TECHNICAL SCIENCES

ANALYZE OF WELDING ARC PARAMETERS IN SHIELDED METAL ARC WELDING

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ABSTRACT

Shielded metal arc welding is widely used in heavy industries in partly shipbuilding and ship repair. This method didn't required special personal skills and equipment. Different scientists are analyzed welding parameters, mechanical characteristics and chemical composition in welding seam but interesting is to be investigated welding arc characteristics in different electrodes. The paper deal with analyze of welding arc parameters in shielded metal arc welding. For this purpose on mild steel plates are welded seams with different diameters of electrodes and different welding current. In welding process are measured welding arc burning time, length of electrodes melted part, welding machine voltage and weight of melted electrodes part. For analyze welding arc parameters are used response surface methodology method (RSM). Used RSM in the paper is 2^k factorial design where k=2 factors. The influence of each to other factors of welding arc is presented by meta models.

Keywords: shielded welding, arc length, models, experimental planning.

1. Introduction.

Welding arc is main component of welding seams. Its role is to transfer melted metal in weld seam. Transfer of melted metal from electrodes to weld pool depends from electrodynamics forces, gravity, welding arc pressure and gases in welding arc. The type of melted metal transfer is large dropped, middle dropped or like a stream.

Welding arc analyzation is widely area of scientists. Characterization of welding arc and weld pool formation in vacuum gas hollow tungsten arc welding is analyzed in [1]. In this paper authors obtain the effective arc radii for various welding conditions in vacuum gas hollow tungsten arc welding. They used Abel inversion algorithm to CCD arc image and determine the distribution of arc heat flux, arc pressure and current density from the physical relations of arc irradiance, temperature and current density in gas tungsten arc welding.

Physical characteristics of arc ignition process are analyzed in[4]. In their publication they focused attention on stable combustion state and the research on the mechanism of welding arc ignition process is quite lack. They used tungsten arc welding process for their analysis and physically characteristic of welding arc are investigated by camera with height resolution. The welding arc electron density during the period of the arc ignition is calculated by the Stark-broadened lines of Hα.

In[3] is studied effect of arc length on oxygen content and mechanical properties of weld metal in pulsed gas metal arc welding. For the analyze the authors used Q 690 high strength steel and ER69-G wire with diameter 1,2mm. Shielded gas used for experimental procedure is 82%Ar and 18% CO_2. Conclusion is that arc length raised, oxidation in drop transfer and oxygen content in weld metal increased significantly.

Determination of welding parameters is important stage from welding process. Proper parameters selection resulting to minimization of deformation. This process is widely described in[5]. They describe step by step stages in parameters determine. This information is useful for production of welded construction in heavy industry, shipbuilding and ship repair sector.

There aren't enough information, data and analyses about welding arc in shielded metal arc welding process and mainly about its parameters. The main parameters of welding arc are burning time, burning stability and weight melted metal. Burning stability of welding arc method is developed by akad. Hrenov. It is consist of burned of arc of rigid electrode. The arc burn while length of electrode is enough to touch the steel plates.

2. Description of shielded metal arc welding process.

Shielded metal arc welding is most applicable method in industry. It is characterized with simplicity in equipment and not so special skills of operator. The main method equipment is shown on fig. .

Welding arc is the distance form electrodes to surface where arc is formed. Based on this welding arc can be divided into three types:

- Medium or normal;
- Long;
- Short;

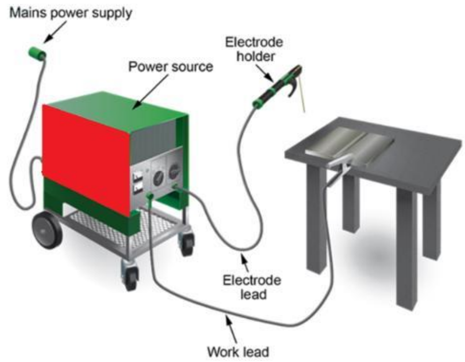

Fig.1. Shielded metal arc welding scheme[8]

Power source is direct or alternative current. This power sources has static dropping V-A characteristic. Welding arc temperature in this power sources is about 6000-9000°C.

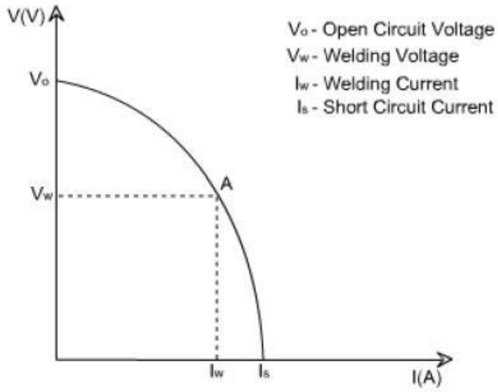

Fig.2. V-A characteristic of power source[9]

Welding arc can be divided into three regions: anode, cathode and arc column. On fig.3. is shown welding arc structure and voltage distribution.

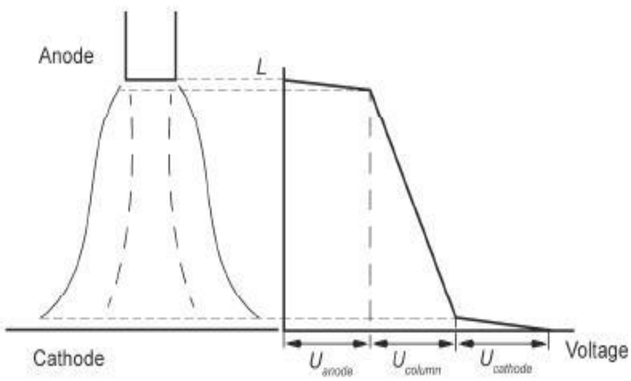

Fig.3. Voltage arc distribution[6]

At anode region as the temperature falls higher voltage is required to maintain ionization in the arc. The heat loss is compensated by electrons in plasma. In cathode area is the same situation with difference that more heat is generate in anode area than cathode. In arc column high temperature concentration is accumulated. This process together with ionized metals kept welding arc burning at temperature about 6000K.

Electrodes for shielded metal arc welding are covered electrodes. The role of cover is to protect welding seams from atmosphere. The cover contains stabilizing, shielding, fluxing, deoxidizing and other elements supporting welding process. Depending on the type of electrode being used, the electrode covering provides the welding seam in air[7].

In proper selection of cored electrodes is important to be considered followed rules:

- R_m electrodes≈R_m base metal
- Chemical composition electrodes≈ Chemical composition base metal

If this rules are considered working characteristic of welding construction is absolutely reliably.

According[2] shielded metal arc welding cored electrodes are with diameter range 2.00, 2.5, 3.0,3.25,4.0,5.0,6.0mm and length from 350mm and 450mm.

The value of welding current depends form electrodes diameter. It is calculated by following formulae:

$$Iweld = de * k \quad (1)$$

where: de- diameter of electrode, k- coefficient depended from steel grade, k=40 for low carbon, low alloyed steels, k=30 for other carbon steels.

Shielded metal arc welding method is used in different welding positions. This gave it widely application in industry, shipbuilding and ship repairing.

3. Experimental procedure.

The experimental procedure is consisting of welding seams on the mild steels plate St 235. Welding is done by rutile electrodes with different diameter and different values of welding current.

Table 1.

Welding current for different electrodes diameters

№	De, mm	I weld, A
1	3.25	80
2	2.5	100
3	3.25	120
4	4.00	150

For achieving purpose in the paper is used welding machine for shielded metal arc welding shown of fig.4.

In selection of electrodes rules for equal or approximate chemical composition and mechanical characteristic of electrodes and base metal are kept. Chemical composition of steel plates are shown on table 2 and chemical composition of electrodes are shown on table 3.

Table 2.

Chemical composition of steel plates base metal

C	Si	Mn	Ni	S	P	Cr	N	Cu
≤0.22	≤0.05	≤0.6	≤0.3	≤0.040	≤0.040	≤0.3	≤0.012	≤0.3

Table 3.

Chemical composition of electrodes

C, %	Si, %	Mn, %
0.08	0.3	0.4

Fig.4. Overview of welding machine

Mechanical characteristic of steel plates and electrodes are shown on table 4 and table 5.

Table 4.

Mechanical characteristic of base metal

Rm, MPa	Rpl, MPa	A, %
470	340	26

Table 5.

Mechanical characteristic of electrodes

Rm, MPa	Rpl, MPa	A,%
510	400	28

In welding process are measured parameters of welding arc: welding arc burning time, length of electrodes melted part, welding machine voltage.

To analyze influence of parameters on each other are used response surface methodology. The commonly used response surface methodology is simplest 2^k factor design. In this 2^k factor design every factor has two levels(+1, -1) and each run at two levels. The levels of the factors can be called „ low” and „ high”. The two levels can be quantitative and qualitative. In engineering analysis for example quantitative factors are forces, pressure, speed and etc. and qualitative can be number of machine, ships and other. To convert factorial design into regression model are used some of following models:

- First model

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots \beta_k x_k \quad (2)$$

- Iteraction model

$$y = \beta_0 + \sum_{i=1}^{k} \beta_i x_i + \sum \sum_{i<j}^{k} \beta_{ij} x_i x_j \quad (3)$$

- Second model

$$y = \beta_0 + \sum_{i=1}^{k} \beta_i x_i + \sum \sum_{i<j}^{k} \beta_{ij} x_i x_j + \sum_{i=1}^{k} \beta_{i\,j} x_i^{\,2} \quad (4)$$

where: x_1 is the coded variable that represent the reactant concentration, x_2 is the coded variable that represent the feed rate, β-s are correlation coefficients.

Design matrix of 2^2 factor planning is shown on table 6.

Table 6.

Design matrix

№	X1	X2
1	-1	-1
2	+1	-1
3	-1	+1
4	+1	+1

4. Results

Experimental results are processed by software STATISTICA and Excel worksheet. To analyzed impact of welding arc parameters is used first regression model of RSM. Widely matrix of experimental plan is shown on table and actual matrix of plan is shown on table 7.

Table 7.

Full design matrix

№	X1	X2	X3	X4
1	1	-1	-1	1
2	1	1	-1	-1
3	1	-1	1	-1
4	1	1	1	1

Time for welding arc burning time and length of welding arc are objects of analysis. These two parameters described and characterize welding arc Based on the model are done graph dependence of:

Length of welding arc against diameter of electrode and welding current fig. 5.

Welding arc burning time against voltage of welding machine and welding current fig.6.

Table 8.

Experimental data

№	Voltage, V	L weld arc, mm	de, mm	I weld, A	T weld arc, sec
1	14	24	2.0	80	30.3
2	17	27	2.5	100	44.45
3	21	30	3.25	120	67.7
4	26	34	4.0	150	79.5

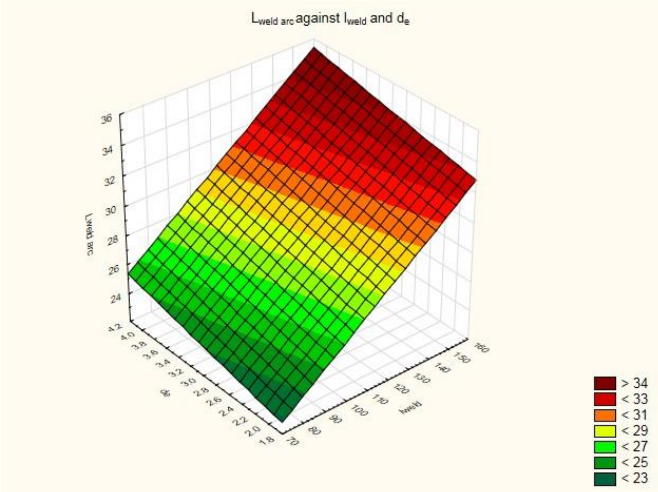

Fig.5. Length of welding arc against diameter of electrodes and welding current

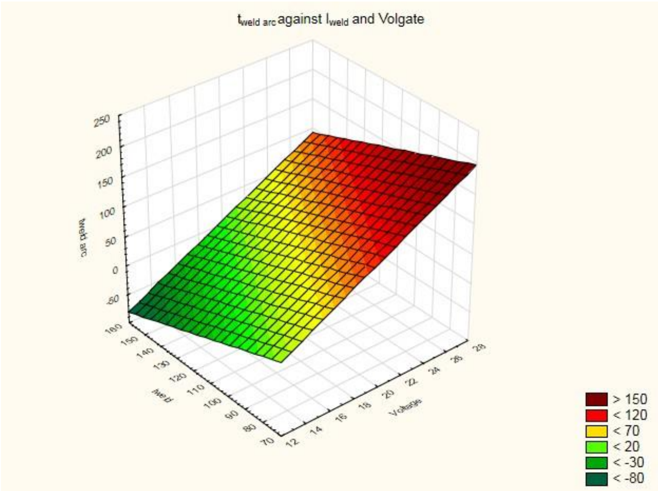

Fig.6. Welding arc burning time against voltage and welding current

$$t_{weldarc} = -25.5333 + 10.8306V - 1.1567 I_{weld} \quad (5)$$

$$L_{weldarc} = 13.0385 + 0.1115V + 1.0769 I_{weld} \quad (6)$$

5. Conclusion

In the paper are analyzed welding arc parameters in manual shielded metal arc welding. For experimental procedure are used retile electrodes with diameters of 2.00; 2.5; 3.25 and 4.00mm and steel plates grade ST235.

To analyze the results are used response surface methodology. Two-level factorial design of experiment is used. Based on methodology are done regression model, regression equations for analyzed welding arc parameters are developed.

Length of welding arc closely depends form welding current. In higher welding current values length of welding arc is higher. Type and diameter of electrodes haven't so important impact on length of welding arc. This is confirmed from developed regression equation.

Time for welding arc burning closely depends from voltage of welding machine. Impact degree of welding current in burning time is not so clear expressed. In higher values of welding machine voltages burning time is bigger. This is with close relation with welding current.

6. Declarations

Conflict of interests: The author has no conflicts of interest to declare that are relevant to the content of this article.

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РОЛЬ ТЕРМИНОЛОГИИ В РАЗВИТИИ КИБЕРНЕТИКИ

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АННОТАЦИЯ

Результаты научных исследований в значительной мере зависят от языка, в котором они проводятся. И в этом случае играют большую роль его словарный состав, в который входят термины, обозначающие понятия, отражающие явления в природе. Произвольное, недостаточно обоснованное, их введение приводит к тормозу в научных исследованиях. Этот негативный процесс в настоящей статье показан на примере развития, как самой науки кибернетики, так и его раздела развития средств обработки информации.

ABSTRACT

The results of scientific research largely depend on the language in which they are conducted. And in this case, its vocabulary including terms denoting concepts that reflect phenomena in nature plays a big role. Arbitrary, insufficiently substantiated, their introduction leads to a brake in scientific research. This negative process in this article is shown on the example of the development of both the science of cybernetics itself and its section of the development of information processing tools.

Ключевые слова: кибернетика, физика, ботаника, биология, проблема, задача, фундаментальная наука.

Keywords: cybernetics, physics, botany, biology, problem, task, fundamental science.

В научно-исследовательском процессе возникают ситуации, когда требуется введение терминов, обозначающих новые понятия. Однако, не все они могут быть удачно сформулированы, и это отрицательно влияет на познание природы. Ведь в своем определении термины должны, как можно содержательней отражать свойства материи той области, в которой происходят исследования. Весьма часто новое понятие, а значит и термин, его обозначающий, вводится известным ученым, и, как правило, основным доказательством правильности нововведения выступает, в этом случае только, его авторитет. Хороший тому пример имеется в кибернетике. Известно, что фундаментальным направлением в этой науке есть развитие Электронных Вычислительных Машин (ЭВМ), результатом которого выступают машины, представляющие различные поколения. В свое время само понятие и признаки отличия одного такого поколения от другого были предложены авторитетными конструкторами этой научно-технической отрасли. По их мнению, различие между поколениями находится в особенностях аппаратуры, на которой созданы машины. Так для **первого** поколения ЭВМ, с позиций ее разработчиков, в качестве основного отличия выступает элементная база, в основу которой положены электронные лампы. Что касается **второго** поколения, то в этом случае, вместо ламп выступают навесные транзисторы, а следующие поколения уже потребуют микросхем. Таким образом, еще раз подчеркнем, что конструкторы в XX-м веке видели и сегодня видят дальнейшее развитие ЭВМ по поколениям, которые отличаются друг от друга, только, элементной базой.

Известно, что научно-технический прогресс базируется на полученных ранее достижениях. В случае с ЭВМ в качестве таких достижений выступают знания физики электроники, которые вкладывались и вкладываются в элементную базу вычислительных машин соответствующего поколения. Причем, практика показала, что многоразовое использование одних и тех же достижений в изделии, с целью улучшения его параметров, не всегда позволяет получить желаемый результат. То есть, функция эффекта, в этом случае, не является линейной. Более того, избыток такого использования может привести к негативным последствиям, что и послужило тормозом в развитии средств обработки информации.