5th European Symposium on Super Capacitors & Hybrid Solutions
April 23-25, 2015

SUPER-CAPACITOR FOR ARC WELDING

V. Bršlica*
* University of Defence in Brno, Czech Republic, Faculty of Military Technology y

Abstract

The paper is focused on an implementation of the super capacitor SC into the arc-welding power source to improve its properties. There are namely the mobile power-sources for maintenance and repair service which are power limited due to the fusing of low voltage installations in buildings. The variable power output for the electric arc power source can be with advantage "smoothed" by the energy storage device, which must be able to deliver high power from low volume (and mass), other way said to have high power density. The proposed solution of the power circuit in its most simple version allows eliminate the power peaks from starting the arc to the grid behind the plug and improve also the reverse effect on the network and eliminate the flicker creation. The fixed installation of SC at the output terminals prevents any accidental voltage increase and ensures the safety of the operator. The sufficient power reserve brings also higher metallurgical quality.

Introduction

The electric arc represents very nonlinear resistor and the perfect welding process needs the special properties of the electric power source for supplying of the arc, dependent on the welding method (MAG, TIG etc.), during all the process from ignition to extinction. This paper is focused on the traditional manual arc welding with coated electrodes known as MMA, which can be in principle AC or DC supplied. The AC supply needs heavy 50 Hz transformer with great leakage and soft characteristics, the special rutile coated electrodes, and here it is not more studied. The DC supply can be realized by the same transformer plus the one-phase bridge rectifier, but it needs moreover the big and heavy inductor to remove large current ripples. The modern power electronics components (IGBT, MOS, Shottky) bring the new generation of portable DC power sources called on the market INVERTERS, which are light-weighted, efficient, but with the same limit of power given by the fuse protection of plug, which is typically 10 Amps. The weight is reduced thanks to high frequency transformer with ferrite core, operated at 40 kHz or higher frequency.

Inverter

The configuration of inverters is generally known, the addition of the SC requires the new topology in the end of the power flow chain with separate control of the power from plug and the power for the arc (Fig.1).

R1		INV	TR		R2	SC	WCC	
U_1	U_2		U_3	U_4		U_5		U_6
230 V	210 V		0 – 220 V	0 – 50 V		50 – 70 V		5 – 50 V
I_1	I_2		I_3	I_4		I_5		I_6
0 – 10 A	0 – 11 A		0 – 25 A	0 – 100 A		0 – 100 A		0 – 200 A
AC 50Hz	**DC**		**AC 40K**	**AC 40KHz**		**DC**		**DC**

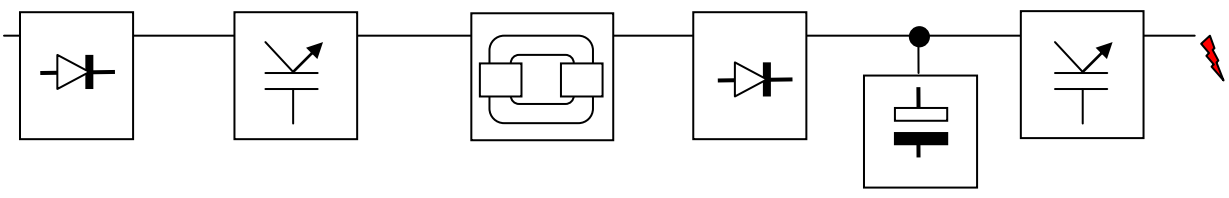

Figure 1 Structure of the power conversion chain with SC for the arc-welding supply

The insertion of the energy buffer represented by SC all the block from left side (from the plug to the SC) can be designed for maximal current under 100 A, the inverter INV which has in original power source also the function of welding current control has now only one function to control the charging of SC. The volt-amps characteristics now are controlled by simple DC/DC inverter WCC, which is designed for the full welding current 200 A. This limit allows maximal electrode size up to 4mm (Table 1).

Ø electrode (mm)	1,6	2	2,5	3,25	4	5	6
Rutile	30-55	40-70	50-100	80-130	120-170	150-250	220-370
Basic	50-75	60-100	70-120	110-150	140-200	190-260	250-320
Cellulose	20-45	30-60	40-80	70-120	100-150	140-230	200-300

Table 1 Survey of welding currents for various electrode thickness

Not looking on the price of SC, the additional weight of this component in the relatively light inverter, which is typically about 6 kg, limits the available energy in SC. The model parameters of the block of individual cells are briefly in Table 2. Thirty super capacitor cells of 350 F/2.7 V each are connected in series with resulting capacity 11.6 F and 75 V. It were used Electric Double Layer Capacitors (EDLC) with nonaqueous electrolyte have a total equivalent series resistance (ESR) under 100mΩ. The additional weight of SC is 2 kg, and the stored energy is 38 KJ.

350F	2,7V	66g	3,2mΩ	5,4Wh/kg	0,35 Wh	1,26kJ
11,6F	81V	2kg	96mΩ		10,5 Wh	37,8kJ

Table 2 battery of 30 in series EDLC cells type S501LF357V2R7A

It can be seen in Table 3, that from the thermal reasons the standard inverter cannot be loaded continuously at higher welding currents and for the cycle 10 minutes the duty cycle is defined. Typical time for one electrode is under 2 minutes, then the SC is again recharged.

Duty cycle	I (A)	U (V)
25%	170A	26,8V
60%	120A	24,8V
100%	100A	24V

Table 3 The typical inverter output parameters for MMA coated electrodes

The proposed configuration saves the power of first four blocs (R1, INV, TR, R2) in Fig. 1 where the smaller components can be used, and only the output bloc WCC must be realized from stronger components, which his practically only one power switch because it is simple DC/DC converter.
The SC parameters are suitable for elimination of the power ripples, but his energy is not sufficient for the cycle declared by EN 60974-1.

Alternatives

The very interesting mobile power source for welding is the simple set [1] of three automotive batteries 3x 12V/60Ah or greater capacity, which has a sufficient amount of energy for typical maintenance works and it can be with advantage used in isolated areas out of grid. The weight is nearly the same as of the transformer. This power source can be easily charged from low power fuel cells or from some week rotating generator with advantage. If the lead acid battery is replaced by modern Lithium battery the weight of such mobile power source for welding is about 11 kg for 450Wh and it is sufficient for eight 3,25mm electrodes or 18 electrodes with diameter 2,5 mm respectively.
Only the expected new generation of SC with graphene electrodes can bring the significant advantage of SC comparing to the modern lithium batteries.

REFERENCES (SELECTION)

[1] Rozmarynowski et al. BATTERY POWERED WELDING SYSTEM, Patent US 2012/0006792 A1, Jan. 12, 2012

[2] Emergency Welding Using Automotive Batteries http://www.lcool.org/technical/80_series/bat_weld/battery_welding.html

[3] Bruce Patrick Albrecht, Hybrid welding systems and devices, US8415588 B2, EP2454045A1

[4] http://www.weldguru.com/welding-history.html

[5] J. Motloch, Akumulátorový zdroj MMA pro mobilní a pohodlné svařování, Technický týdeník, 3. 8. 2014, http://www.technickytydenik.cz/rubriky/archiv-technik/akumulatorovy-zdroj-mma-pro-mobilni-a-pohodlne-svarovani_26131.html

[6] Arc welding equipment - Part 1: Welding power sources, EN 60974-1

[7] World Novelty: Battery-Powered Welding with MicorStick and MobilePower, http://www.lorch.biz/index.php?id=5743&L=6&PF=5

[8] S501LF357V2R7A in http://www.mouser.com/ds/2/212/KEM_S6003_S501-453789.pdf