ADAPTIVE PULSE TECHNOLOGICAL PROCESSES OF WELDING AND PAD WELD IS A NEW HIGH-PERFORMANCE METHOD OF OBTAINING OF PERMANENT JOINTS OF HIGH-STRENGTH STEELS

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Introduction

At the present time traditional processes of welding and pad weld (arc welding, electroslag welding, plasma arc welding) is almost exhausted their manufacturing capabilities. Energy concentration of welding heat sources has not solved and can not solve many problems including problems of productivity and improvement of welding quality. It is necessary to find new untraditional high-performance variants of use of welding electric and plasma arcs as heat sources which could raise welding technology to a higher level [1,2].

Qualitative indexes of welded joints and pad surfaces depends not only on technical capabilities of the mechanical part of the used equipment, but also flexibility of realizable engineering procedure – ability to maintain constant or periodically changing on the certain program its electric and thermal characteristics at the level of instant values.

Application of pulse technological processes of welding and pad weld implemented by the special-purpose equipment developed by the well-known research centers of the world opens such possibilities. The approach formed by them to development of pulse technological processes allows considerably expand the borders of possibilities of traditional technological processes of welding and pad weld [3,4,5]. Russian welding school makes the great contribution to development of the above-named approaches, it has created essentially new direction of technologies improvement of arc welding, plasma arc welding, electroslag welding, and pad weld on the basis of realization of adaptive algorithms of pulse control power parameters of a mode. Such technologies are called «Adaptive pulse technologies» (APT) [6] which are actively supplants the traditional technologies from welding production, that implemented on a direct current, or performed on strictly set program.

It is significant to note that compared to traditionally applied technologies of welding and pad weld at stationary modes adaptive pulse technology methods provide:

– processes control of fusion, transfer and crystallization of metal independently of spatial position of weld pool at much smaller average values of the basic technological parameters;

– increase the rate of welding bath crystallization in 2-3 times due to non-stationary power influence of a heat source to the welding bath which reduces the molten metal temperature;

– decrease of deformation processes degree in welded construction and pad surfaces;

– increase of qualitative characteristics of welded joints and coating during surfacing (improvement of seam forming independently of spatial position, increase of uniformity of a chemical composition on all volume of coating, structure refining in welded seam and HAZ). Noted advantages are reached by directed welding bath crystallization and strengthening of hydrodynamic processes in the fused metal contributing to the intensive degasification of a welding bath and more uniform distribution of alloying elements throughout volume of melt;

– increase of mechanical properties of the obtained welded construction associated with significant decrease of HAZ and crushing of its structure.

The important advantage of pulse processes is possibility of stabilization of instant values of the basic technological parameters of fusion range and transfer of each drop of electrode metal. It becomes possible thanks to availability of feedback channels supervising a condition of control object on the basic instant values of technological parameters, carrying the greatest information, for example to arc voltage, welding current, average power of a single micro cycle, the energy for fusion of a single drop of electrode metal [6].

The work purpose – research of application features of adaptive pulse technologies of welding and pad weld for obtaining of permanent joints of high-strength steels in high-duty constructions.

Materials, equipment and experimental techniques

To achieve formulated purpose, in work, the research complex for a high-speed video filming of fast processes at gas shielded consumable electrode welding was used. The equipment that implements adaptive algorithms of pulse control of power parameters of welding mode was applied in experiments [3,5,6]. Research of microstructure and mechanical characteristics of welded joints was carried out with use of traditional techniques.

Results and discussion

The paper analyzed two main views of electrode metal transfer at consumable electrode pulse-arc welding: «long-arc welding» – without short circuit of arc space, and «short-arc welding» –electrode metal transfer is carried out during short circuits of arc space. The conducted researches have established:

– **APT application** allows to perform programmed

input of heat in a weld zone, to control processes of fusion and drop transfer of electrode metal, forming of seam and HAZ structure, to reduce degree of residual deformation of welded joints at stability of pulse mode at welding in various spatial positions at both types of transfer;

– in contrast to known processes of arc welding, including pulse ones with use of strictly control programs, adaptive pulse processes allow to correct modes on instant values of the basic power parameters of the welding process depending on a condition of the control object «power source – arc – welding pool».

In addition it has been established that putting the given method into practice depends on solving a number of technological and electrotechnical problems [4]. The first problem is drop formation, electrode metal transfer, and molten metal crystallization control. To complete it a number of feedback channels is introduced into the welding equipment, in order to control the changes in the most important process parameters: arc voltage, welding current and instantaneous arc power [4].

To solve the second group of problems (electrotechnical) the set of the welding equipment should include either special high-current pulse commutators of the welding current, as a rule quick-response, with satisfactory mass-dimensional characteristics and reliable, or use as a power supply system of welding arc the modern inverter sources having required dynamic properties and power characteristics changed in welding depending on condition of control object: power source – arc – welding pool – product.

Conclusion

Estimating directions of improvement of pulse technological processes on the base of realization of adaptive control laws, it is possible to state that at their practical realization there is a possibility of considerable expansion of technical possibilities borders of welding and pad weld processes as one of the basic methods of obtaining permanent joints. At controlled welding processes it is possible to lower requirements to dynamic properties of feed system because required value of rate of rise and current falling are warranted by welding microcycle control algorithm. Thus, there is a possibility to give up the traditional inductors at the short circuit phase. So, short-circuit duration can be 30-40% reduced, making the process more efficient and less sensitive to the disturbing factor influence at the phase of electrode metal transfer into the weld pool.

Adaptive pulse technological processes of welding and pad weld provide possibility to program heat input in a weld zone, to control processes of fusion and transfer of each electrode metal drop, to provide forming highly dispersed structure of seam and HAZ, to reduce degree of residual deformations of welded joints and to provide stability of a pulse mode at welding in various spatial positions. In contrast to the arc welding processes used in the world today, including the pulse ones, which use fixed program control algorithms, the APT methods allow to adjust the chosen algorithm through the feed-back channels according to the momentary values of the main energy parameters of the welding process depending on the state of the control object "power source – arc – weld junction". The given advantages can be effectively used for developing various robot-aided technological processes realized with the help of computer and microprocessor-based adaptive automatic control systems, including various hybrid approaches.

References

1. Патон Б.Е., Сараев Ю.Н., Лебедев В.А. Совершенствование технологических процессов сварки и наплавки на основе методов управляемого высокоэнергетического воздействия на характеристики плавления и переноса электродного металла/Сборник трудов Международной научно-практической конференции с элементами научной школы для молодых ученых «Инновационные технологии и экономика в машиностроении». 20-21 мая 2010 г. Юрга. – С. 15 - 22.

2. Сараев. Ю.Н. Обоснование концепции повышения безопасности и живучести технических систем, эксплуатируемых в регионах Сибири и Крайнего Севера, на основе применения адаптивных импульсных технологий сварки//Тяжелое машиностроение. – 2010. - № 8. – с. 14 – 19.

3. Сараев Ю.Н. Адаптивные импульсно-дуговые методы механизированной сварки при строительстве магистральных трубопроводов//Сварочное производство. – 2002. - № 1. – с. 4 – 11.

4. Сараев Ю.Н. Управление переносом электродного металла при сварке в CO_2 с короткими замыканиями дугового промежутка (обзор)//Автоматическая сварка. – 1988. - № 12. – с. 16 – 23.

5. Сараев Ю.Н. Импульсные технологические процессы сварки и наплавки. – ВО «Наука». – Новосибирск, 1994. – 121 с.

6. Saraev Y. Adaptive pulse-arc welding methods for construction and repair of the main pipelines / Proceedings of The 2nd South-East European IIW International Congress «Welding – HIGH-TECH Technology in 21st century». Sofia, Bulgaria, October 21st-24th 2010. – P. 174-177.

** This work is executed with financial support of the Russian Foundation for Basic Research in 2010 – 2011 years, the project № 10 – 08 – 01109*