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Endurance of turning tools subjected to overlay welding

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1. Introduction

The shortage of tungsten and continuously increasing cost of high speed steel stimulate the search of alternative tool production methods. The ussage of overlay welding for tool production is promising; in this case the surface of structural steel is overlay welded with high speed steel powder. Various chemical compositions, hard and heat resistant composite work pieces for turning and milling cutters and other tools can be obtained by this technology [1].

Using for overlay welding materials containing tungsten carbide, wear resistant composite coatings were developed [2]. Optimal amount of reinforcing tungsten carbide particles in the coating should be from 50 to 60 %. The application of cobalt alloy (steelit) and cast tungsten carbide (relit) powder mixture for overlay welding, 2, 3 times higher wear resistant, layer in comparison with the layer overlay welded by steelit only, was obtained.

In order to obtain high wear resistant coatings, Fe-W-Ti-C system additives are used [3]. In the course of welding the tungsten diffuse into titanium carbide, forming hard W Ti C phase, which is evenly distributed in the increased hardness iron alloy matrix.

Hard alloys based on tungsten carbide often are used in parts and tools production, due to their wear resistance and satisfactory ductility [4]. Hard alloys without tungsten carbide – tungsten carbide cermets (with Ni alloy or steel matrix) are effectively used as well, because they have lower friction coefficient, they are strong and have higher corrosion – resistance [5]. At the same amount of carbide phase, the composition with tungsten carbide has some advantages in conditions of abrasive wear [6].

Cutting tools subjected to overlay welding in argon or helium atmosphere using high speed steel 3-5 mm diameter additional bars, are characterized by outstanding operational properties, and can be used in production processes [7]. Commercial tests show that the tools subjected to overlay welding have 1.5-2.3 times higher durability in comparison with the tools, produced according to traditional technology. Lathe tools, dies and other tools are overlay welded by electrodes, plasma and laser treatment using powder, and powder wire in protective gas atmosphere. No papers, describing overlay welding of metal cutting tools by automatic arc under flux using high speed steel and hard alloy powder, were found.

2. Results of the investigation

Structural steel was overlay welded by P6M5K5 steel, WC-8%Co, alloying elements (Cr, Mo, W, Co), graphite and boron carbide powder. A possibility to apply for overlay welding steel P6M5 and cast iron milling and turning chips was investigated. As a result of overlay welding of a structural steel Cт3 by electric arc under flux AMS1 using chips and powder spread over the surface or powder inserted into the flux, layers of various composition (Table 1), structure and hardness (Table 2) were obtained. Cutting unit of the metal cutting tools should be hard, resistant to wear and heat, i.e. heated to high temperature during work it should not be tempered.

Table 2 shows overlay welding variants, which enable to obtain hard and heat-resistant layers. The Table 2 presents tempering temperatures, at these temperatures maximal hardness of the layer was obtained.

Table 1

Chemical composition of the overlay welded layers

Specimen №	Chemical composition, % mass parts								
	C	Si	Mn	Cr	Mo	V	W	Co	Remainder
1.	1.19	0.96	1.79	4.37	3.54	1.69	7.55	4.63	Fe
2.	0.71	0.95	1.97	1.29	1.61	0.66	1.25	1.24	Fe, B
3.	1.04	1.11	2.15	1.66	1.85	0.86	2.05	1.62	Fe, B
4.	1.05	0.8	1.65	0.06	0.05	0.03	20.5	2.50	Fe
5.	1.2	0.82	1.70	0.08	0.06	0.03	16.5	2.25	Fe
6.	0.712	0.65	1.75	0.06	0.02	0.02	13.82	1.15	Fe
7.	0.95	1.05	1.92	0.06	0.04	0.01	10.5	0.95	Fe
8.	0.59	1.15	2.05	0.06	0.02	0.01	12.8	1.25	Fe
9.	0.77	0.91	1.80	0.65	0.74	0.29	0.39	0.02	Fe, B
10.	1.06	0.95	2.18	4.06	8.92	1.42	4.17	0.10	Fe
11.	0.85	1.55	2.46	1.11	1.26	0.53	1.72	0.05	Fe

Table 2

Overlay welding variants resulting hard and satisfactory heat – resistant layers

Specimen №	Overlay welding materials and the mean of its application: welding of spread over the surface powder, or the powder inserted into flux		Hardness of welded layers (HRC)	
	Composition of spread over powder, % and layer thickness, mm. Chips layer thickness, mm	Amount of the powder inserted into the flux AMS1, %	After welding	After tempering
1.	Mixture (C-7.0; Cr-17.0; W-20.0; Mo-14.0; FeV-16.0; Co-18.0. P6M5K5-8.0), 4 mm	Without additives	47	650° C, 63
2.	Mixture (P6M5K5-90; B_4C-10), 4 mm	Without additives	62	550° C, 62
3.	Mixture (P6M5K5-90; B_4C-4.5; graphite-4.5), 4 mm	Without additives	62	550° C, 63
4.	WC-8%Co, 4 mm	Without additives	47	570° C, 63
5.	WC-8%Co, 4 mm	Graphite, 9	56	550° C, 65
6.	WC-8%Co, 4 mm	Cast iron grinding waste, 33	49	560° C, 63
7.	-	WC-8%Co, 31 Graphite, 6	54	550° C, 61
8.	-	WC-8%Co, 33	61	550° C, 62
9.	B_4C, 1.5 mm P6M5 steel chips, 3.5 mm	Without additives	64	550° C, 63
10.	Mixture (Cr-10.0; Mo-30.0; FeV-5.0), 2 mm P6M5 steel chips, 3 mm	Graphite, 10	60	550° C, 63
11.	P6M5 steel chips, 6 mm	B_4C, 4.5 Graphite, 4.5	63	560° C, 63

Working unit of lathe tool stems made of Ст3 steel was overlay welded, using WC-8% Co powder, because, it is proved that layers produced from this powder are the most wear – resistant. WC-8% Co powder was spread over in 4 mm thickness layer and welded under the AMS1 flux, containing 33% cast iron grinding waste powder. One lathe tool was overlay welded by P6M5 steel milling chips. Ст3 steel stems were overlay welded by three passes, replacing the burner after everyone pass in transverse direction at 4 mm. 6 mm thickness layers were obtained, which after tempering at 560°C temperatures were hardened to 63 HRC. Microstructures of the overlay welded lathe tools cutting units are shown in Fig. 1. X-ray investigation (Fig. 2) shows that in the layers subjected to overlay welding by WC-8%Co powder there is some amount of Fe_3W_3C carbide, martensite and residual austenite. However, in the layer welded by P6M5 steel chips the main structural component is martensite (there are no peaks of Fe_3W_3C and residual austenite in X-ray photograph), and less amount of carbides.

Durability of the lathe tool subjected to overlay welding was investigated by turning 45 steel 56 mm diameter and 750 mm length specimen. The geometry of lathe tool cutting unit was as follows: α=8°, γ=18°, φ=45°, φ_1=45°, λ=5°. Turning regimes: cutting speed 51.9 mm/min, cutting depth 0.2 mm, feed rate 0.074 mm/rev. The wear was determined according to the concavity area worn out on the front surface (Fig. 3). Lathe tools subjected to overlay welding by WC-8%Co powder used to wear in the same manner as those made of standard P6M5 steel. Higher wear was observed in the lathe tool subjected to overlay welding by P6M5 steel chips. Fig. 4 shows the areas of concaves worn on the front surface after the lathe tool covered 2100 m distance.

a

b

c

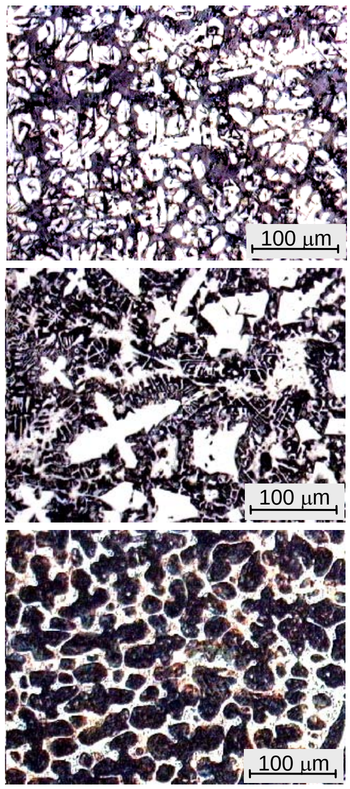

Fig. 1 Microstructure of lathe tool cutting unit subjected to overlay welding: a - welding under AMS1 flux with WC-8%Co powder spread over the tool surface; b - welding under AMS1 flux mixed with 33 % cast iron grinding waste powder and WC-8%Co powder spread over the tool surface; c - welding under the flux mixed with 4.5 % B_4C and 4.5 % graphite powder and P6M5 steel chips spread over the tool surface

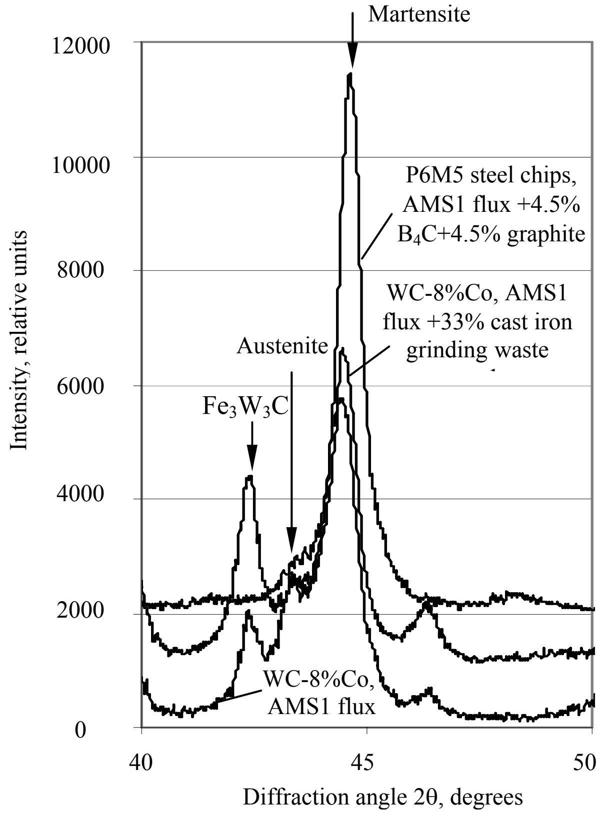

Fig. 2 X-ray photographs of the lathe tool cutting unit subjected to overlay welding

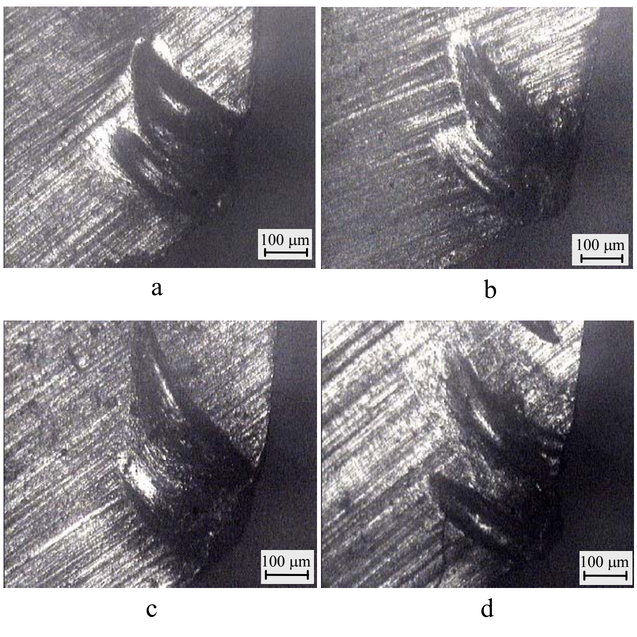

Fig. 3 The concaves worn on the front surface of lathe tools subjected to various overlay welding procedures: a - WC-8%Co powder melted under AMS1 flux; b - WC-8%Co powder melted under AMS1 flux mixed with 33 % cast iron grinding powder; c - P6M5 steel chips melted under AMS1 flux mixed with 4.5 % B_4C and 4.5 % graphite powder; d - standard P6M5 steel lathe tool (62 HRC)

Commercial tests show that the durability of lathe tools subjected to overlay welding depends on welding materials and technology. Table 2 presents various variants of structural steel overlay welding. Not all metal cutting

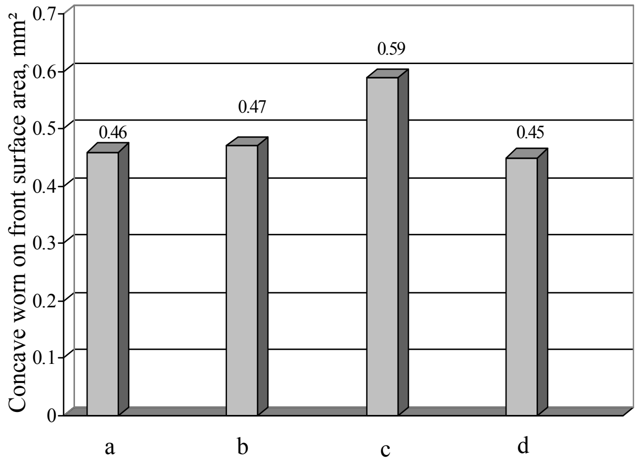

Fig. 4 Areas of concaves worn on the front surface of lathe tools subjected to various overlay welding procedures: a - WC-8%Co, AMS1 flux; b - WC-8%Co, AMS1 flux + 33% cast iron grinding waste powder; c - P6M5 steel chips, AMS1 flux + 4.5% B_4C + 4.5% graphite powder; d - standard P6M5 steel

tools are suitable for overlay welding, because not always the resistant enough layers are obtained satisfying hard metal cutting conditions.

3. Conclusions

1. Durability of metal cutting tools subjected to overlay welding depends on microstructure of the welded layer and its hardness. Durability of lathe tools subjected to overlay welding by WC-8%Co powder is the same as that of standard P6M5 steel lathe tool.

2. Durability of lathe tool subjected to overlay welding by P6M5 steel chips is lower than that of standard steel tool. Overlay welding by P6M5 steel chips can be applied for wood cutting and other tools, which work in better conditions than metal cutting tools.

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APVIRINTŲ TEKINIMO PEILIŲ PATVARUMAS

R e z i u m ė

Darbe buvo tiriamos dangos, gautos lankiniu automatiniu apvirinimu po fliusu ant apvirinamojo paviršiaus užbėrus nesurištų medžiagų miltelių arba juos įterpus į fliusą. Konstrukcinis plienas apvirintas P6M5K5 plieno, WC-8%Co, legiruojančiųjų elementų (Cr, Mo, W, Co), grafito ir boro karbido milteliais. Lankiniu apvirinimu nesurištais medžiagų milteliais sudaryti kieti, dilimui ir kaitrai pakankamai atsparūs sluoksniai. Ištirtas apvirintų tekinimo peilių patvarumas. Gamybiniai bandymai parodė, kad apvirintų tekinimo peilių patvarumas priklauso nuo apvirinamųjų medžiagų ir technologijos.

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ENDURANCE OF TURNING TOOLS SUBJECTED TO OVERLAY WELDING

S u m m a r y

In the present work coatings obtained by automatic arc welding under the flux using unbinded powder of materials spread on the surface of overlayed surface or inserted into the flux were investigated. Structural steel was overlay welded by P6M5K5, WC-8%Co, alloying elements (Cr, Mo, W, Co), graphite and boron carbide powder, as well as steel P6M5 chips. By the arc overlay welding of unbinded powder, hard, wear resistant and having satisfactory heat resistance layers were formed. Durability of the lathe tools subjected to overlay welding was investigated. Commercial tests show that the durability of lathe tools subjected to overlay welding depends on welding materials and technology.

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СТОЙКОСТЬ НАПЛАВЛЕННЫХ ТОКАРНЫХ РЕЗЦОВ

Р е з ю м е

В работе исследованы покрытия, полученные дуговой автоматической наплавкой под флюсом по слою насыпанных на наплавленную поверхность или внедренных во флюс порошков материалов. Конструкционная сталь была наплавлена порошком стали P6M5K5, WC-8 % Co, легирующих элементов (Cr, Mo, W, Co), графита и карбида бора. Дуговой наплавкой несвязанными порошками материалов получены твердые, износостойкие, довольно высокой теплостойкости слои. Была исследована выносливость наплавленных токарных резцов. Производственные испытания показали, что выносливость токарных резцов зависит от наплавляемых материалов и технологии.

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