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CHANGE THE STATUS OF PLASMA JET SURFACE TO METAL BENCHMARKS (TO INCREASE ADHERENCE, ROUGHNESS) ASSEMBLED BY GLUING

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Abstract: *Plasma processing technology was first used in the World War II in the US aviation factories. In the early 60s, engineers made a new discovery, the increase of the jet speed by narrowing the plasma nozzle. Due to the rapid development of science engineering, the plasma technology is used today in various fields: automobile manufacturing, aerospace, automotive industry, medicine, biology, etc. . . In processing of plasma jet, there are two patterns: at low pressure and at atmospheric pressure. Research carried out at atmospheric pressure have their advantages: size bodies is not limited, surfaces can be modified without altering the volume properties, low temperature can avoid destroying the materials. Surface modification of plasma materials refers to changing the properties of the surface, creating surfaces with unique properties and characteristics thus improving the mechanical properties. Modification of surfaces ,,texture'' permit infiltration of adhesive thus improving mechanical resistance, that will be verified in some tests:tensil strength, shear strength, resistance to separation and resilience.*

Keywords: *plasma arc, plasma jet, superficial surface, roughness, penetration, mechanical strength.*

1. INTRODUCTION

Plasma technology is based on a simple physical principle, this phenomenon was first discovered by Irving Langmuir in 1928.

The material is presented as one of the four types of state: solid, liquid, gas or plasma. Material changes its state when applied to a power source (temperature): the solid becomes liquid, and the liquid becomes gas.

If more energy is applied to a gas, it ionizes and it goes into a state of energy-rich plasma, thus, the fourth state of material. [2]

It is called the state of plasma, the state obtained under certain conditions of temperature and pressure and a degree of ionization of a gas, when it reaches in a quasi-stationary state made of a mixture of ions, electrons and photons, which is representing the state of the plasma.

Plasma technology is an unconventional technology comprising different processing methods: cutting and plasma arc trimming are the most common processing methods and plasma welding, erosion processing by plasma (drilling plasma, plasma grooving, filleting with plasma jet, rolling – assisted turning with plasma, assisted milling with plasma jet, assisted adjustment with plasma arc) and plasma metallization. [5]

2. PLASMA GENERATOR

The plasma jet processing is the technological operation that seeks the total or partial separation of a portion of a material or in the case studied, the modification of surface ,,texture''. This operation is achieved by bombarding with electrons. These electrons hit at high speed the workpiece and split molecules. (Fig.1.).

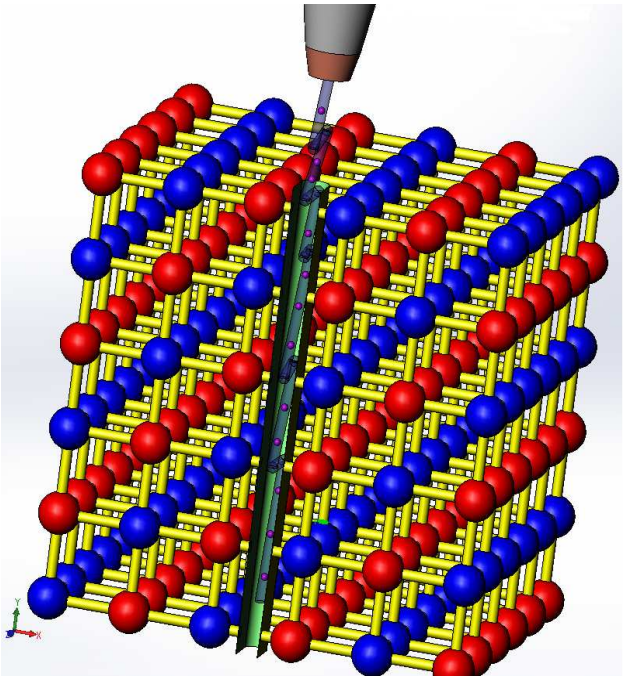

Fig. 1. Electrons splitting molecular bonds and passing through molecular structure of the workpiece.

Bombarding is achieved by using plasma generators where two running versions are distinguished:

- Plasma arc, the arc burns between the cathode electrode and anode piece passing through nozzle (Fig.2.):

The most well known technological operation with plasma arc is: cutting, trimming and welding.

In vehicle manufacturing it is used plasma, with temperatures at 5700 . . . 29700˚C (6000 . . . 30000˚K), obtained as a result of electrical discharges by arc in gas environment. (Fig.3.). The working gases which are used, can be: argon, hydrogen, nitrogen, helium, krypton or mixtures thereof. Plasma is developed by plasma generators, where the electric arc column is forced under a gas jet to pass through a limited space to fit a nozzle. [4]

Devices used for plasma cutting can be portable, of small size (Fig.4.), or mehanical with CNC for cutting different profiles using the CAD software (Fig.5.).

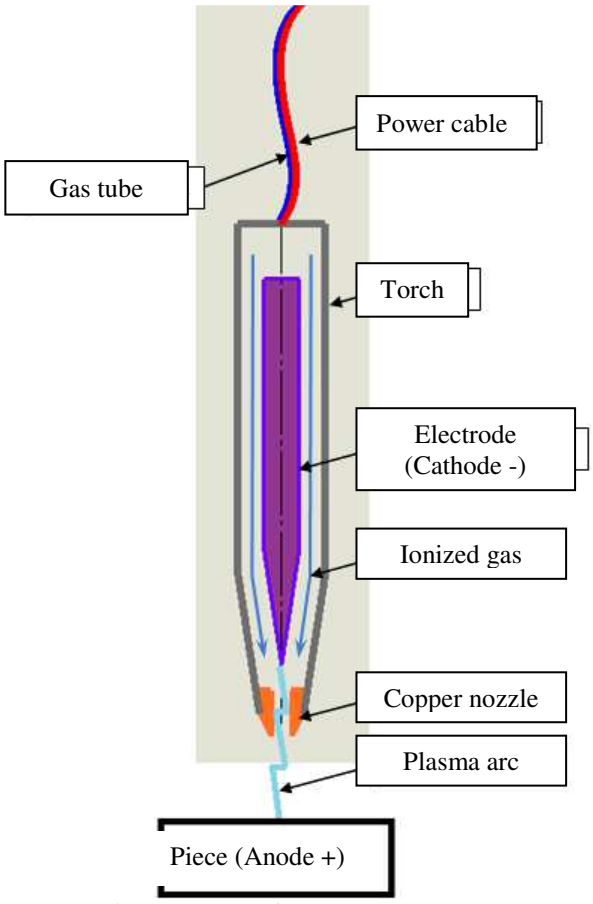

Fig. 2. Layout of plasma arc generator.

Fig. 3. Plasma arc.

Fig. 4. Cutting using a portable device.

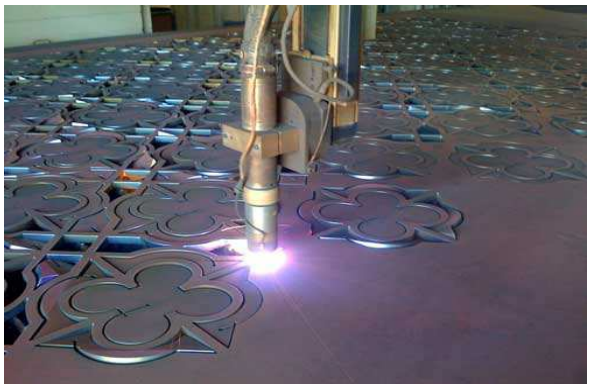

Fig. 5. Cutting using a mechanical device.

- With plasma jet when the arc burns between the cathode electrode and anode nozzle, plasma is blown by the jet gas pressure (Fig.6.): [4]

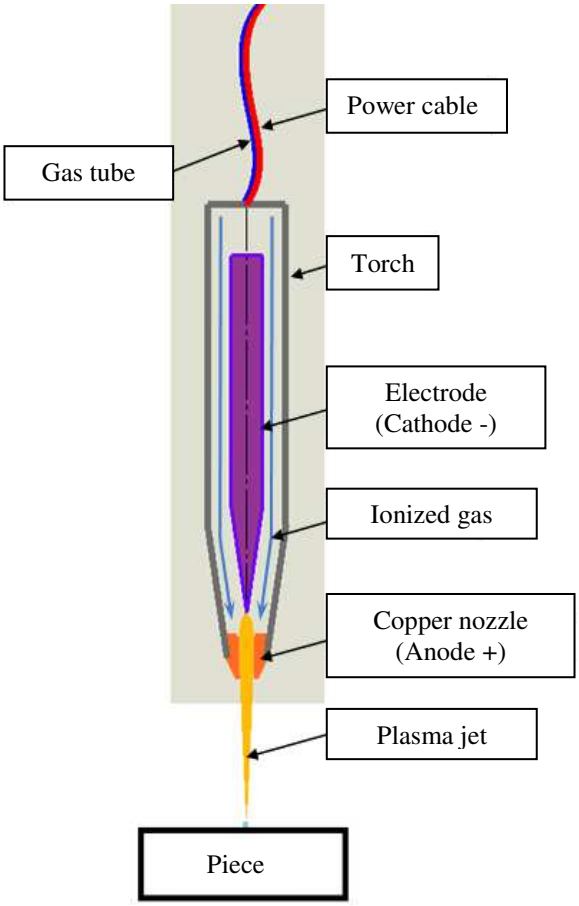

Fig. 6. Layout of plasma jet generator.

Recently, new techniques for surface modification were exploited, a new alternative method for processing the materials' surface is the plasma jet treatment. Modification of the material surface using the plasma jet means changing the surface properties, thus obtaining unique surfaces. (Fig.7.). Through this method, mechanical properties can be improved.

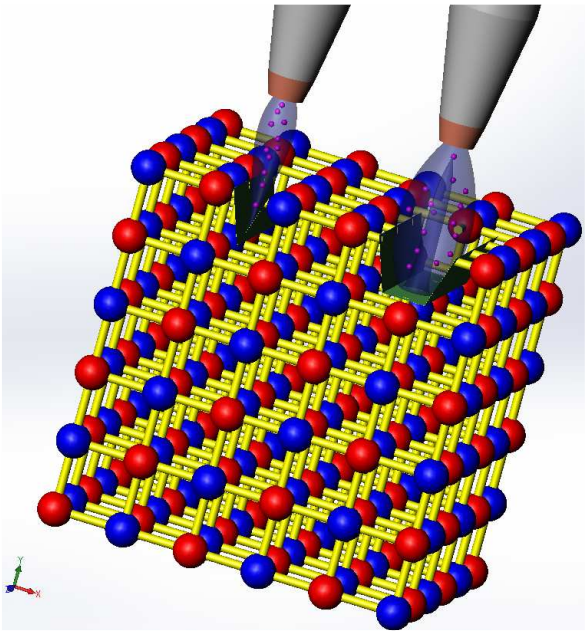

Fig. 7. Electrons splitting molecular networks at superficial surface using nozzles with different fits.

3. PRESENTATION OF GENERATORS PARAAMETERS.

At plasma technology operations There are two types of generators used in plasma technology operations, to compare their parameters we are presenting two generators which are basic devices of their category.

- Powermax30 XP generator is portable device of small size. [7]

Powermax30 XP device (Fig.8.) is designed to cut quickly and easily, while providing a high capacity for cutting thich metal and a detailed cutting on thin metal. [8]

Fig. 8. Powermax device 30 XP.

- FG 5001 generator is more complex as it is equipped with a transformer and a controller.

FG 5001 device (Fig.9.) is designed to repair or prepare areas depending on the technological operation that follows. [9]

Fig. 9. FG 5001 device.

FG 5001 device has a greater advantage than Powermax30 XP allowing processing or repairing materials surface that do not conduct electricity, for example: plastics, polymer foils, ceramics, painted surfaces, fabrics and fibers, paper, wood etc.

Table 1.

	Powermax30 XP	FG 5001
Power supply	120 - 240 V	100 - 260 V
Power generator	5,5 kW	1 kW
Supply safety	15 - 30 A	16 A
Output voltage	125 V	1 kV
Output frequency	50 - 60 Hz	15 - 25 kHz
Gas source	Air or N_2	Air
Work pressure	5 - 6 bars	Atmospheric
Work temperature	min. 1500℃	0 - 40℃
Dimensions	360x170x300	600x510x310

Analysing the parameters operating value (Table 1.) we have noticed the following:

Powermax30 XP:

Disadvantage:

a. a more powerful generator should be used for cutting and trimming ensuring total removal of workpiece;
b. moreover, a stronger fuse is needed for current intensity;
c. to fully remove the processed material it is necessary to ensure the working pressures from a compressed air network or special tubes;
d. high work temperature;
e. use protection equipment;
f. protect work area, ignition hazard.

Advantage:

a. due to its small size, it provides a high level of mobility;
b. it is a simple construction with a pleasant design;
c. fast and easy use;
d. it is very cost effective in serial production use or households.

FG 5001:

Disadvantage:

a. due to its size and high complexity cannot be portable;
b. provide a transformer to obtain high frequency;
c. high cost due to its complexity.

Advantage:

a. allows surface processing and treatment without altering its volume properties;
b. no sparking;
c. atmospheric pressure;
d. ambient temperature.

4. STUDIED SURFACE AFTER USING PLASMA JET.

Due to the high speed of electron bombardment when applying plasma jet a hissing sound that can achieve a noise level of 70 dB (Fig.10.) can be heard, depending on the nozzle used. Moreover, after applying the plasma jet, the surface is cleaned of impurities resulting a clean surface, almost sterile.

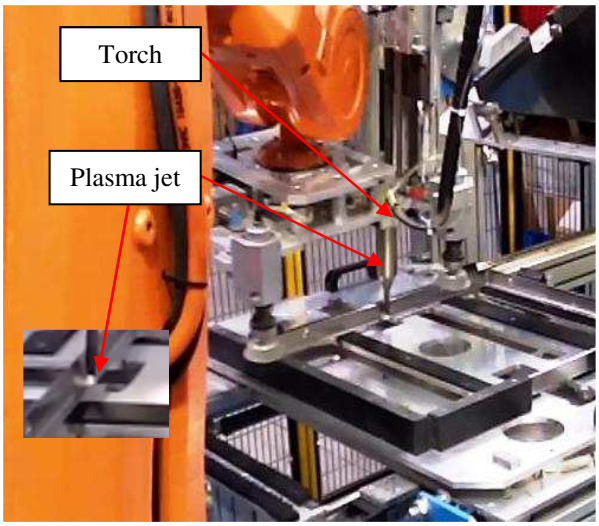

Fig. 10. Applying plasma jet using an industrial robot.

Areas were studied with a scanning electron microscope at the UT-CN Department of Materials Science and Technology.

Studied metalic support (Fig.11.), as a result of the plasma jet is made of stainless steel - 304-2B ASTM, (X5CrNi18-10), numeric symbol 1.430 [3]

Chemical composition: C_{max} - 0,07%;
Si_{max} - 1 %;
Mn_{max} - 2 %;
Cr - 17-19 %;
Ni - 8-11 %;
P_{max} - 0,045 %;
S_{max} - 0,015 %.

Mechanical features
Tensile strength:R_m = 520 MPa.
Flow strength, flow limit: $R_{p\,0,2}$ = 205 MPa.
Elongation: A = 40 %.

Steel 304-2B ASTM, (X5CrNi18-10), is the type of chromium nickel austenitic stainless steel most commonly used. Its most important property is: ductility (elongation) and roughness, cold processing and light marking. The content of at least 7% Ni makes its structure to become fully austenitic, which provides ,,non-magnetic'' properties and a very good weldability. It is widely used in the manufacture of household appliances, industrial pipes and tanks, industrial buildings.

2B (DIN 17441) – is the most common finished surface to ensure corrosion resistance and flatness, roughness of R_a= 0,10 - 0,30 µm and max.reflectance 40 %.


Fig. 11. Studied metalic support.


Fig. 12. Initial surface, enlarged by 500.

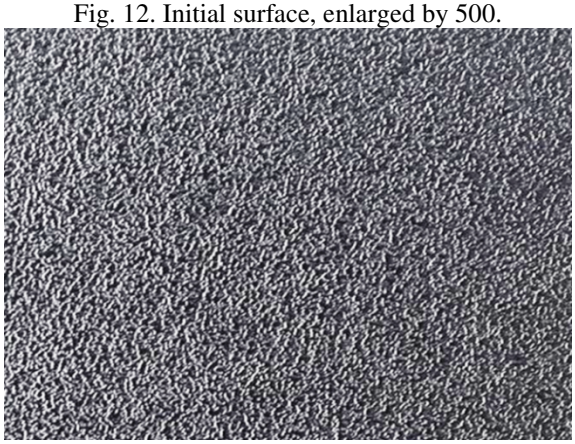
Fig. 13. Initial surface, enlarged by 1000.

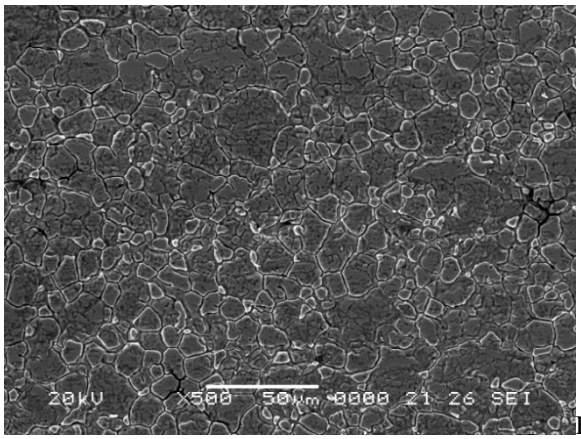

Fig. 14. Treated surface, enlarged by 500.

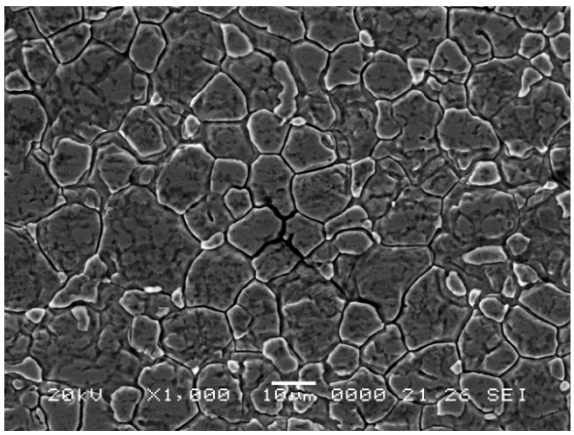

Fig. 15. Treated surface, enlarged by 1000.

After applying the plasma jet on the studied surface (Fig.14. and 15.), we obtain some „craters" ,in comparison to the initial surface (Fig.12. and 13.). These craters have resulted from electron bombarding and are very useful when adhesive, paint or other have to be applied on their surface.

According to theory of mechanical connection [1] bonding between adhesive and bearing surface(or any coating, paint) is made by adhesive infiltration into the pores, asperities (roughness) of bearing surface.

4.1. Study of superficial surfaces.

The study and analysis of the superficial surfaces is a relatively new branch of science which is known in the last 15-20 years.

The description of multidisciplinary activities aims the modification of properties of superficial parts (materials) to improve their functional performance and their lifespan, primarily it seeks to increase resistance.

Surface engineering involves a new vision in the activity of design and manufacturing. Basically, the mechanical parts are tested by different specific technological methods for modifying the properties of each element to finally get the desired functional performance of the piece as a whole.

Surface engineering uses a wide range of technologies, some of them well known and applied successfully for a long time, while others are unconventional advanced technologies. The technological principle used in this research is the modification of structural features without changing the chemical composition. [6]

Analyis and study of surfaces is carried out by ImageJ program.

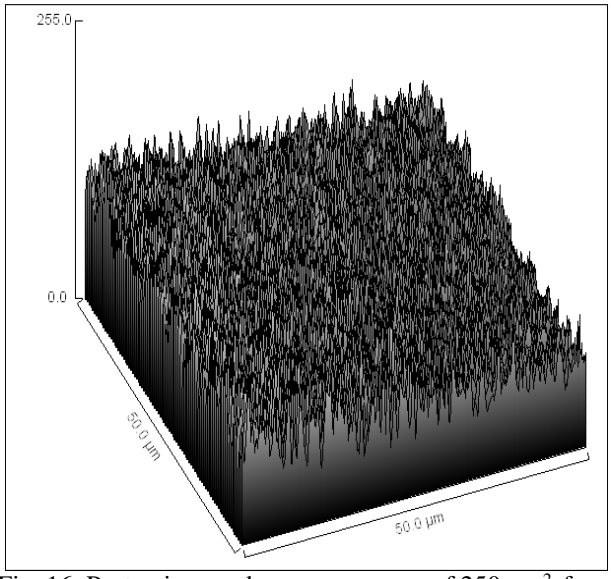

Fig. 16. Protrusions and gaps on an area of 250 µm^2 from the initial surface, enlarged by 1000 times.

The surface can be defined in several ways: general: the crystal structure, topographic: industrial and laboratory practice.

After applying the plasma jet on the studied surfaces, protrusions suffer changes (Fig.16. and 18.). In Figure 16, the protrudings are almost uniform and tidy, while in Figure 18 they have different heights and are disorderly scattered. These differences, structural changes are caused by break in the links between molecules.

Similar differences can be noticed at topographic views (Fig.17. and 19.), height value of initial surface is between 40 and 120

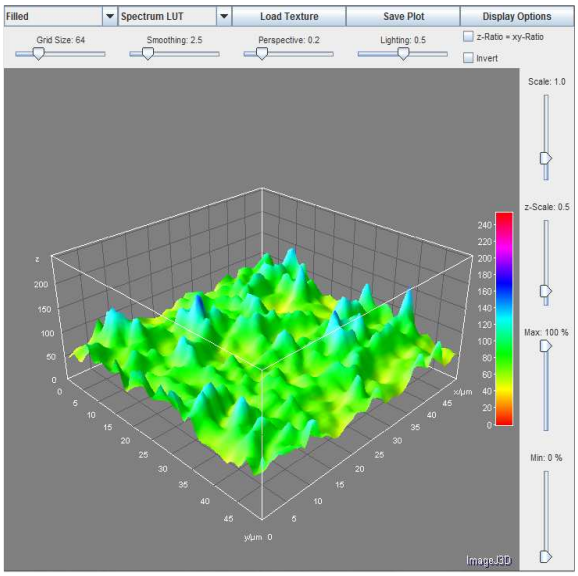

Fig. 17. Topographic view of initial surface.

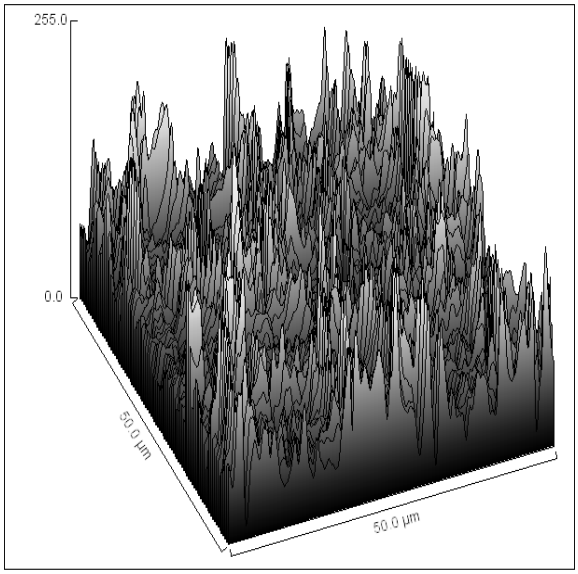

Fig. 18. Protrusions and gaps on an area of 250 µm^2 from the treated surface, enlarged by 1000 times.

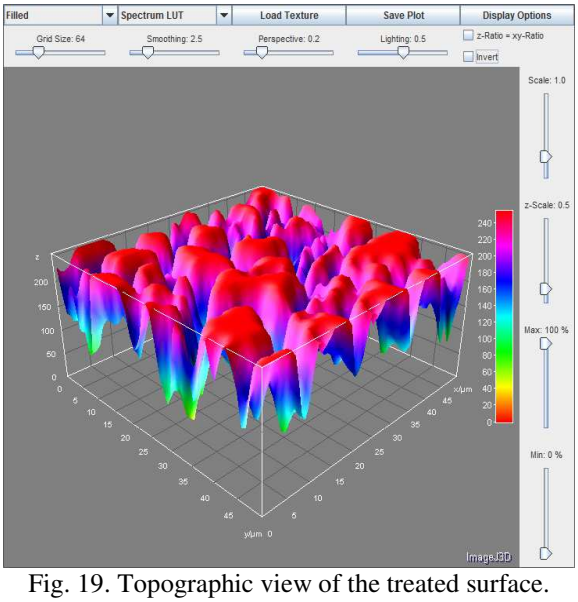

Fig. 19. Topographic view of the treated surface.

de µm and at the treated surface -between 120 and 250 µm. Overall protrusions and gaps on the surface layer were changed (increased) with a percentage of 130%.

With this increase in roughness, performance is improved, firstly, the mechanical strength of the bonding increases.

5. CONCLUSIONS

The most common and best known plasma technology operation is cutting and trimming. We know two types of plasma generators, which also offer other kinds of processing (processing or surface treatment).

In the field of car manufacture, we tend to get finer surfaces, more smooth and less roughness. This is an upside down case, where we, ,,distroy'' the surface but it helps us improve the mechanical properties. These damages are of microns size and help glue or paint infiltration ensuring a better grip.

Following plasma surface treatment, areas with unique characteristics and surface properties are obtained due to high frequences of 15-25 kHz.

Therefore, the plasma treatment is more and more often used in the industrial sector: automotive industry, electronic devices industry, textile industry, etc

In the medical field and biology, plasma processing allows activation of surfaces to prepare them for growth /or cell attachment or protein binding.

Moreover, due to the high speed of electron bombardment, a clean surface free of impurities is obtained, therefore the plasma treatment can be used for sterilizing components surfaces and medical devices.

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MODIFICAREA STĂRII SUPRAFEŢEI SUPERFICIALE CU JET DE PLASMĂ LA REPERELE METALICE (ÎN VEDEREA MĂRIRII ADERENŢEI, ASPERITĂŢII) CARE DEVIN ASAMBLATE PRIN LIPIRE

Rezumat: *Tehnologia de prelucrare cu plasmă a fost utilizată prima dată în al doilea război mondial în fabricile aeronautice ale Statelor Unite. La începutul anilor '60, inginerii făceau o nouă descoperire, mărirea vitezei jetului de plasmă prin îngustarea duzei. Datorită dezvoltării accelerate a ştiinţei inginereşti astăzi tehnologia cu plasmă este utilizată în diferite domenii: construcţii de maşini, industria aeronautică, industria automobilelor, medicină, biologie etc. La prelucrările cu jetului de plasmă distingem două modele de procesare, adică la presiune joasă şi la presiune atmosferică. Cercetările sunt efectuate la presiune atmosferică beneficiind avantajele acestora: dimensiunile corpurilor nu este limitat, suprafeţele pot fi modificate fără alterarea proprietăţilor de volum, temperatura joasă poate să evite distrugerea materialelor. Modificarea suprafeţelor materialelor cu plasmă se referă la schimbarea prorietăţilor de suprafaţă, creând suprafeţe cu caracteristici şi proprietăţi unice astfel se pot îmbunătăţi proprietăţile mecanice. Suprafeţele „textura" modificate permit infiltrarea adezivului astfel îmbunătăţind rezistenţele mecanice, care se vor verifica experimental: rezistenţă la tracţiune, rezistenţă la forfecare, rezistenţă la desprindere şi la rezilienţă.*

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