ELECTRON-BEAM WELDING AS A HIGHLY EFFICIENT ENERGY-SAVING METHOD OF JOINTING THE METALWORK MATERIALS

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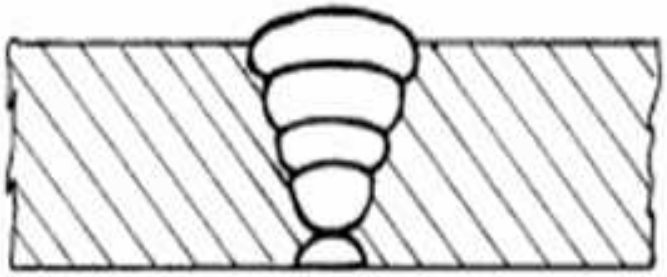
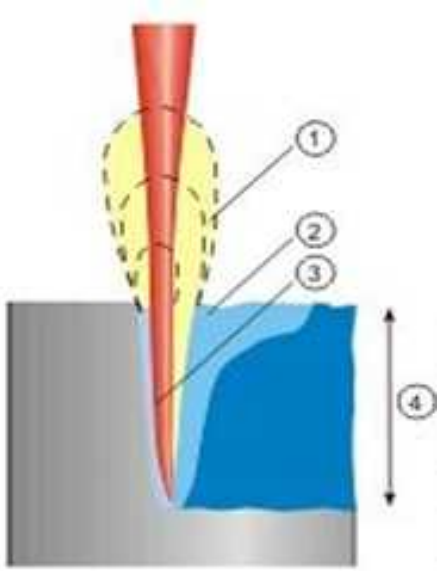
Electric arc welding

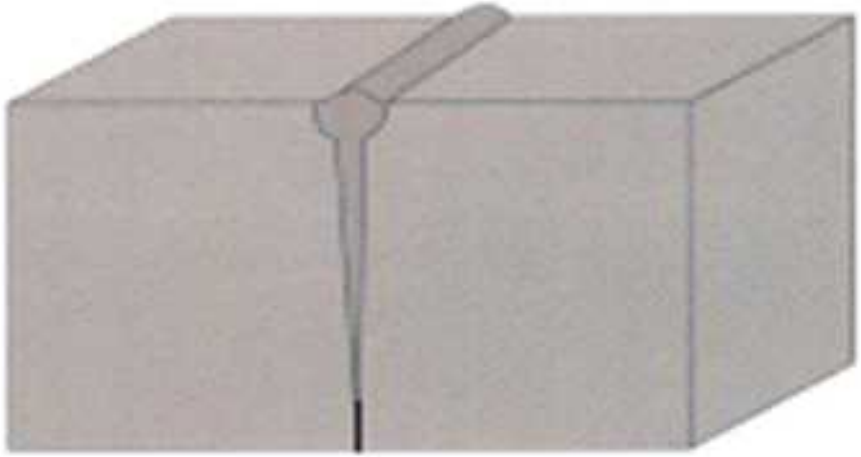
Despite the high efficiency of the electric arc welding, this technology is very energy-consuming with performance factor of 50…65% which also strongly depends on operation conditions and implementation. When a metal material is relatively thick, the multiple-pass arc welding is required which consumes much more energy compared to the normal arc welding.



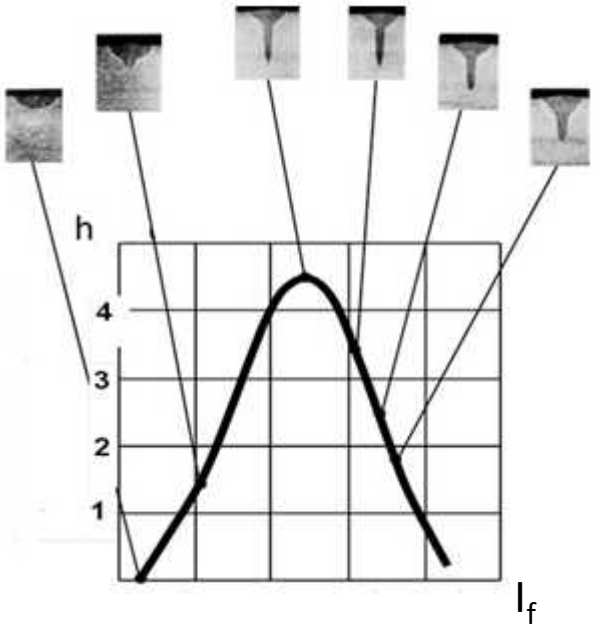
Penetration channel and cross-section of a welded joint



1. Plasma
2. melting metal
3. Keyhole
4. welding depth

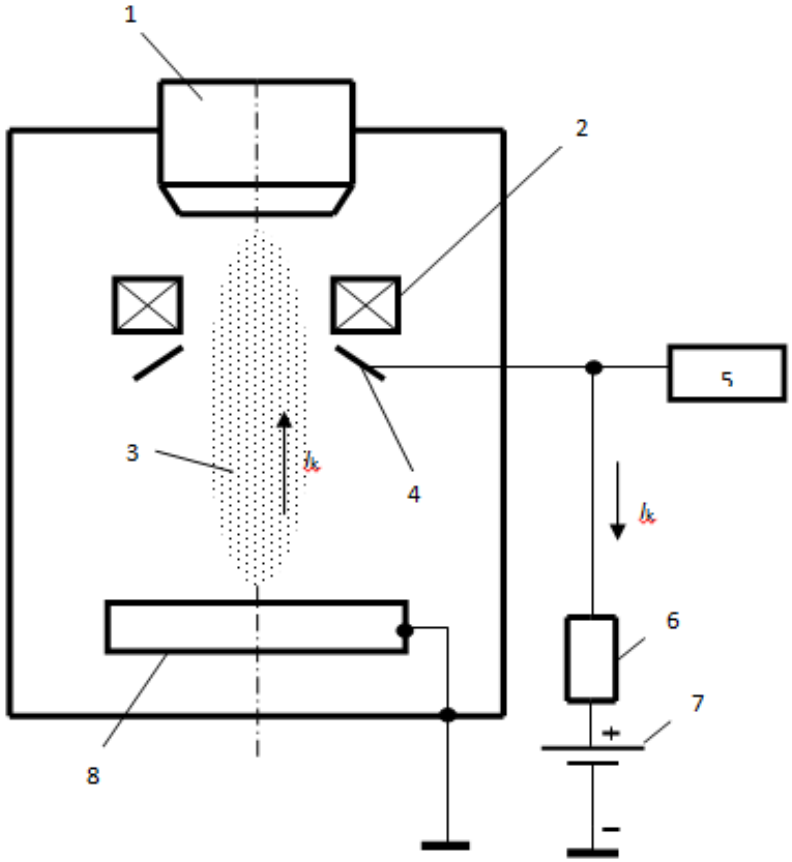


Dependency of the penetration depth from the focusing current



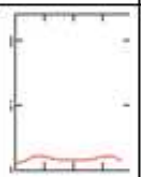
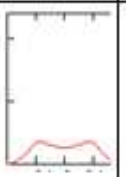
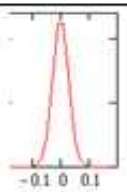
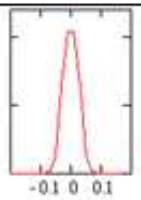
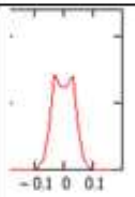
Efficiency of electron beam welding can amount to 90%. But, in some cases, it may be difficult to efficiently save energy using the electron-beam welding since geometric dimensions of the penetration area cannot be exactly reproduced. The electron beam which significantly impacts the profile of the future joint is often hard to focus properly by adjusting the current in the electromagnetic focusing subsystem of the electron gun.

Registration of the secondary current in plasma above the area of the electron-bean welding



1. electron gun
2. focusing lens
3. plasma above the are of the electron-beam welding
4. electron collector
5. registration system
6. load resistor
7. shift source
8. item being welded

The cross-sections of the welding of steel and corresponding unnormalized experimental probability densities of the signal component within the specified amplitudes for the 9 kW electron beam in different focusing modes

Focusing current, mA	715	720	725	730	735	740	745	750
Cross-sections								
Joint depth, mm	10	14	16	17	21	19	17	13
Joint width in the upper part, mm	10	9	8	9	9	9	10	12
Experimental unnormalized probability densities								
Modal values in percentages	1.089	1.835	9.777	10.425	10.672	10.386	7.115	2.535
Root mean square, percentage	0.11	0.093	0.056	0.053	0.047	0.049	0.058	0.073

Conclusions

- Efficient usage of the electron-beam welding as an energy-saving technological process for welding thick materials is a challenge due to difficulty of reproducing the geometric dimensions of the penetration area caused by inaccurate control of the electron beam focus.
- Our researches proved that the most efficient control method for the electron beam focus is registration of the high-frequency component of the secondary current signal spectrum in plasma within the electron-beam welding area.
- The researches showed that the parameters of the experimental probability density of the above mentioned component of the secondary current spectrum contain the information about the focus-based electron beam intensity per area, and thus can be used for controlling the optimal geometric dimensions of the welded joint profile during the electron-beam welding.

Thank you for attention

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