and globular metal transfer modes. These metal transfer modes are determined by the magnitude of output current and voltage. Short-circuit metal transfer is performed at low output current levels, while globular metal transfer is performed at high output current levels. Consumable wire electrode is meltedby the arc heat between the tip of the wire and the molten pool or base metal in the region of low welding performance current, i.e. less than about 200A, and then molten wire is expanded and contacted with molten pool or base metal. It forms a short-circuit bridge at this point, causing a broad output current to flow. The short-circuit bridge is broken by the massive output current, and the arc re-ignites. Short-circuit and arc states are repeated after metal transfer mode. In the high

current region (above 270A), however, another metal transfer mode, globular metal transfer mode, exists in addition to the form of metal transfer mode mentioned above. In the globular metal transfer mode, the molten wire is enlarged in an arc state before being lowered into a molten pool or base metal without creating a short circuit. Thus, large spatters are produced in globular metal transfer mode. (a) The power produced at this point needs to be decreased in order to reduce the spatter in t4. One efficient approach is to quickly reduce the current to a minimum before the arc re-ignition. The current quickly decreases to the minimum level before reignition of the arc, awaiting re-ignition. If the arc reactivates at t4, the power is also at the minimum, as the current is in the lowest position. This will produce the minimum spreader level. After reignition of the arc at t4, the current increases and the wire finishes melt for the next cycle. (b) In addition to reducing the spread, more precise and fast power or voltage control can be applied to different applications, such as thin material cold arc welding; deep penetrations for thick material, fast speed welding for high production and other applications. A number of machine manufacturers have researched the new regulations for lowsparkling GMAWs. In Figure 4, Lincoln proposes to demonstrate and describe a collection of the desired current and tension waveforms in Surface Tension Transfer (STT) [10]. The advanced GMAW machine has two control modes, i.e., current control and voltage management. During the short-circuit phase, the system is controlled and the current of the output is regulated to monitor the reference current signal in red solid line, while during the arcing phase, the voltage is regulated to track the reference voltage signal, as shown in blue solid line. If a short circuit occurs on t1, vo drops below a threshold of vsc to show that the short circuit is occurring. The computer is then moved to the new control. In order to enable the occurrence of a firm short circuit, the output current from t1 to t2 shall be controlled at a minimum level (io r2).

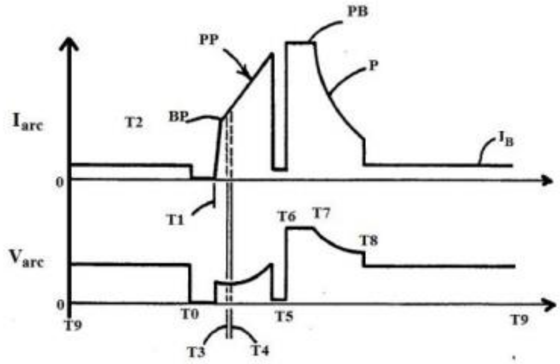


Fig.4 Desired Current and Tension Waveform

After t2, the current increases to produce magnetic force to link the wire to the welding reservoir. io r1 will remain constant afterwards if io exceeds the maximum stage. As the cross-sectional area of the connection is smaller, the connection resistance is greater. The voltage increases accordingly because of the constant current. If dvo/dt attain a certain value at t3, which shows that the relation is about to break, the output current is forced to decrease quickly. The output current is regulated if the output current approaches io r2, to maintain the current level in minimum order to wait until the arc is reignited. The arc is revived at t5, the voltage of the output increases by vo sc, which shows that it is in the arcing process. Then the voltage control is turned on. The voltage of the output from t6 to track vo r1 is adjusted to permit the wire end to melt at high current. After t7, the output voltage decreases when a melted ball at the end of the wire, reducing the heat produced in the arc, waiting until the next event occurs. On t8, the short circuit takes place and repeats the process above. A hybrid control method for rapidly regulating the voltage and output current as per the desired waveforms is proposed in this article.

II SYSTEM DESIGN

The circuit and control device of the power phase must both be adjusted to incorporate the desired waveforms as shown in fig. 4. A semiconductor switch between the correction diode and the inductor output is applied to the power stage circuit as shown in the figure 6. This switch, T5, has the feature of quickly reducing the output current just before reigniting the arc [11]. A hybrid control circuit, as shown in Fig. 5, is proposed in the control system. This will describe the function of the control system. Usually the user's received information, such as demand voltage or request current and solder, such as the arcing phase, the short circuit phase or the necking signal, are managed using the microcontroller, and subsequently sent demand message to an analogue feedback controller. Analog demand signals as shown in Figure 5 are sent from the microcontroller to second order low-pass filters. To get the second

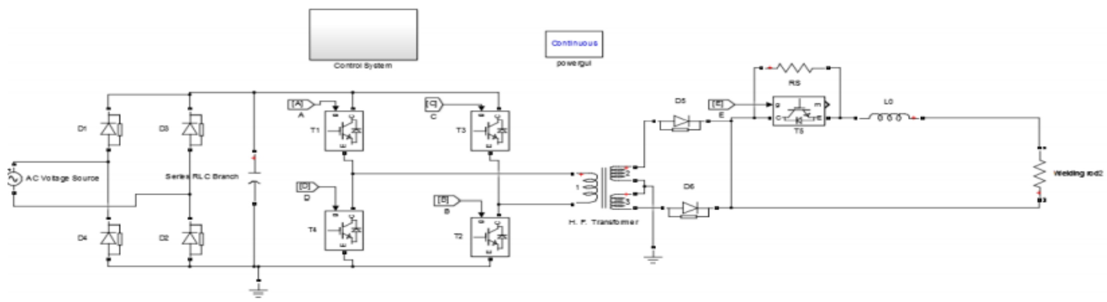
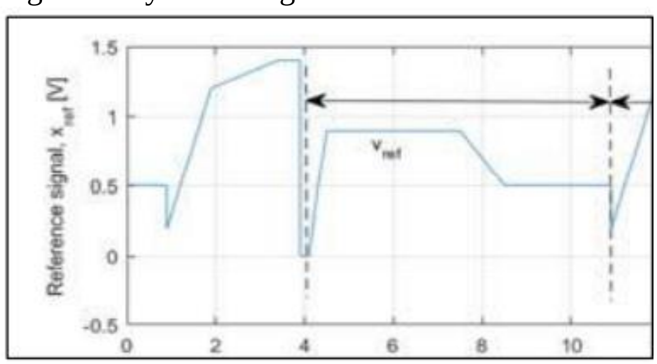
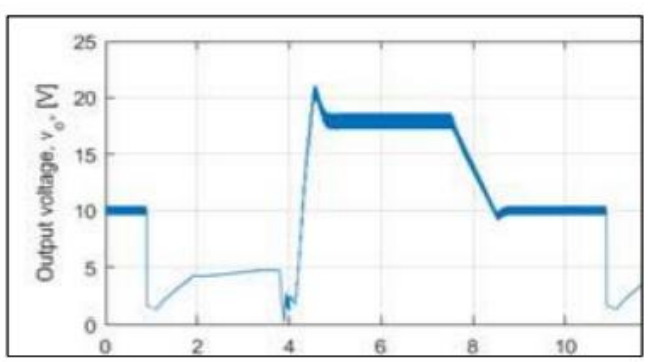


Fig.5 Modified GMAW circuit

III SIMULATION AND RESULTS

The power transducer circuit is the same as the circuit shown in Fig. 4. A load circuit is developed and constructed to simulate the load in the GMAW with short-circuit mode. A 2-inch load is used to simulate the load of the system during the arcing stage, which consists of 8 1-inch resistors. In short circuit step the load of the welding machine is simulated with a 0.1 TEL load, which is connected to the electronic power circuit output by an IGBT power. This IGBT power is operated by a control cycle to produce repeated operating conditions during arc and short-circuit phases. When the load necking signal is given on the control circuit at point A, the generator PWM will be switched off in the control circuit and the T5 turned off to decrease rapid output current. The generator and T5 are enabled when the output current is reduced to a low level at point B and the output current is controlled to a lower level before the arc re-ignition. If the arc at point C is reinflamed, the output voltage increases and circuit is regulated by the voltage.





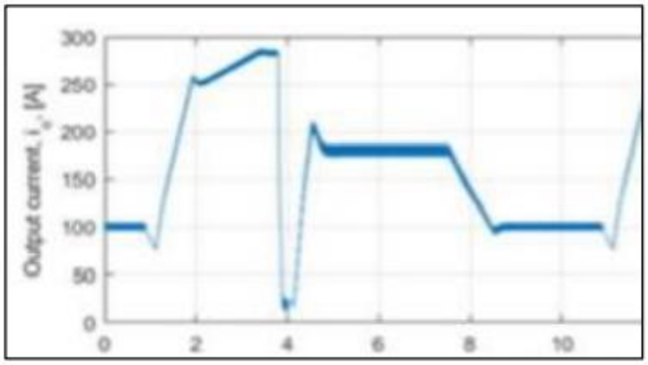


Fig 6 a)Reference signal b)output voltage c)output current

IV CONCLUSION

This paper demonstrated a hybrid control system to introduce an advanced GMAW. The main advantage of this control is that it can reduce the amount of spatter during short circuit GMAW. The power supply for the welding is operated in the voltage arcing process and in short-circuit phase under current control. The advantage of this hybrid approach with integrated digital control rely on the specifications of the welding needs and is the ability to decide optimal control mode and generation of the corresponding signal. A welding machine prototype with the proposed control method will be developed in the future to check the reduction of spatter in the welding process.

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