AUTOMATED WORKSTATION FOR PRIOR-TO-PAINTING CLEANING OF METALLIC SURFACES

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Abstract. The subject of the present report is an automatic shop for cleaning of metal surfaces before painting, which is a key factor for the quality of the varnish coating. A contemporary automatic technology is suggested by processing the metal surfaces with a flow of accelerated spherical shots providing cleaning from corrosion and surface texture improving the adhesion of the coating to the treated surface.

Keywords: automated workstation, metallic surfaces, cleaning, variability, methodology, optimal variant

1. Introduction

Cleaning of surfaces prior to their painting has a crucial impact on the quality of paint and polish layers. Customers often raise claims due to broken or fallen out parts of such layers. Hence, in demand are modern technologies intended at a proceeding cleaning of the metallic surfaces, i.e. removing of stains and turbine shot-blasting processing.

Object of this article are large sized products, such as: column, cantilevers, frames and similar welded constructions.

2. Problem background

Aim of this research is to design a prototype of a product-oriented automated workstation (POAWS) for cleaning and preparation of metallic surfaces before painting them. In this regard specific measures were taken: conceiving of a design methodology; methodology testing and deliberating of variants; variant analysis and choice of the optimal one; completing of technological documentation for original parts Manufacturing; completing the Manufacturing schemes and drawings; conceiving of typical units and aggregates for POAWS.

3. Development of a design methodology for POAW

Prior to cleaning and preparing of a metallic surface for an upcoming painting operation, a number of problems must be approached, among them: conception and choice of structural schemes for POAWS; optimization of the technological process; generating of constructive and composition variants; variants analysis and evaluation; choice of the optimal POAWS variant; definition of basic POAWS features; simulation of the POAWS work zone; optimization of the work cycle.

In most cases automation is done in regard of the pre-existing production equipment. In the rule, machines already posses automatic work cycles and are fitted with CNC control devices.

The cleaning of metallic surfaces and welded constructions prior to their painting is based on a previously developed technological process, which runs on the POAWS and is fully suitable due to the segregation of technological operations in conformity with the single work positions.

Before starting with the POAWS design a matching methodology has to be developed. The methodology for design of an experimental POAWS for cleans up of metallic surfaces and welded constructions before their painting passes various stages as listed bellow:

- Synchronization and optimization of the technological process;
- Definition of the logistic flow;
- Conceiving of POAWS variants;
- Defining the work positions number;
- Design of the single work positions;
- Design of the automated parts flow;
- Developing of the transportation and manipulation systems;
- Preparing of a preliminary specification for purchasable components of the intended POAWS;
- Acquirement of the purchasable elements in line with the specification;
- Project conception development;
- Deliberation of variants, analysis, assessment and choice of the optimal variant;
- Simulation of the POAWS optimal variant functioning;
- Preparation of design documentation on hand of the ideational project;
- Development of routine technology for production of original aggregates and assembly groups;
- Preparation of specification for production of original aggregates and assembly groups;

- Conceiving of schedule for producing and testing of aggregates and assembly groups;
- Development of methods for control tests of each aggregate and assembly group;
- Initiating a Journal for precise and detailed recording of surveillance results and corrections;
- Exercise of active authorial control during the parts production and assembly in line with the time-table;
- Performance of functionality tests and verification of aggregates and groups according to test methodologies;
- Undertaking of fundamental repair operations on existing production machinery intended as parts of the POAWS;
- Conceiving and coordinating of time schedules regarding assembly, tests and industrial implementation;
- POAWS assembly at the plant in cooperation with plant's representatives under active authorial control;
- POAWS programming and tuning;
- Arranging of functional tests and pivotal production;
- POAWS tests and exploitation start at the plant;
- Conceiving and applying of Instructions for safe exploitation of POAWS;
- Training of POAWS operators selected among the plant's staff;
- Assessment of the commercial efficiency of the POAWS implementation;
- Warranty maintenance and optimization of the POAWS;
- Conclusions from the POAWS implementation and conceptions for further researches.

The above listed main stages and their interactions are visualized on figures 1a and 1b.

The automation of the part flow must meet a series of requirements:

- ✓ The feeding with details automation must be "compatible" with the production machinery in a way that allows for repairing, tuning and operating activities;
- ✓ The feeding with details automation must provide for repair works and exploitation that are not depends on the machinery type;
- ✓ The feeding with details automation must lead to minimizing of machine delays in the POAWS;
- ✓ The feeding with details automation must guarantee a minimal change in the production machinery
- ✓ The feeding with details automation must proceed with technical devices of a sophistication level similar or lesser than that of the existing machines (mechanical part, electrical control, pneumatic drive);
- ✓ The feeding with details automation must be least time and money consuming;
- ✓ The feeding with details automation must proceed with optimal operations synchronization in order to minimize delays on the single work positions;
- ✓ The feeding with details must provide for a flexible interaction between work positions so that failure in one position does not harm the functioning of the others.

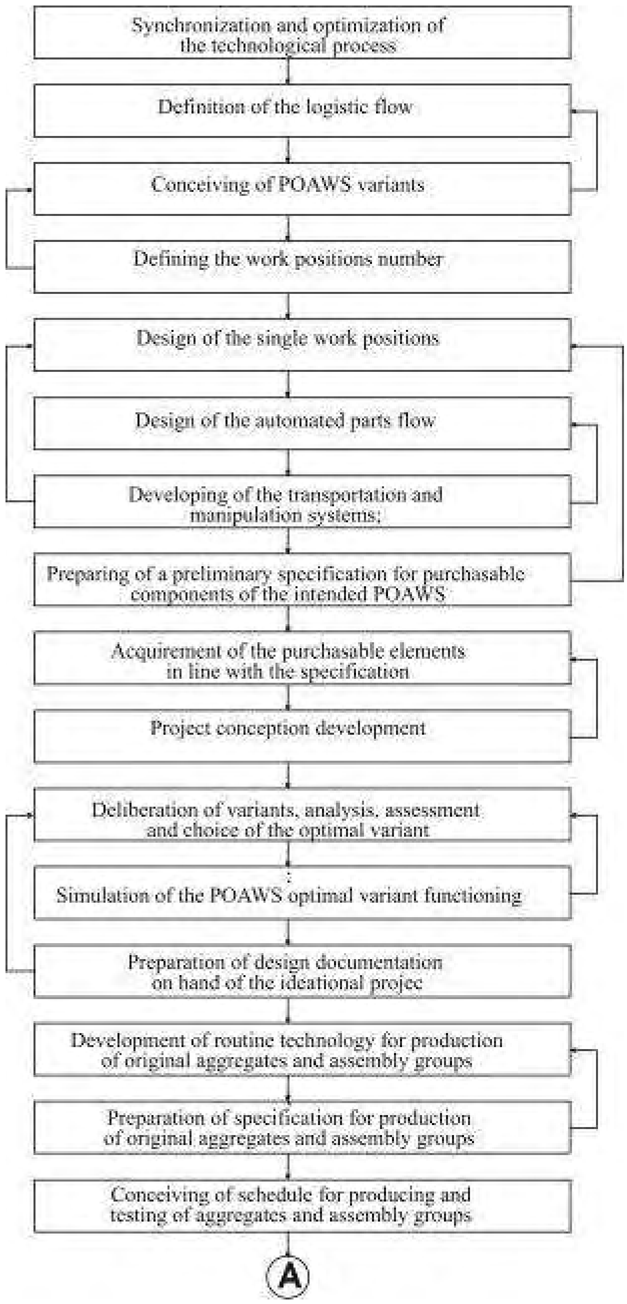

Figure 1a. Methodology for design and implementation of POAWS for cleaning of metallic surfaces and welded constructions prior to-painting

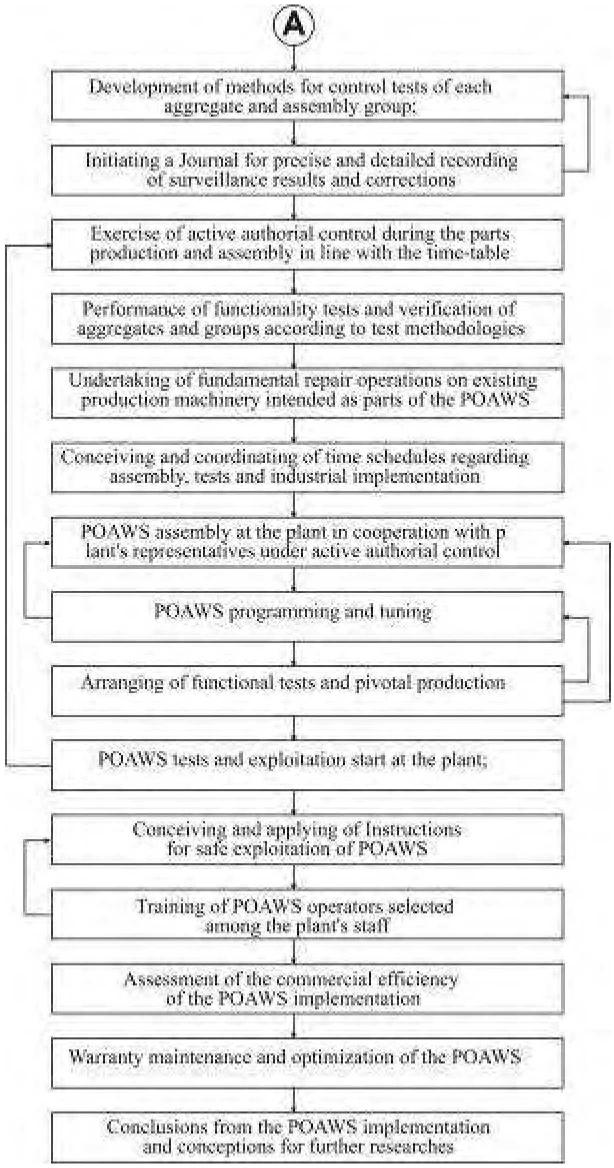

Figure 1b. Methodology for design and implementation of POAWS for cleaning of metallic surfaces and welded constructions prior to-painting

4. Methodology testing and conceiving of POAWS variants

The assessment results for different variants of the technological process regarding the cleaning of metallic surfaces and welded constructions prior to their painting shows that the second one is optimal for a trajectory technology featuring a maximal summarized coefficient $\mathbf{K_{O3} = 0.535}$.

Optimal technological route for prior-to-painting cleaning of metallic surfaces:

- ➢ Tailoring of details by plasma or oxygen cutting;
- ➢ Mechanical processing of the sharp edges after cutting;
- ➢ Removing of dust particles and cleaning of metallic surfaces;
- ➢ Oil and grease removing and cleaning off organic particles;
- ➢ Removing of rust stains through turbine shot-blast processing
- ➢ Blasting off of dust and metallic particles;
- ➢ Welding and mechanical processing;
- ➢ Oil removing together phosphating of welded units;
- ➢ Drying by air-blasting;
- ➢ Final blasting through turbine shot blasting processing in order to clean the surfaces and the welded edges;
- ➢ Dusting off;
- ➢ Preservation of the openings from dust particles getting in;
- ➢ Ground laying;
- ➢ Painting.

When generating POAWS variants for cleaning of metallic surfaces and welded constructions the bellow listed variables are put in use:

- Structural units type;
- Structural units model;
- Structural units drives;
- Structural units control;
- Transportation and manipulation modes;
- Mutual positioning of structural units;
- Types of positioning and fixing of processed parts;
- Types of changing the automation objects;
- Etc.

On figure 2 is shown a logistic scheme based on the chosen technological process route for cleaning of metallic surfaces and welded constructions prior to their painting.

The scheme is used to derive the single POAWS variants.

Suggested are 6 variants. The selected one is shown on figure 3.

The basic variant of a POAWS for cleaning of metallic surfaces and welded constructions prior to their painting features two specific zones:

- ➢ Zone for oil/grease removing (figure 3);
- ➢ Zone for turbine shot-blast cleaning.

Based on the basic variant of a POAWS for cleaning of metallic surfaces and welded constructions prior to their painting are offered variants both for the zone of oil removing and for the zone for turbine shot-blast processing.

The Oil removing zone can be set in several variants:

- manual passing of products for oil-removing;
- semi-automatic passing of products for oil-removing;
- automatic passing of products for oil-removing.

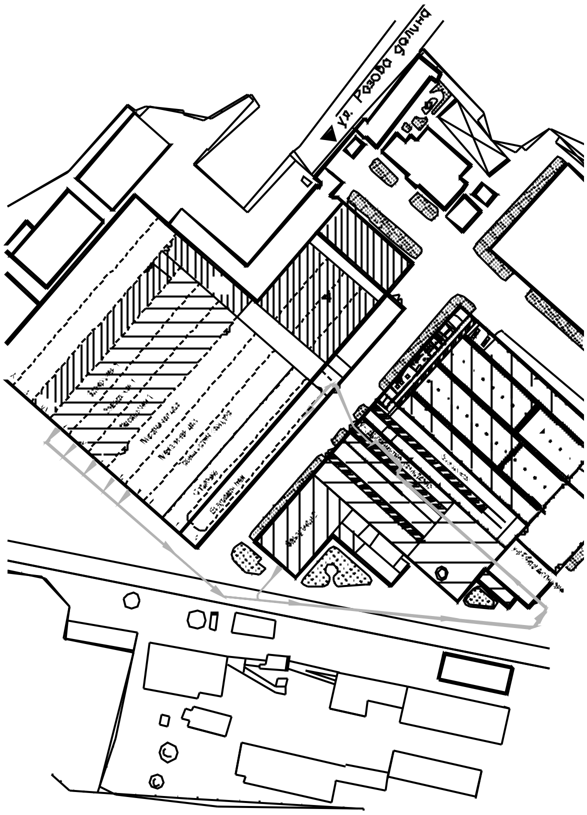

Figure 2. Logistic scheme for performing the new technology for cleaning of metallic surfaces prior to painting

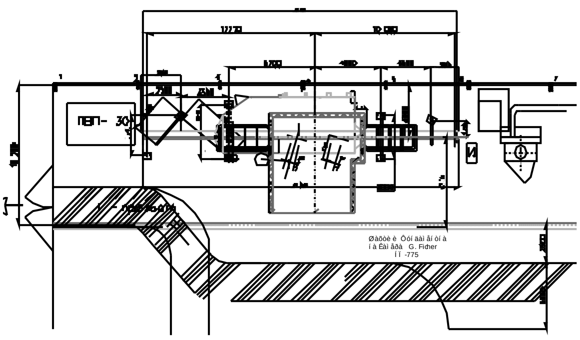

Figure 3. Basic variant of an oil removing installation

The variant type notwithstanding, the products passed into the zone are of large sizes and heavy weights. Therefore it is recommendable to apply the automatic variant. Thus any hard manual labor can be spared and the negative influence of subjectivity in regard of operations timing can be avoided.

Variant I - the cleaning of metallic surfaces proceeds in a G. Ficher-type chamber. The latter is suitable for a simultaneous automatic turbine shot-blast cleaning of 2 objects. The chamber has a predetermined capacity and is divided into two sections allowing the processing of two products. The turbine shot-blast turbines (three in each section) are placed against one of the chamber sides in different angular positions. Thus the direction of the cleaning blast is fully focused on the cleaned surface. The one-side arrangement of the turbines requires that the cleaned hanging object to be repeatedly turned during the whole work cycle.

The abrasive substance is gathered in a hopper magazine and repeatedly fed via an elevator into the dividing section and towards the working turbines.

Variant II the cleaning of metallic surfaces proceeds in a G. Ficher-chamber type adapted for manual operations. The chamber can be expanded in order to provide for the feeding of large-sized objects and to grant enough work space for perform a manual shot blasting.

Variant III the cleaning of metallic surfaces proceeds in a G. Ficher-chamber type adapted for both automatic and manual operation modes.

In the automatic mode an appropriate object is mechanically passed to the operation zone. The chamber doors close automatically and a signal for staring the object's rotation is given. Simultaneously, the operating equipment is switched on together with the recycling system. After the work cycle runs off (in approx. 5 [min]) the doors open. The conveyors are set into motion and the object is led away to the unloading zone.

5. Analysis of the POAWS variants and choice of the optimal one

Six variants are selected for assessment:

- **Variant 1** – Manual oil removing in a special chamber and manual shot blasting cleaning in the cleaning chamber;
- **Variant 2 –** Semi-automatic oil removing in a special chamber and manual shot blasting cleaning in the cleaning chamber;
- **Variant 3 -** Automatic oil removing in a special chamber and manual shot blasting cleaning in the cleaning chamber;
- **Variant 4 -** Manual oil removing in a special chamber and manual shot blasting cleaning in the cleaning chamber;
- **Variant 5 -** Semi-automatic oil removing in a special chamber and manual shot blasting cleaning in the cleaning chamber;
- **Variant 6 -** Automatic oil removing in a special chamber and a combined cleaning / automatic turbine shot-blasting and manual shot-blasting / in the cleaning chamber.

The assessment results for all variants prove that the sixth variant of a POAWS for cleaning of metallic surfaces and welded constructions prior to their painting is the optimal one hence it features a summarized coefficient $K_{O6} = 0.302$.

Table 1. Quantity values of non-scaled coefficients

K_i / V_i	K_1	K_2	K_3	K_4	K_5	K_{Oi}
V_1	1.2	0.95	0.4	0.85	0.3	0.116
V_2	1.3	0.93	0.5	0.83	0.28	0.140
V_3	1.5	0.90	0.6	0.80	0.2	0.129
V_4	1.6	0.89	0.6	0.83	0.2	0.141
V_5	1.8	0.87	0.8	0.80	0.23	0.230
V_6	2.0	0.85	0.95	0.75	0.25	0.302

$\max\{K_{Oi}, i = 1 \div m\} =$

$= \max\{0.116; 0.140; 0.129; 0.141; 0.230; 0.302\} = 0.302$

6. Conclusions

- Generated is an optimal technological process for cleaning of metallic surfaces and welded constructions prior to their painting.
- Developed is a methodology aimed at designing a product-oriented automated workstation (POAWS) for cleaning of metallic surfaces and welded constructions prior to their painting.
- Generated are variants of POAWS for cleaning of metallic surfaces and welded constructions prior to their painting. The same are analyzed and evaluated and the optimal one is selected on the ground of the non-scaled-coefficient method.

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