RESEARCH ON THE ESTABLISHMENT OF AN EXPERIMENTAL MODEL FOR METAL FACILITY

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Abstract: *This paper presents studies for building a new plant for thermal spraying of various metallic materials used for making or refurbishing items in stock composition.*
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1. INTRODUCTION

Data from the literature and personal experience regarding existing installations of metal worldwide indicates that the installation of metal arc consists parts as shown in Figure 1.

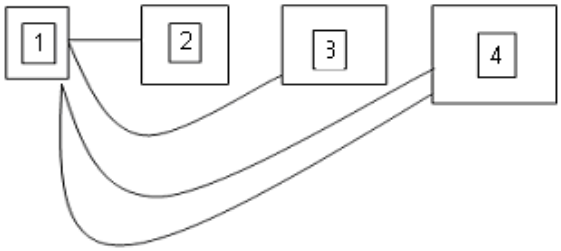

Fig.1. Schematic presentation of the metalizing facility:

1 - device metallization
2 - support material added under the form of wire
3 - unit control and compressed air preparation necessary to metallization
4 - source that provides the energy required to melt the material contribution.

2. EXPERIMENTAL DESIGN AND EXECUTION DATE

After trials and technological data was obtained with the original experimental model, was completed and optimized the installation of metal enhanced model. They looked at three aspects: optimization of plant experimental model of metal, melting optimize material delivery and optimize spraying molten material.

Optimization of experimental model of metal plant

Knowing the composition of a conventional metallization facility, was designed and executed the installation of a metal plant that respects the classical composition, to be competitive with existing plants and useful to the goal: i.e. to achieve corrosion protection of steel structures for transport.

To compete against existing installations worldwide, in the design of experimental model metal plant were considered the following conditions:

- Facility can work with wire diameter metallic materials between 1.6 - 2, 5 mm
- The plant is mobile and able to work both on site and in specially equipped workshops;
- Facility to be operated and maintained by trained personnel average;
- Protective layers deposited have maximum grip material submitted;
- Return the deposit to be lodged within the material.

For the installation to meet the above conditions there has been considered several options and chose the experimental model of metal facility composed of:

- Rectifier-type source that can provide electricity needed for metalizing with the following parameters: voltage between 0-40V and intensity between 0-350A. Charger is powered from the mains of 380 V
- Metallization machine can be manual mounted in a mechanical motion;
- Control unit and preparation of compressed air to provide fresh and filtered air;
- Support of metal wires on which can be mounted coils that are wound on metal wire.

Source of energy required to melt the material contribution

Energy sources to supply electricity are of two types:

- Type converter, which feature a shooting and using manual welding electrodes. These devices maintain constant voltage and current intensity adjustment allow work to keep burning arc for manual welding electrodes, where manual handling can not maintain a constant distance-piece electrode.
- Type rectifier having a characteristic rigid and semi-automatic or automatic welding using the environment protective or under flow. These devices provide the electricity necessary welding equipment that keeps the distance constant electrode-piece and allow adjustment of the arc voltage, the intensity is directly proportional to the electrode feed rate found, mostly in the form of coil wire.

Since one of the most important working parameters is metallization voltage current, which is directly influencing the efficiency and smoothness of the deposit sprayed particles, layer by default appearance, it has been chosen the use a rectifier type welding sources because this energy source has a rigid characteristic, slightly falling, which allows adjusting the arc voltage. CSR 400 charger, especially built in the M version for use in metallization, allows adjusting voltage between 0-40 V, working with intensities up to 350a which decisively affects plant's productivity and can provide

electricity to the parameters that ensure the conditions above;
Because regulate of the operation is done by adjusting the operating voltage and intensity adjustment is made by adjusting the wire feed speed allows operators to choose metal working arrangements possible with minimum loss and deposition of thin layers of powdered material.
Continuous voltage adjustment allows the choice of the minimum voltage at which the arc is stable, offers a fine particle spray and obtain compact layers with good adhesion. Feature rigid, slightly deciduous, the charger can keep blood adjusted at the beginning of the arc metallization and it's necessary for it to have a uniform and consistent operation.

Device metallization

Installation of metal component is performing deposit layers protection and how it works depends on the success of the metallization process.
Usually metallization apparatus runs according to the objective of metallization and are:
- Fixed equipment, refurbishing used parts in a technological flow;
- Mobile devices, used more in corrosion protection but can run and repair operations by metallization.
It was chose to be design and executed a mobile device metallization which do not depend on a fixed work, and that the unit can be mounted on a fixed support and work as a fixed device metallization.
The design of metal device was taken into account current variations of metal movable equipment:
- Light switches that are only meant to serve current and wires of metal particles to direct jet spray. These devices work by the system "to push", wire (material input) is "pushed" by a remote device to device metallization. This system has the disadvantage that at least two devices using wire as material input, pushing their distance from the pusher to the device, can create differences in advance due to friction between different wires on this route, which means operation with disruption and deposition of layers with large drops and inconsistent with direct influence on the quality and characteristics of the layers deposited by metallization
- Devices that work after the "firing" which are heavier because they built the drive system of metal wire
Of the two systems work chosen for the design and implementation of a device of metal working in the "firing" (material input is pulled by a mechanical device metallization in the existing mechanism and arc very close), because material corrosion protection additives are used in soft materials (Al, Zn), in the "to push '(the input material is pushed by a mechanical device located remote from the arc electrical) would be very difficult to use metallization process and would not go smoothly.
The design of metal device keeps in mind that it is as easy as weight, to be maneuvered easily.
Metallization device has three roles:
- The role of lead material under consideration as a wire;
- Role of melt material input using arc energy;
- Role of melt spray arc performed.

Involvement of metal wires

For involvement of metal wire was chosen solution using a pneumatic motor which has the advantage of small size and provides the energy required by compressed air entrainment. Pneumatic engine, placed in the handle device of metal, rise two floors scalers with motion of satellites that transmit to a scaler worm-wheel gear worm and further to the drive wheels of metal wire. For the device of metal can make 8 kg / hour, in case of deposit layers of Al, drive roller speed should be about 8 m / min. For reasons of gauge, drive rollers have a diameter of 26 mm, which means that to achieve speeds of 8 m / min, their speed must be
$n = 1000x\ V/ \pi\ x\ D = 1000\ x\ 8/ \pi\ x\ 26 = 98$ rot/min.
Since the pneumatic engine speed is 12,000 rpm and is scalars through two floors of gears with 1:5 reduction gear ratio satellites each, out of scalers to obtain 480 rpm. To obtain the required rotational speed wires involvement, worm drive gear worm-wheel will have a reduction gear ratio of 1: 5 which is unsuitable for such gear. By giving up one of the floors of Gear with satellites and from the pneumatic motor + gear assembly with satellites will get 2400 rpm.
This means that worm drive gear worm-wheel will have a reduction gear ratio of 1:26. Solution was chosen using a screw with a start and a snail wheel 26 teeth reduction gear ratio providing necessary scalars.
On the same drive roll speed, when using zinc as a corrosion protection material, will be able to make 8 x 6.36 / 2.41 = 21.2 kg / hour. As the drive roll, the solution adopted in the design and its implementation was as follows: a heat-treated steel crown placed on a block of textolit for electrically isolated from the spindle drive. Crown was fitted with a "moat" triangle of metal wires for training. This solution was adopted because if you design a reel with teeth on the periphery, in soft materials (aluminum and zinc) creates these teeth which pass through the nozzles of electrical contact, break and gradually obstruct the nozzle hole wire ended clog nozzle and stop the advance wire and metallization process.
For this reason these soft materials designed and executed to run this type of reel, electric insulated drive shaft as the roll classic types nicked the outside, which has practiced a triangular groove profile on outer surface of the crown, as shown in Figure 2.

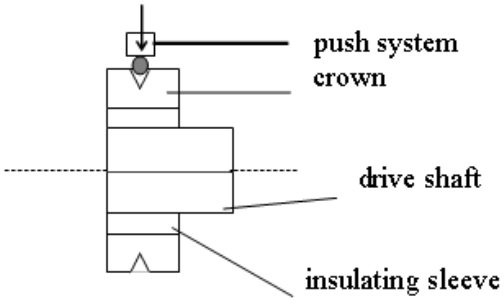

Figure 2. Roll

By pressing the wire into the groove is triangular wedging phenomenon of wire which can be trained. Even if they produce a small deflection, it no longer creates difficulties caused by the first type of roller drive.

Optimizing melt material input

Metallization apparatus ensure uniform melting of metal wire and a maximum efficiency of electricity use. Own experience and literature data showed that a 300 angle between the metalizing wires leads to better melting and the formation of a molten metal bath easier to spray.

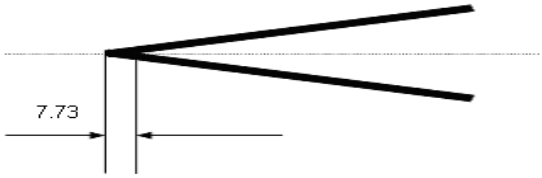

Figure 3.

Surface area resulting from the intersection of 2 mm diameter wire, with a slope of 150 plan metallization apparatus axis, is the axis of an ellipse area less than 2 mm and 7.73 mm axis.

This area is:

$A = \pi \times 2 \times 7, 73/2 = 24, 3\ mm^2$

To achieve this angle meeting of metal wire device of metal nozzles were fitted with two wires leading to a role that dual leadership and power supply wire to wire them through nozzles that are mounted in their continuation. Nozzles wire made of copper wires of metal take over and drive them into the arc. Because they always meet at the same point and remove the mechanical effects of subjecting wire arc mechanical forces whose action we could no longer meet, wire nozzles are calibrated and set rigid device metallization, their position is adjusted so that the wires are brought more than 15 mm outside.

Wire tip

Wire tip has the following roles: leads wire to the arc that would meet in the center air nozzle and transfer its rate of current needed to produce arcing and melting wires. Wire nozzle design was made considering that the portion of contact between the metallization and wire nozzle is only half the circumference of the wire section and has a maximum current density 4 A/mm^2, its length should be 30 mm, hindering its processing (nozzle hole diameter is 2.2 mm).

Considering that metal wire receives current from nozzles and stands on all surfaces in contact while traveling (and have power), was designed and executed a nozzle in the nozzle area that can be reduced and can be processed relatively easily. Another important aspect in designing nozzles that wire was connected inside the nozzle passage diameter: the diameter smaller than the diameter of the contact area of the nozzle. If the transition occurs abruptly or with an angle greater than 60°, an edge remains vivid, sharp enough to cause wire cutting of metal (for soft materials), gathering chips and hampering the advance wire, reaching even stop the advance and the metallization process.

Figure 4 presents two possibilities considered in the design of nozzles Wire:

a) nozzle break

b) nozzle with smooth transition.

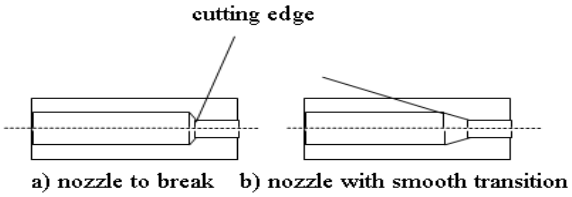

Figure 4. Types of nozzle

Optimizing molten metal arc spraying

Analyzing the mode of existing equipment in the world of metal, shown in Figure 5, it was found that spraying using nozzles of various shapes and sizes, placed behind the arc, which creates swirls spray particles spread, producing a stream of particles large scattering. The scattering particles do exist in running different temperature, different speed and direction of impact trajectory and different angles which affect their adhesion to the surface to be loaded by metallization. Figure 4 shows how installations of metal classics work.

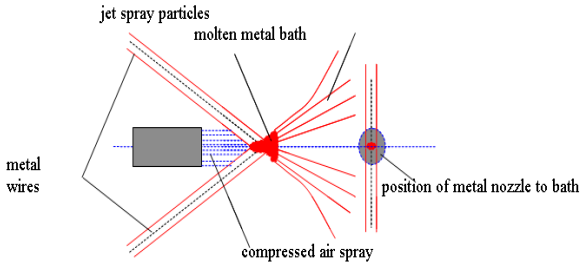

Figure 5. Operating mode of metal classics installation

Figure 4 noted that the compressed air spraying of metal is cutting the wires and will swirl and jet spray particles will have a large scattering.

As shown, scattering large particles jet spray means:

- Different temperature particle jet - thanks scattering particles quickly lose the edge jet temperature taken to spraying molten metal bath.
- Different speed particle jet – thanks to swirls of spraying compressed air, which no longer runs quietly and has areas where speed is less so and the metal particles sprayed in these areas are smaller.
- Sputtered particles will strike the surface loading different angles, so it is clear that the particles have a trajectory jet periphery under a different angle than the center of the jet particles.

This procedure will determine:

- A greater oxidation of sprayed particles, due to scatter over a large area will be a larger volume of air around oxidizing them.
- Less grip on the surface of charged particles due to low temperature and particle velocity at the jet periphery.
- Spray in larger drops and uneven due to molten metal bath in a stream of compressed air swirls.
- Danger that particles flow adheres poorly to the

outskirts and a load area without the operator realizing, but the adhesion layer will be weak and will not function properly in service.

Taking into account these disadvantages of traditional method of spraying, the metallization apparatus was designed to eliminate these disadvantages and to deposit metal layers with superior characteristics in terms of adhesion, porosity and return the deposit.

The solution adopted by the molten metal bath is arc sprayed by a jet of compressed air which takes the main bath and powder particle jet is "close" to a second air circuit that leaves him not to scatter surface and carries it to upload the metallization.

This system has the following advantages:

- Avoid training in the airflow swirls spray;
- Jet spray particles is more concentrated, so its temperature will be higher and more uniform within the jet because it is bound to remain in a smaller space;
- Sputtered particle velocity will be more uniform throughout the jet and will directly influence their kinetic energy and mechanical work that occurs at impact loading surface can be made more micro points between them and especially on this surface roughness is created;
- Impact angle of ground and surface charged particles will be approximately constant for all angles smaller particles and avoid the impact of particles on the periphery of the jet with direct influence on their adhesion.

Figure 6 shows the manner of metal working machine designed and executed.

This spray system will result in the deposit of metal layers with superior characteristics in terms of adhesion, porosity and productivity of deposit (in the sense that it will pay a higher amount of metal filler material than is currently submitted).

Preparation and control of compressed air

Figure 8 presents the preparation and control of compressed air. The compressed air is a basic element in the process of metal having a leading role in spraying molten metal bath.

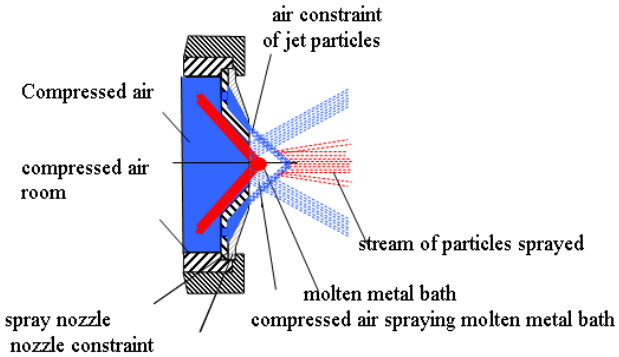

Figure 6. Operating mode of the designed and made metal apparatus

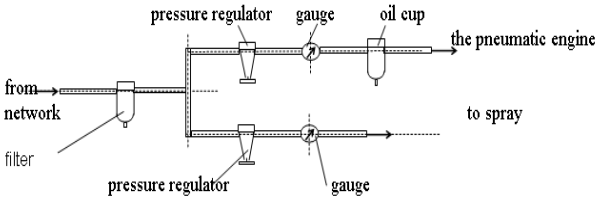

Figure 7. Preparation and control of compressed air

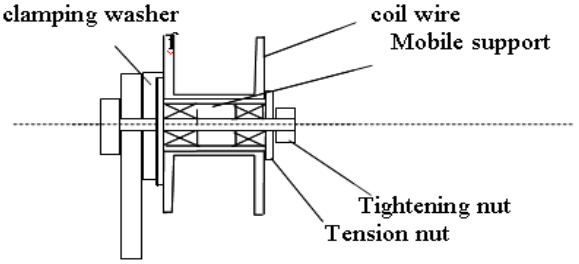

Figure 8. Fastening set screw-nut

Taking into account that the device uses a pneumatic motor metallization drive, compressed air required by the metalizing installation is used for two purposes:

- To drive the pneumatic engine, so the metalizing wires
- For spraying molten metal bath formed between the wires of metal.

To achieve both goals, compressed air is divided into two circuits, each circuit having appropriate equipment purpose.

Before splitting into two circuits to achieve the requirements set on compressed air supply circuit is mounted an air filter to clean the air of any impurities (water, oil, etc.) Circuit of the compressor provides compressed air to the control unit and prepares the compressed air. Compressed air from the pneumatic motor drive circuit must have different characteristics from circuit compressed air spray. Thus, if the flow of compressed air spray must be completely devoid of water, oil, and compressed air from the circuit pneumatic drive motor oil should contain necessary lubrication and pneumatic engine mounted planetary gear meant to continue with reduced speed.

Circuit compressed air to drive the engine must have the following components pneumatic air preparation, adjustment and control:

- Pressure regulator to adjust the input pressure compressed air into the engine pneumatic pressure can be varied by adjusting the pneumatic engine speed and hence, the wire feed rate of metal.
- Pressure gauge for reading the amount of compressed air supply pneumatic engine.
- Drip oil cup for lubricating pneumatic motor and planetary gear.

Circuit for spraying molten metal bath will have the composition:

- Pressure regulator to adjust pressure of compressed air spray. This is necessary for the two phases of the operation of metal: phase deposition layer adhesion and

deposition stage loading layer that runs with different values of pressure.
- Pressure gauge for reading the amount of compressed air spray.
Pneumatic equipment is placed in a box that allows operation of pressure regulators, access to oil cup (for food, oil) and reading gauges. Unity of command and preparation of compressed air is not having parts wear parts moving relative to each other .
A design support wire coil
Wire of metal is another important factor metallization process, its choice is a key determinant in the quality and behavior in service layer. Of metal wires can be supplied in coils or coils wound on plastic. For convenience and simplification of work to metallization, plastic coils are preferred. Support of metal wire was designed to use plastic bobbins, trapping and the possibility of fixing them. Besides the role of catching and fixing the plastic coil support has meant to impede progress in the process of metal wire.
During the metallization process, due to inertia, metal wires tend to run, in which case appears the danger achieve each of the wires and occurrence of faults that lead to surface damage wires or even breaking them.
To avoid these phenomena possible product support is provided with a brake system tensioning the wire of metal with the possibility of adjusting the brake force depending on the nature and availability of wire to run from inertia.
Adjusting the braking force must be such as to not require too much engine pneumatic drive, which is manifested by decreasing its speed, the wire feed speed, so work with current intensity directly affect the productivity of the metallization process.
From the support of wire coils, wires are sent to the arc metallization manual device thought two plastic sheaths which has blocked direct contact.
Wires of metal (material input) are wound on plastic spools fixed-support device of metal wire.
The device was designed and executed with a braking system of metal-tension wires to prevent their sale on the spool for metallization stop (because inertia reel)
The fitting provided with screw-nut, shown in Figure 7, produces tension in wire through a thrust bearing, without the nut being in contact with mobile holder and wire coil, preventing the dissolution of wedging or coils, while achieving tension of metal wire.
Thrust bearing design support transmitting the clamping force of metal wire tension required to properly design meant mobile holder of wire coils, which are their axes.
From reels of metal wire passing through flexible tubes in the gun of metal, where training and direct them to arc and melt spraying jet of compressed air. Kinematic chain for training the metalizing wires include: pneumatic motor, a planetary gear, a worm and worm gear-wheel rollers drive the wire. Pneumatic engine and gearbox is mounted planetary metalizing gun handle, the calculation and design of wire drive kinematic chain of metallization started from the pneumatic engine speed, due to inefficiencies in execution can have values between 10,000 and 15,000 rpm. To reach the wire feed rate of about 8.5 m / min, we need to drive the wire roll, whose diameter is 26 mm, to spin around 100 rpm. This means that planetary reducer and Worm drive-wheel drives have a reduction ratio of 1: 100 in the first case, or 1: 150 in the second. Taking into account the planetary gearbox has a reduction ratio and = 1:5 and works directly coupled with the pneumatic drive motor, so it may change size and clearance rates, means that the only place where speed can reduce the amount required for the proper functioning of its operation is wheel drives worm.It will have a reduction ratio of 1:20, or 1:30 in the first case, where the pneumatic engine speed is 15,000 rpm. Reduction ratio of drives for use with a pneumatic engine speed 15.000 rpm. at 1:26 was chosen because it was found that the pneumatic engine load reduces its speed about 15% (reaching about 13,000 rpm.). If the wire drive roller speed of metal is smaller, operation can be made of metal, wire melting current absorbed is directly proportional to feed rate. In this case the deposit will be less productive.

3. CONCLUSIONS

Device metallization own design, developed and tested functional parameters is superior to existing devices worldwide and outstanding performance in service.

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