APPLICATION OF LIQUID NITROGEN TO PAINT REMOVAL

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Abstract: *The phase of paint removal has a very important role for efficient painting, especially for the quality, energy consumption and productivity of painting. This paper deals with the new method of the painting preparing and the benefits which are increased by using liquid nitrogen in the paint removal phase. It is compared this method to the other ones, which are most used, such as chemical, mechanical and thermical methods. The estimated parameters of advantages are costs, functionallity and influences on the environment.*

Introduction

Industrial activities, comprising the painting phase of the metallic surfaces, parts and assemblies, are extensively widespread. All of these, however, have the same problems related to the paint applying, such as completely or partly paint layers removal, badly painted points repair or the cleaning of supports, racks and hooks.

Used paints are permanently improved and their chemical resistance, mechanical strenght and steadiness are increased, while at the same time the paint dissipation is not decreased, so that at the painting process more than 50% of the paint amount is left over on supports which are then cleaned. Accumulated paint sediments on supports, racks and hooks make heavy an electrostatic painting, increase a number of omissions, as well as energy consumption in polimerisation furnaces. Therefore, the phase of painting removal gains more important role, may be as important as the phase of painting.

The basic purpose of the painting removal system is to achieve the optimal ratio of the costs and results, taking as the parameters of estimating:

- costs,
- functionallity (efficiency, productivity),
- influences on the environment (reliability, cleanness).

New method - The liquid nitrogen paint removal, so-called the cryo-method

At the painting processes, especially at the electrostatic coating, the faultlessly clean surfaces of all racks, hooks and supports are needed because an opposite situation will not give a needed quality of the coating. When deals with a mass production (cars, tractors, mashines, domestic apparatus) it must not be permitted a husking of accumulations from the hooks and supports and their dropping on the fresh painted parts. Besides, a dirtiness of the floor-racks, caused from the paint accumulations, diminishes a fresh air flow rate in the paint chamber, wherewith the working area quality is reduced.

This method uses the difference between the metal part contraction and the paint contraction after immersion in liquid nitrogen. Thermical gradient causes "the shock" bringing on both the

paint layer cracking and separating. The whole process takes approx. 1 - 3 minutes with the liquid nitrogen consumption of about 0.5 - 0.7 lit/kg of the treating part, taking into account the losses due to liquid nitrogen s natural evaporating.

Regardless of various time intervals the weakness of paint layers occurs on all paint types, whether based on powder or liquid, and on all types of epoxy-coatings, polyuretane, acryle, etc. Increasing paint brittleness does not depend on the paint type and it is directly proportional to temperature and thermal conductivity and at the same time it is inversely proportional to the paint layer density. If an achieved temperature is lower, both the brittleness and an ability of readily paint removal are greater.

Liquid nitrogen paint removal technique, which is proposed, takes place through the following phases:

1. Immersion the paint accumulated parts into liquid nitrogen.
2. Holding the parts in the liquid nitrogen container, depending both on the type of paint and the accumulation greatness.
3. Cracked paint removing by mechanical acting.
4. Collecting the solid remainders and their taking off to the waste destination or the recycling paint plant.

Liquid nitrogen paint removal facilities can to be with a manual, semi-automatic or a fully-automatic directing, depending on activities, campaign durations or part types.

Liquid nitrogen paint removal facility

It is composed of the container for the parts immersion into liquid nitrogen, the liquid nitrogen storage tank, the liquid nitrogen pipeline to fill the immersion container from the liquid nitrogen storage tank, vaporised nitrogen exhaust system, conveying and immersing devices of the parts from which the paint to be removed and finally the cracked paint removal device ("shotblasting device").

The container to the parts immersion represents a vacuum-insulated container filled with liquid nitrogen under atmospheric pressure (something like big Dewar) with a movable cover cap. Container dimensions have to correspond to dimensions of parts from which paints is to be removed. Because of an influence both of outer heat and immersioned parts heat, liquid nitrogen vaporises and goes out from the container (the nitrogen losses), so that its vapor has to be exhausted and got out from the working area. The temperature both of liquid nitrogen and its vapor at atmospheric pressure is - 193 °C. Protection means, such as gloves, safety glasses, clothes and footwears, are required for trained personnel.

The liquid nitrogen storage tank represents also a vacuum-insulated container in which liquid nitrogen is stored under low pressure (approx. 3 barg) to prevent an effect of vaporisation during the liquid nitrogen s flow into the immersion container, whereby to less the nitrogen losses.

Costs

For the selection of an investment solution, which will solve efficiently the problems of the paint removal, both the careful analysis and the costs of different systems which are used, are necessary. As the proposed method using liquid nitrogen is not applied in our country, at present, the costs of the methods compared, according to the

To this costs the expences both of the investment and the current maintenance, i.e. repairs and the exchange of an existing technology, have to be added.

Energy and material costs					
	Chemical	*Mechanical*	*Thermical*	*Liquid nitrogen hand-operated*	*Liquid nitrogen automatically*
Energy and material	*Dissolvents*	*El. energy, Compr. air, steel-balls*	*Natural gas*	*Liquid nitrogen*	*Liquid nitrogen El. energy*
Consumption:					
m^3			*150*		
lit	*1,400*			*1,200*	*1,000*
kW		*1,250*			*200*
Price:					
DM/m^3			*0.25*		
DM/lit	*2*			*0.30*	*0.30*
DM/kW		*0.10*			*0.10*
Total price of energy and material (DM)	*2,800*	*125*	*37.5*	*360*	*320*
Number of supports	*400*	*400*	*400*	*400*	*400*
Weight per support (kg)	*3.5*	*3.5*	*3.5*	*3.5*	*3.5*
Cost per support (DM)	*7.0*	*0.31*	*0.09*	*0.90*	*0.80*
Cost per kilo (DM)	*2.0*	*0.09*	*0.03*	*0.26*	*0.23*
Labour costs					
Duration per support (min)	*6*	*5*	*15*	*3*	*1*
Number of supports	*67*	*80*	*27*	*133*	*400*
Total labour costs (DM)	*2 employees 40*	*2 employees 40*	*2 employees 40*	*1 employee 20*	*1 employee 20*
Cost per support (DM)	*0.60*	*0.50*	*1.48*	*0.15*	*0.05*
Cost per kilo (DM)	*0.17*	*0.14*	*0.42*	*0.04*	*0.01*
Total energy, material and labour costs					
- per support	*7.60*	*0.81*	*1.57*	*1.05*	*0.85*
- per kilo	*2.17*	*0.23*	*0.45*	*0.30*	*0.24*

Functionallity

To estimate the functionallity of the method, both the whole efficiency and the productivity must be observed. Although liquid nitrogen has all characteristics enabling the solving of the paint removal problems, existing experiences have shown necessities for prolonged immersions at the thicker layers of paints. Thus, the total process time is prolonged, as well as the costs increased. According to those experiences the paint layer thickness must not to be over 150 μm prior to be removed.

This problem can to be solved by the preparing procedure comprising the coating supports or racks by so-called the means for separating. The means for separating are the products which are dissolved in water or dissolvents. Apart from that, to prevent the condensation on the cooled supports, it is possible a heating to environmental temperature.

Productivity of the method proposed is provided by short and numerous cycles, where is the advantage of this method.

Enfluences on the environment

Comparing to the other methods requiring particularly protective measures, the liquid nitrogen method represents both clean and safe technology without the risk to employees or to the environment.

Nitrogen is an inert gas. It is neither tocsic nor flamable, nor corosive, as well. The whole process of the paint removal by liquid nitrogen has phisical nature, not chemical. Remainders, appeared during the paint removal phase are the pices of polymerised pitch and according to the rules of ways of remainder removal they are equalled as a city-waste.

Method	*Fumes and waste*
Chemical	*Chemical fumes, liquid chemicals, solid waste*
Thermical	*Flue gases, chemical fumes, solid waste (25-30 % of paint)*
Mechanical	*Solid waste*
Liquid nitrogen	*Solid remainders as a city-waste*

Summary

1. The working cycles takes only few minutes comparing to hours for the classical methods.
2. Better quality of the paint removal.
3. Low temperatures do not have any permanent enfluences on the metal.
4. The waste represents dry powder unharming the environment.
5. Personnel are not undergone to the harmful enfluences of chemicals.
6. The production costs are low.