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RESEARCHING THE TRIBOLOGICAL PROPERTIES OF THE MODIFIED SURFACES TREATED VIA THE REMELTING UNDER THE HIGH FREQUENCE MAGNETIC FIELD

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In the article the cladded surface on the 42Cr4 steel under high frequency magnetic field were remelted and modified via TIG (Tungsten-Inert-Gas) welding and the tribological proporties of the specimens were analysed after experimenting at the tribosystem – "ball on disc" with paraffin and on the basis of the tribological, physical – mechanical properties the friction coefficient and wear resistnace of them were evaluated. The productivity and quality of the surface via the application of the additional magnetic field to the remelting process have been increased, because of the additional magnetic field in the weld pool. Under the influence of the magnetic field the molten material is rotated and the additional induced temperature increases the melting velocity. The magnetic rotation mix of alloys and gives to the surface high homogeneity.

It has been found that via the plasma treatment of the surface under high frequency maqnetic field the mechanical and tribological properties of the specimens have been improved. The new technology can be applied to the researching and treating of the materials in high frequency magnetic field to increase the quality and efficiency of the processes, So that the methods can be applied for increasing the Hertzian contact pressure, their tribological properties and repairing of the parts.

Keywords: remelting, tribology, TIG, surface layer, wear.

Introduction. In order to eliminate the adverse effects caused by the wear processes, costs during the operation of the machine are often higher than their production costs. Reducing the amount of such costs is a key issue facing the tribologists. First and foremost, specialists work to find a solution to the problem by selecting the material during the design period. If this is not possible, the surfaces can be modified by mechanical, thermal, chemical, chemical-thermal and so on methods and their tribological characteristics can be enhanced. The technology of surface modification is the more expensive in economic terms, although it is the highest in terms of quality [1–7].

Usually, the wanted characteristics for the surface of the materials is high strength, hardness, fatigue and corrosion resistance, cracking resistance and so on. At the same time, the core of the parts should have a high plasticity and impact strength. This is only achieved by the processing of the surface layer. In the process of surface treatment, in many cases, its hardness is enhanced without creating stratification on the surface. Therefore, this surface layer has good friction and has a high friction strength compared to other methods [8–13]. Thus, the friction, wear, reliability and durability of machine parts under stress depend essentially on the structure and properties of the surface layers. For this reason, nowadays the surfaces of moving parts are required to have high wear resistance. Despite the fact that many studies have been carried out on the acquisition of wear-resistant layers on the surface of tribological couples, there are numerous uncertainties about the practical potential and places of a specific problem [2, 13–16].

1. Materials. The surface of the base material from the 42Cr4 steel were cladded with the electrodes given in the Table 1 [17] and in order to increase the physic-mechanical and tribological properties of the layers made by processing by using electrodes, they are further modified by processing with the TIG method in the high frequency magnetic field.

2. Equipment. The TTH15 branded induction device with a 15kW capacity for heating or melting with a high-frequency current was utilized. A TIG200AC / DC welding apparatus that uses 200 amperes of electric current was utilized for plasma surface processing. The energy given to the material in the transmission of the high-frequency current is shown by percentages. The induction current frequency can be increased up to 450 kHz.

Table 1
Types, chemical components and the oretical hardness of the applied electrods to the cladding operations

Type of electrods	Chemical component, %										Theoretical hardness, HV
	C	Si	Mn	V	Mo	W	Nb	Cr	B	Rest	
UTP7100	5	–	–	–	–	–	–	35	–	İron	790
UTP Ledurit 65	4,5	–	–	1,5	6,5	2,2	5,5	23,5	–		860
UTP DUR 600	0,5	2,3	0,4	–	–	–	–	9	–		660
T590	3,2	2,2	1,2	–	–	–	–	25	1,0		840

The average frequency of the induction current and the range of power at the main material in the high frequency magnetic field was changed by 200 kHz and 25–100% respectively, and magnetic compression of the liquid metal was observed. In order to ensure the stability of the molten material, the intensity of the current was 140 Amp when the TIG was applied for melting the material and during high frequency current application, the current intensity was determined to be 90A, and the power of the induction device was 25%. The diameter of the tungsten electrode was 2.4 mm in all experiments, depending on its loading.

3. Test programme. Samples that will be studied in terms of tribological characteristics, some of their physical and mechanical properties, experimental conditions and parameters to be investigated are shown in Table 2.

Table 2
Some physico – mechanical and tribological parameters of the objects and parameters to be studied

Research objects		Types and parameters
Ball		Steel 100Cr6, Rz = 250 nm, hardness 1028 HV, R = 5 mm
Examples	Base material	42Cr4
	Modified surface	T590, UTP Ledurit 65, UTP DUR 600, UTP 7100
Tribolojical parameters		
Type of friction		Friction with paraffine during oscillatory motion
Ambiant		Air
Namber of osillation		100.000
Osillation frequence		20 Hs
Normal force		20 Newton
Amplitude of osillation		0.40 mm
Avarage air humidity		50%
Avarage air temperature		24°C
Type of lubricant		Paraphin
Researched parameters		Friction coefficient; wear coefficient; volumetric wear; wear trace and profile; linear wear.

The specimens were the cladded and remelted surfaces via MMA and TİG welding respectively. The contour part was the ball from the 100Cr6 steel. The value of the friction force and linear wear have been measured by the horizontal and vertical electric sensors, which are fixed on the weakened cross section of the ball holder and frame of the machine, respectively [18–20].

Before the experiments, the surface of the samples is polished up to the range of 3 microns, washed with alcohol and a very thin layer of paraffin is applied to the surface after drying.

4. Results and discussion. Hardness. The hardness values for the 42Cr4 and cladded material after remelting and modification process on it is presented graphically in Fig. 1. According to the figure, mainly due to the modification of different coatings in the high frequency magnetic field by using TIG, their hardness values have increased up to 20HRC. Increased hardness can be explained by the favourable conditions (the high content of carbide-forming elements, magnetic pressure and temperature) for the formation of chromium carbides in the molten material by using the high frequency magnetic field. Increased hardness values depend also on the amount of carbide contained in the material and its size as well. Increasing the hardness and modulus of elasticity, which allows the microstructures of the samples to be improved in terms of tribological properties and contact stress, but it does not guarantee the wear resistance. The complexity of the factors affecting the surface during the friction process requires additional tribological experiments.

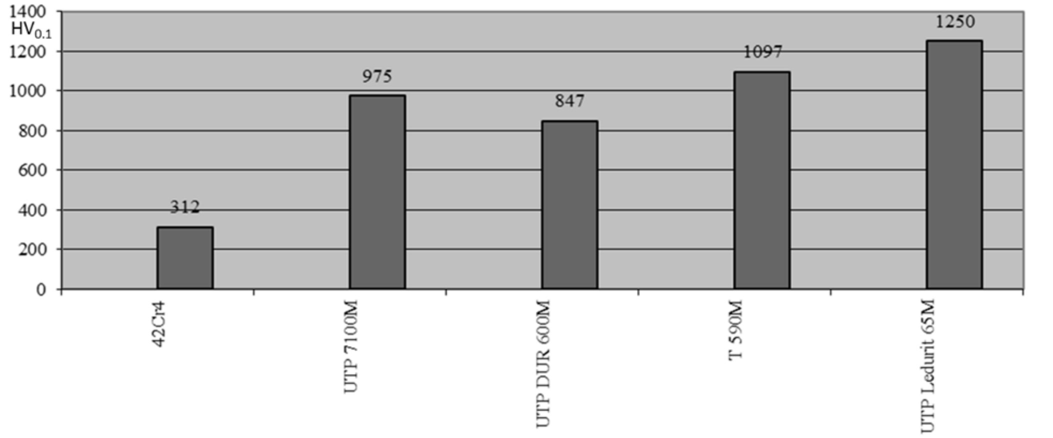

Fig. 1. Hardness of the 42Cr4 steel and cladded surface layer on it after remelting and modification processes

Tribological Quantities. The traces of the wear, their trajectory (profiles) and the values of the friction coefficient on the surfaces of the materials which were modified in the high frequency magnetic field are shown in Fig. 2 and Fig. 3 respectively.

As can be seen from Fig. 1, compared with other samples, the larger wear area of the samples graded 42Cr4 and UTP DUR 600, which were molten onto the surface of the 42Cr4 material and modified under the high frequency magnetic field were noticed. The cause of the wear is due to higher value of the friction coefficient and lower value of the hardness depicted in Fig. 3 and Fig. 1, respectively. In the above mentioned examples, the friction coefficient is not only high, but also showed variable values during the experiment period, Fig. 3. The higher value friction coefficient of the 42Cr4 material and its gradual increase can be related to its plastic deformation. Plastic deformations on the surface cause it to become hardened, yielded and suddenly broken, which in turn creates fluctuations in the values of the friction coefficient.

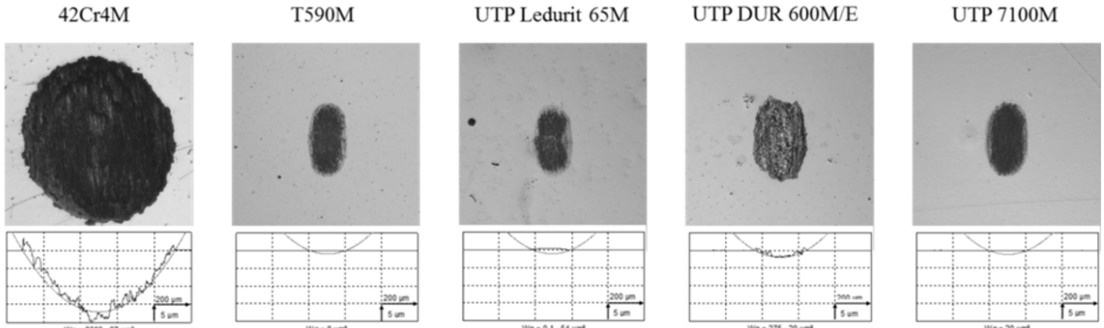

Fig. 2. Wear profile and trace (track) on the surface of the different specimens, modified via TIG under high frequency magnetic field

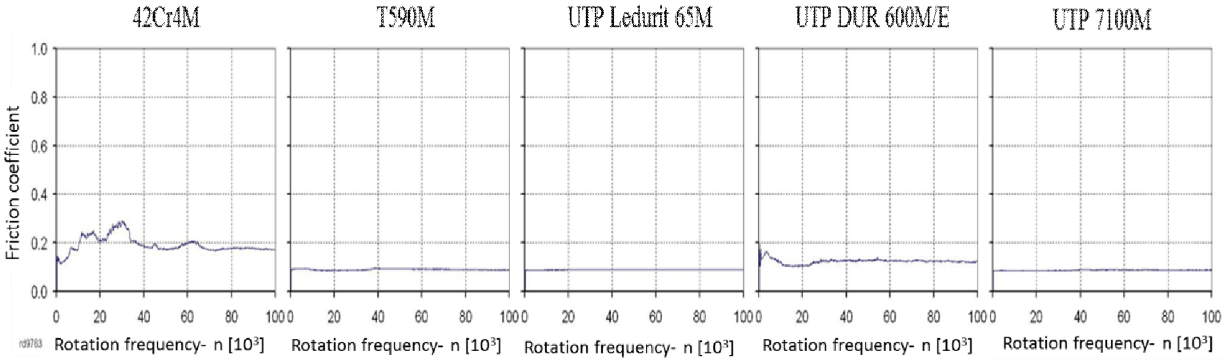

Fig. 3. Friction coefficient of the different specimens, modified via TIG under high frequency magnetic field versus rotation frequency

In the sample graded as UTP DUR 600, the wear has adhesive nature and the adhesion that occurs creates oscillations in the friction coefficient (Table 3, 20µkm^2 adhesion). It should be noted that UTP Ledurit 65 has also an adhesion-coated couple, which results in an additional coating on the surface of the sample.

The average friction coefficient of the 42Cr4 steel and the UTP DUR 600 coating of 9% chromium (Table 1) is higher than that of other coatings (Fig. 4). The higher friction coefficient in the 42Cr4 material indicates also the adhesion of the ball to the sample. Since, the ball penetrate into a softer 42Cr4 material, adheres and there is no relative displacement between the pairs. The average value of the friction coefficients of T590, UTP Ledurit 65 and UTP7100 coatings is almost identical.

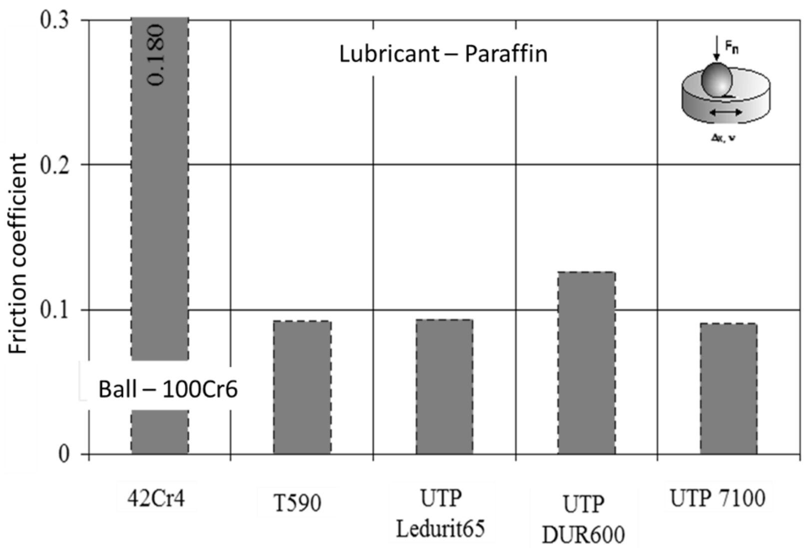

Fig. 4. Avarage friction coefficient of the different specimens, modified via TIG under high frequency magnetic field

Table 3

Areal wear of the surface of the different specimens, cladded and modified via TIG under high frequency magnetic field

Areal wear- Wq [µkm^2]				
42Cr4	T590M	UTPLedurit65M	UTP Dur 600	UTP7100M
8609 (89 adhesion)	8	0.1 (54 adhesion)	275 (20 adhesion)	20

The wearing volumes of the various coatings modified in the high-frequency magnetic field are presented in Fig. 5 relative to the known correlations the similar values of the ball and the samples. According to the chart, almost the largest amount of wear occurs to the 42Cr4, which is the base material. This material is softer in comparison with other materials, and wear occurs due to plastic deformation caused by the penetration of the ball onto its surface under the 2 kg loading (Table 2).

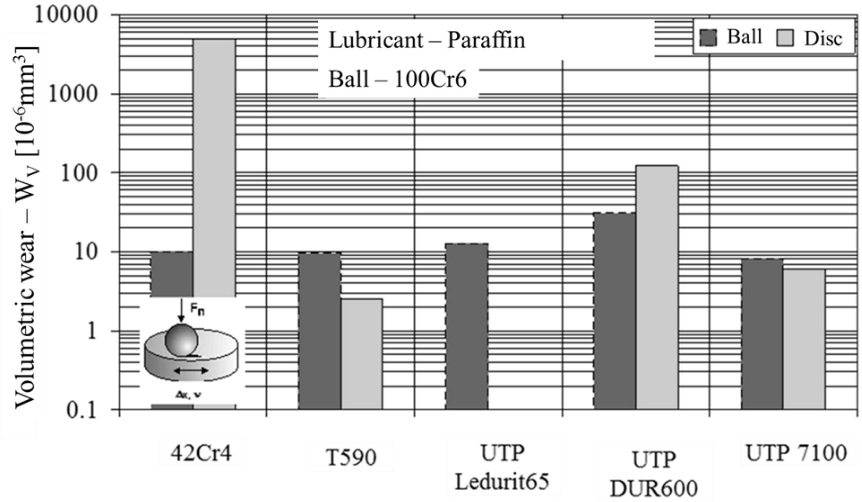

Fig. 5. Volume tricwear of the different specimens with paraffine, cladded and modified via TIG under high frequency magnetic field

The next wear scale refers to the UTP DUR 600 coating that can be correlated with either a high friction coefficient between the sample and the ball or due to the adhesion rate (Table 3). The minimum amount of wear is in the UTP Ledurit 65 coating. In spite of the fact that the surface of the sample itself is not worn too much, the adhesive wear of the ball has been worn during application and the worn material is adhered to the surface of the sample.

Conclusions. The article describes the mechanical and tribological parameters of the cladded and modified layer on the steel 42Cr4 by TIG method in the high frequency magnetic field compared to the base material 42Cr4 steel. The tribological properties of the achieved surfaces on the base of the applied technology were studied at the tribological machine – “ball on disc” at the same conditions and the results of tribological experiments and hardness of specimens were evaluated comparatively.

It was determined that after the modifying of the cladded surface on the 42Cr4 steel by TIG processing in the high-frequency magnetic field, the hardness and the wear resistance in wet friction environment with paraffine have been increased. These effects can be explained with the incresing value of the Hertzian contact pressure of the surface and having efficient tribological structure of the material.

Based on improved wear resistance and hardness, the proposed technology can be used both in production and repair processes to increase the contact pressure of the surface layer, to overcome surface defects by reducing the geometric defects via TIG method, and increase the physico-mechanical and tribological properties of parts.

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ИССЛЕДОВАНИЕ ТРИБОЛОГИЧЕСКИХ СВОЙСТВ МОДИФИЦИРОВАННЫХ ПОВЕРХНОСТЕЙ, ОБРАБОТАННЫХ С ПОМОЩЬЮ ПЕРЕПЛАВКИ ПОД ДЕЙСТВИЕМ ВЫСОКОЧАСТОТНОГО МАГНИТНОГО ПОЛЯ

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Одной из главных задач технологии машиностроения является непрерывное повышение качества поверхностного слоя деталей машин в целях улучшения их эксплуатационных характеристик. В качестве подобных характеристик могут быть физико-механические и трибологические свойства. В статье наплавленная поверхность на стали 42Cr4 под действием высокочастотного магнитного поля была переплавлена и модифицирована с помощью сварки TIG (аргонодуговая сварка), а трибологические свойства образцов были проанализированы после экспериментов на трибосистеме – «шар на диске» с применением парафинов и на основании трибологических и физико-механических свойств оценен их коэффициент трения и износостойкость. За счет приложения дополнительного магнитного поля к процессу переплава были существенно увеличены производительность процесса и качество поверхности из-за наличия дополнительного источника магнитного поля в сварочной ванне. Под действием высокочастотного магнитного поля расплавленный материал вращается, и дополнительная индуцированная температура увеличивает скорость плавления. Вращение в электромагнитном поле смешивает сплавы и придает поверхности высокую однородность. Таким образом, удалось достичь желаемых свойств исследуемой поверхности.

В результате проведенных исследований было обнаружено, что за счет плазменной обработки поверхности в высокочастотном магнитном поле улучшаются механические и трибологические свойства образцов. Новая разработанная технология легирования поверхностного слоя образцов может быть применена для исследования и обработки материалов в высокочастотном магнитном поле для повышения качества и эффективности процессов, так что методы могут быть применены для увеличения контактного давления Герца, трибологических свойств образцов и ремонта деталей.

Ключевые слова: переплавка, трибология, TIG (аргонодуговая сварка), поверхностный слой, износ.

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