IOP Conf. Series: Materials Science and Engineering **95** (2015) 012010 doi:10.1088/1757-899X/95/1/012010

Contributions regarding the use of ultrasound capabilities in the reconditioning by metallization of some automotive parts

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Abstract. Paper presents the ultrasonic energy possibility in the reconditioning by powder metallization process. Three separated ultrasonic methods of energy activation in the deposition metal zone are presented. Advantages and disadvantages are studied for the following technological methods: filler material ultrasonic activation, base material ultrasonic activation, reconditioned metal piece activation, both filler and base material ultrasonic activation. Metallization devices design, are presented according to ultrasonic method activation for the ultrasonic field metallization process using metal powder.

1. Introduction
Restoration of automotive parts by reconditioning by powder metallization is the process of restoring the functional size of the piece by deposition of melted particulate filler material mechanically anchored on used surfaces properly prepared, wearing their microroughnesses. When certain energetic conditions are met, appear microweldings formed by microirregularities melting and diffusion [1]. The structure of the deposited layer by powder metallization has the following components (figure 1): particles of filler material 1, flattened due to the impact with the base material (support) 2 and that it adheres to this by wearing the microirregularities of the appropiate prepared surface 4 (line of demarcation). After filling the voids, the filler particles adhere to each other, layer by layer, until the required thickness and the following are happening:
-oxide microparticles 5 formed by oxidation of the filler material, located either at the interface of the base material - the first layer, or between the particles of the various layers deposited 6 (the highest protection is formed between the base material and the first powdered layer), where oxides resulted in surface preparation phase can be found).
-the oxide films reduce adhesion to the base material of the coating, and adhesion to each and other layer.
- a network of microchannels 7 and pores 8 that occur between filler particles deposited on top of another, or between the filler particles and the base material;
-filler particles that were not molten 9, whose adheshion is very weak compared to neighboring particles and lead to poor mechanical properties of metallization [1, 2].
-poor adherence or lack of adherence of filler layer due to weak diffusion process;

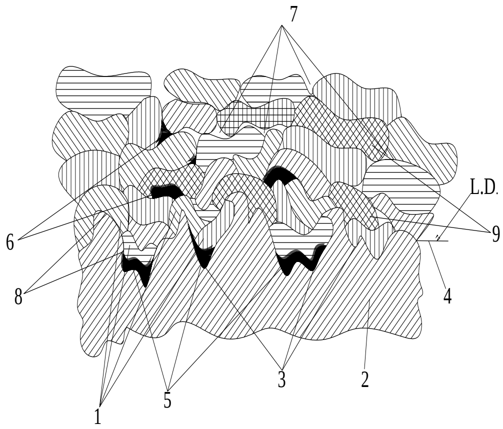

Figure 1. The structure of the deposit layer by powder metallization

1- deposit filler material particles; 2 - base material (suport material); 3 - microirregularities; 4 - line of demarcation (LD); 5 - oxide particles; 7- microchannels; 8 - voids; 9 - unmelted filler material particles

The reconditioning by powder metallization process has several advantages, but also some disadvantages, the most important are [1]:
-low resistance to tensile and bending, to mechanical and thermal shock of the deposited layer and of the resulted joint;
-low resistance of the deposited layers;
-the deposited layers cannot be plastic processed;
-the torque resulting from the metallization cannot be processed threads, grooves and any surfaces that interrupt material fibre of the deposited layer;
-needs post-metallization thermal treatment;
-needs a very good cleaning of the surface to remove any oxide film and impurities to an optimal adherence;
-causes significant emissions of dust and gas and therefore a significant impact on the environment [2, 3].

To prevent and reduce some of these disadvantages, this paper proposes a repairing method – the reconditioning by powder metallization in ultrasonic field, taking into account the main basic effects of ultrasound propagation in different environments. [1, 2, 7].

2. Possibilities of ultrasound use in the reconditioning by powder metallization

Research undertaken on different couples of materials and results obtained by metallization reconditioning [14] process showed that all the changes that occur in the deposited layer, the heat affected zone (if any) and in the support material depend primarily on how to enter ultrasounds in the deposited material, the base material or in both at the same time depending on the geometry of the part to be reconditioned and functional characteristics required [2, 4, 5, 9].

The efficiency of the technological process of powder metallization depends primarily on the behavior of the joint basic material-filler material but also how it connects between atoms marginal homogeneous or the two materials in contact area and near the contact area.

Homogeneous joint formation is the result of technological steps for depositing the filler material over the support material. The most important technological steps in the process of reconditioning by powder metallization are: suitable processing of the used surface that will be covered with filler; cleaning, pickling, degreasing to create optimal conditions of adhesion of filler material to the support material; pre-heating the support material (if appropriate) to reduce the temperature gradient, the actual metallization; ensure optimal conditions of solidification of the deposited material; application of appropriate heat treatment and processing of required dimensions for carrying out the same functional role [1, 2].

Each of these steps is influenced more or less if the ultrasonic energy overlaps conventional energy due to the pursuit phase in ultrasonic field.

The efficiency of the reconditioning by metallization in ultrasonic field depends primarily on the input mode of ultrasonic energy in processing furnace (deposit area). Experiments have shown that ultrasound propagation in the workplace has significant influence over the transfer process of the filler material to the support material, the adhesion process, the process of crystallization and solidification and even on the stress relaxation. All these influences are attributed to three basic phenomena occurring in ultrasound propagation, namely: ultrasonic cavitation, acceleration of diffusion; acceleration of crystallization and solidification.

The most difficult problem that arises in the metallization process in ultrasonic field is related to how the introduce the ultrasonic energy in the loading area of the filler material. In this paper, several variants of introducing ultrasonic energy in the deposition area have been investigated, the best results are obtained by the following: ultrasonic activation of filler material; ultrasonic activation of the reconditioned piece and simultaneous ultrasonic activation of reconditioned piece and filler material [2, 3, 10].

3. Methods proposed for the introduction of ultrasound in the powder metallization

Ultrasound input mode ultrasound in the area of deposition and overlapping ultrasonic energy over conventional energy is essential in obtaining materials with the required properties of the functional role. The introduction of ultrasound in the metallization process must meet the following requirements: ultrasonic system should not be affected by the temperature that develops in the processing area of the filler material, meaning that in the ultrasonic transducer must not be reached the Curie temperature; enabling the phenomenon of cavitation during cleaning and removal of impurities and oxides to create optimal conditions for adhesion of the filler material to the base material; avoiding possible oxidation of filler material droplets on their path to the depositing surface [11],[13]; to accelerate the crystallization and solidification of the deposited material with the base material forming a joint:
- have technological and constructive simplicity;
- enabling economic efficiency.

4. The possibility of introducing ultrasound through the filler material as wire electrode

In this case (figure 2), the filler material as wire electrode is passed through an ultrasonic system [11, 13] that vibrates longitudinally, the tested processes in the paper being [2, 3]:
- oxyfuel flame spray metallization with electrode-wire activated ultrasonic;
- electric arc spray metalization with three wires ultrasonic activated.

In oxyfuel flame powder metallization and ultrasonic activated wire electrode (figure2), the wire electrode 1 made of filler material is driven by the drive rollers 2, passes through acoustic reflector 3, piezoceramic disc 4, acoustic radiant 6, nodal flange 7, amplifier 8, ultrasonic energy concentrator 9 and makes contact with the active element 10 activated ultrasonic, achieving the oxyfuel flame 11 formed by the combustion of fuel gas 12, introduced through the nozzle 13. The wire electrode melts into droplets 14, protective gas entrained introduced by coupling 15 and are projected on the used surface properly prepared very finely pulverized in ultrasonic field created by the active element. Fine spray droplets are entrained by the carrier gas introduced through nozzle 15 and projected onto the used surface adequately prepared of the part 16, resulting filler layer 17 deposited on the surface of the piece. The wire electrode is ultrasonic activated in the active element of ultrasonic energy concentrator, a very fine polarization taking place and controlled projection of the droplets on the used surface [1, 2, 3]. In the case of introducing ultrasound by the wire electrode [8] made from the filler material, the following advantages are obtained: spraying the filler material in the form of very fine droplets with sizes of the order 0.01 …. 10.0 μm; substantial improvement of the transfer of filler material to support material; uniformity of the filler particles that are deposited on the used surface adequately prepared; ultrasonic cavitation occurs that increases the speed of subcooling and cooling and accelerates solidification; prevention of oxidation of the micro particles of filler material that increases the adhesion of the layer deposited on the support material; as a result of the propagation of ultrasound through the environment, accelerating the diffusion of filler material in the base material; degassing and uniformity of pores due to the transmission mode of ultrasound through the filler material; efficiency of deposition is maximized [10].

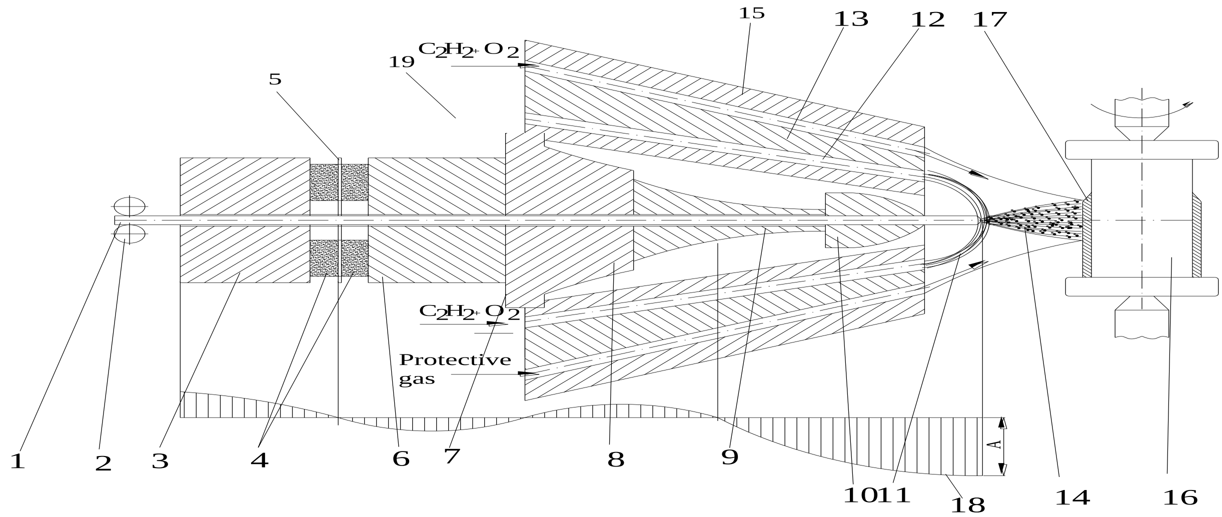

Figure 2. Schematic diagram of the introduction of ultrasound in the metallization process with flame and wire: 1- filler material wire-electrode; 2 - roller drive, 3 - acoustic reflector, 4 piezoceramic discs: 5 - contact electrode, 6 - acoustic radiant, 7 - nodal flange; 8 - amplifier; 9 - ultrasonic energy concentrator; 10 - active electrode; 11 - oxyacetylene flame;12- combustion of fuel gas, 13 - nozzle; 14 - drops of filler; 15 - nozzle; 16 - piece needs to be reconditioned; 17 - deposited layer; 18 - variation diagram for the amplitude of particle velocity along the ultrasonic system.

The disadvantages of this method are related to the construction of the metallization torch and heating the active part vibrating at ultrasonic frequency and creates ultrasonic field. There may also be problems with the transmission of ultrasonic vibration to the wire electrode.

5. Possibility of ultrasound introduction in the part that needs to be reconditioned by powder metallization

In this case, the ultrasonic system is conceived, designed and calculated [11, 13] in such a way that the part to be reconditioned to excite longitudinal ultrasonic waves [7], transverse or on the surface, depending on the geometry of the part and overall dimensions. Possible metallization processes with ultrasonic activation of the parts to be reconditioned are [3, 4, 6, 10]. Metallization with flame and powder and ultrasonic activation of the part to be reconditioned is presented in the figure 4. For metallization with oxyfuel flame and powder with ultrasonic activation of the part to be reconditioned part 1 (figure4.), caught in a drive device 2, selected according to the geometric shape of the surface to be reconditioned, through the active element 3 coupled acoustic with the part to be reconditioned, and are inserted in it longitudinal ultrasonic waves from the ultrasonic system composed of ultrasonic energy concentrator 4, the amplifier 5, the nodal flange 6, through which the system is fixed in the installation to be reconditioned, the acoustic radiant 7, piezoceramic disks 8 and the acoustic reflector 9 mechanical polarized with the polarization screw 10. Through the nozzle 12 is introduced the fuel gas 11 that forms the oxyacetylene flame 13, in which it is brought the powder filler material 16 with the aid of a carrier gas 15 introduced through the central nozzle 14. The powder is melted in form of drops 17, which are projected by the carrier gas to the surface to be reconditioned 18. The ultrasonic system is calculated so that it works under resonance, vibrating according to a diagram of the amplitude variation of the form 19.

When entering the ultrasound directly in the part to be reconditioned by metallization (figure 4), we obtain the following advantages:

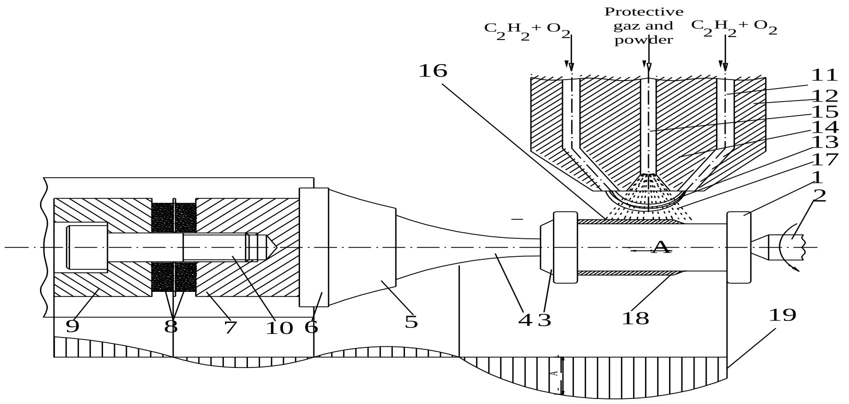

Figure 3. Schematic diagram for metallization with flame and powder with ultrasonic activation of the part to be reconditioned: 1- part to be reconditioned; 2- drive device; 3 - active part;4 - ultrasonic energy concentrator; 5-intermediant element; 6 - nodal flange;7- acoustic radiant element; 8 - piezoceramic discs; 9 - acoustic reflector; 10 - pre-polarization screw; 11- mix C_2H_2 +O_2; 12 - outer nozzle; 13 - oxyfuel flame;14 - central nozzle; 15 - powder carrying gas;16 - powder; 17 - filler material drops; 18- deposited layer; 19 - variation chart of the particle velocity; 20 - along the ultrasonic system.

6. Conclusions

The efficiency of the powder metallization reconditioning depends primarily on the behavior of couples filler and base material and the way how the homogeneous connection is made between atoms of the two materials in fringe of the contact area [12];

The action of ultrasound on the filler particles in the liquid state changes some basic properties such as superficial surface tension in the boundary deposited layer in the liquid state, base layer in solid state; viscosity, solidification temperature; sub-cooling and cooling speed; solidification temperature; degassing and diffusion accelerates; changes the structure; makes dispersion possible of a material in the others etc;

Introduction of ultrasound in the deposition area of the sprayed filler material can be added in several ways, the most effective being: ultrasonic activation of filler material in the form of wire-electrode, ultrasonic activation of the piece to be reconditioned and simultaneous activation of the filler material and the piece to be reconditioned;

In the case of ultrasonic activation of the filler material in the form of wire-electrode, the following advantages are obtained: the powdered filler material in very fine droplets (atomization thereof), a substantial improvement of the transfer process to the base material, increasing the sub-cooling and cooling speed, accelerating the solidification process, a substantial reduction in the oxidation process and increasing the adhesion process; accelerating the diffusion of the filler material to the base material; uniformity of the degassing process and of the distribution of pores etc;

Ultrasonic activation of the piece to be reconditioned by metallization leads to the following advantages: it provides a nearly perfect cleaning of the surface to be loaded, creating the conditions for a very good adhesion; accelerates the diffusion process; ultrasonic cavitation occurs and increases the rate of cooling and solidification of the deposited layer; obtaining a uniform fine grain structure with equiaxed grains; occurs degassing of the deposited layer and obtaining an uniform and controlled porosity; internal thermal stresses disappear and no post-metallization heat treatment is required etc.

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