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Influence of Dyeing/Drying Booths Operating Parameters on the Painted Products Quality

The article proposes an analysis of the dyeing/drying booths (DDB) operating parameters influence on the quality of products and processes that are specific to an economic agent, which has as its object of activities the design and production of integrated systems made of advanced composite materials, metallic materials and sandwich materials with different cores. In order to assess the product conformity, the production flow of products made of resin reinforced with glass fiber was followed and quality control of painted products was performed by final inspection. Final inspection is an essential factor in any scientific system of production organization and management. There have been highlighted measures in order to solve the spray-painted products nonconformities caused by the change of the dyeing/drying booths operating parameters. In this sense, solutions are proposed in order to correct the defects through three main actions.

Keywords*: dyeing/drying booth, TQM, EFQM model, painted product, nonconformity*

1. Introduction

In the current context, to achieve a level of excellence, economic agents should consider the importance of applying the Total Quality Management (TQM) concepts to specific products and processes. Specialty literature offers numerous studies in TQM field [1], [2] and [3].

The analyzed economic agent , S.C. Clagi-Coplass company, has as basic principles the quality assurance and the guarantee for the products manufactured within the company according to the quality levels specified by the valid regulations and the contractual clauses agreed with the clients, the development of the trust in the organization superior management and the employees, respectively, the quality and seriousness in dealing with all interested partners, guaranteeing the winning of the market. S.C. Clagi-Coplass has implemented a Quality Management System (QMS) in accordance with the requirements of ISO 9001/2000, ISO 14001/2004, OHSAS 18001/2004 and IRIS / 2007 [4].

The ISO 9001/2000 Standard sets out the requirements applicable to any organization that develops a QMS based on processes and directed to meet customer requirements. It sets out the general conditions that determine the QMS elements without aiming to impose their uniformity. The specified requirements are primarily aimed at achieving customer satisfaction. In addition to these general rules, ISO 9001/2000 brings something extra - unifying customer requirements under some worldwide documents.

IRIS "International Railway Industry Standard" is an international standard developed in 2006 by a UNIFE working group to provide products and services of highest quality in the railway sector [6] and [7]. It contents the ISO 9001/2000 requirements, on the structure of which additional requirements are added. The standard stated goal is to achieve continuous improvement, focusing on defective prevention, reducing falls in the supply chain and project management. If ISO 9001/2000 relates in particular to products and product manufacturing, IRIS widens the requirements range, including (where applicable) the project domain and project implementation. The drawbacks of the ISO 9001/2000 standard are solved by the technology of analyzing and assessing the excellence degree of an organization that involves the use of some excellence models based on criterions, subcriterions and quantitative expression methods of the organization performances.

To achieve a higher level within the "quality loop" of products quality compared to the level offered by the implementation of a QMS that meets the ISO 9001/2000 requirements, S.C. Clagi Coplass has implemented TQM principles. The results of the TQM principles implementation are presented in Table 1, compared to the ISO 9001/2000 requirements.

Table 1. ISO 9001/2000 versus TQM

ISO 9001/2000 results	TQM results
Consider processes based on value added	Getting consistent results in terms of organization performance
Determining the capability of processes to achieve the planned results	Costs reduction (cost-effectiveness)
Increasing organization's ability to establish and plan goals	Planned metering / reporting / communication system
Determining customer satisfaction and continual its growth	Authority and responsibility for employees
Ensuring product compliance with customer requirements	Competitive advantages gained through marketing
Continuous improvement of SMQ	Overcoming competition
	Waste elimination
	Effective information management

The model of excellence involves the quantitative expression of the company two performance categories, such as: determinants and results. Determinants are linked to an organization specific activities that prepare the performances and are closely correlated with the ability of the entire management and operational team in order to correctly and efficiently strengthen their performance infrastructure.

The justification of excellence model utilization is that, at this criterion, the organization key processes are analyzed. There are also performed the identification, management and optimization, as well as a process map with a clear definition – (contractual) of the interface between the processes.

In Europe today, the EFQM (European Foundation for Quality Management) model is known.

2. Clagi-Coplass evaluation based on the EFQM model, Criterion 5

The production process has a major influence on the product quality, since it represents the totality of processes of material transformation into a finished product. One of the most important quality characteristics of the industrial production processes is the production system. It includes several production systems linked to each other which aims the final products development, at the required deadlines, in accordance with both the specifications and the efficiency [8], [9] and [10].

Of all the criteria used for the self-assessment of quality provided by the EFQM model, only Criterion 5 - "Technological Processes" is further analyzed. This criterion was used for the quality self-assessment provided by the EFQM model, as the technological process is that part of the production process which directly contributes to the achievement of the final products. Criterion 5 refers to the way the organization conducts and improves processes so as to support, in the value increasing spirit, its policy and strategy for the full satisfaction of its own customers and other participating parties. For this criterion, processes orientated towards customer are at the forefront. The processes are composed of several activities, respective operations that derive from one another and which, as a rule, repeats and consumes resources. Each process has clients and requires suppliers - internal or external, presents start-up conditions, intervention limits, inputs and results, and certain frame conditions, being well-defined as a standard deployment. At the same time, it requires goals and sizes (indicators) to be mastered and improved, but also involves risks to which attention must be drawn.

Criterion 5 analysis was performed by tracking the following sub-criterions:

- The way in which technological processes are managed by systemic manners;
- The way in which technological processes are improved by, if necessary, calling for innovation to fully satisfy and generate value for customers and other partners involved;

- The way in which products and services are driven and developed based on customer needs and expectations;
- The way in which products and services are developed, delivered and supervised;
- The way in which the relationship with the clients are managed, strengthened and developed.

3. Track the quality of spray-dyed products

Clagi-Coplass company has industrial technological equipment (ITE) as dyeing/drying booths (DDB) in a pressurized system type, which are highly electricity and fuel gas consumers [11] and [12].

DDB are used for dyeing and drying parts with sprayed liquid paint. Due to the large filter surface, a constant flow of air in good filtration conditions is ensured by using Andreae filters (+ EU2, EU4).

By accelerating the air from the filter ceiling, it creates an inner overpressure that prevents the penetration of dust from the outside of the booth and accelerates the displacement of the particles loaded with paint vapor towards the aspiring front. The suction front is designed to absorb particulate and vapor-charged air, whose concentration is less than 25% of the LEL (Lower Explosion Limit), if the solvents used are potentially explosive.

3.1. The paint-sprayed products tracking steps

In the product tracking steps, a number of conditions, criteria, and verification methods are respected. The parts shall be checked in accordance with the conditions specified in Table 2.

Table 2. Conditions and control methods

Control conditions					Control method
Verification methods	Distance [m]	Height [m]	Inspection approach	Brightness [lux]	
Visual Stencil (hole of 400mm the middle) SDV 401	1–1,5m	0,7–1.4	In motion, slow with speed of about 1m/s	400 ±20%, measured at 2m above the testing place	1)Quality inspector advancing along the part without stopping 2) Each observed defect is identified quantified

The acceptance criterions and methods for quantifying the painted parts defects are shown in Table 3 and Table 4.

Table 3. Uncountable defects

Defect types	Criterions	Applied method
Tint	Compliance with the standard	Visual compare with the standard. In case of litigation, spectrophotometric measurements will be made
Gloss	≥ 90% measured at 60°±0.5° angle	Utilization of gloss meter si Q.CL-14-IL.44
Defects or abrasion traces	In accordance with gloss value	Visual
Prange peel Paint film peeling Varnish wastage Unpainted areas Craze Adhesive mark Moisture mark	Not allowed	Visual

Table 4. Countable defects

Defect types	Criterions	Global criterion	Applied method
Scrapes	Lower length of 30mm	There are allowed max. 5defecte of all 5 within a circle of ∅ 400mm – SDV 401	Visual
Shocks	Lower surface at $30mm^2$		
Deformation	Not allowed		
Craters Bubble Dust and inclusions	Maximum 5 defects of all types within a circle of ∅25mm - SDV402. The circle ∅25mm is considered as a defect.		
Digital fingerprints	Not allowed		

3.2. Assessment of product compliance

For product conformity assessment, the flow of glass fiber reinforced resin products was followed and quality control of painted products was performed by final inspection. Final inspection is an essential factor in any scientific system of organizing and managing production.

The compliance of a product with the technical prescriptions included in the documentation underlying the manufacturing was carried out by examination, measurement, testing and analysis.

In Fig. 1 there are presented some examples of unacceptable defects for which correction measures have been proposed.

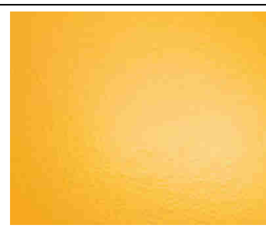
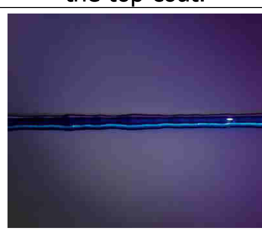
		
Particles projecting through the top coat.	Orange peel/poor flow.	Holograms
		
Color separation on seal-ant.	Paint runs on vertical body parts.	Clouding /mottling in metallic finishes
		
Small bubbles in the top coat, some of them burst.	Edges showing through in the top coat	Sanding marks with swollen edges.

Figure 1. Unacceptable defects [5]

Unacceptable defects are well defined in the procedures issued by the quality department and approved by the management of the unit.

However, during the painting operation it was observed that the modification of the interior parameters in the painting / drying cabin (CVU) influences the quality of the painted surfaces by spraying.

The nonconformities identified, the causes of their occurrence and the verification methods are presented in Table 5.

Table 5. The identified nonconformities, causes and verification methods

Nonconformity	Cause of occurrence	Nonconformity verification
Large number of dots on the painted surfaces	Decreasing the internal pressure due to the clogging of the filters in the suction wall led to the penetration of dust from the outside causing a large number of dust spots on painted surfaces	Visual
Damage to the surface gloss	Decreasing moisture causes the dust micro particles engagement affecting the surface gloss.	Inspection of the gloss with a universal device for painted surfaces model SA0833
Decrease of mechanical resistance	The impossibility of providing a 60 ° C temperature for the drying process results in delayed gel transition with effect on the decrease in mechanical strength. The mechanical result was determined according to the procedure.	Exercise a uniform pressure by drawing at constant speed along the surface over a distance of about 30 mm (blade perpendicular to the surface) and repeating the operation at 90°. Brushing panel along each diagonal of the checked area (soft brush). Cover with the scotch band of the checked area in one of the directions parallel to the set of incisions and tape smoothing. Removing the tape after 5 min. in a very short time (0.5-1)s at an angle of about 60°.

4. Measures proposed for the observed nonconformities

Nonconformity 1: The accepted clogging degree of filters is determined based on the internal procedure at a value of at least 0.5 m/s at the aspirant wall level. Before starting the spray painting operation, the operator has the obligation to monitor the aspirant wall airflow speed. If he finds that the air velocity drops below 0.5 m/s, he must require the maintenance service to replace the filters and to revise the exhaust system.

At the moment of finding the nonconformity before starting the spray painting operation, an air velocity of 0.5m/s, which corresponds to the acceptance of the painting operation, was registered at the aspirant front.

At the end of the painting operation at the aspirant front a speed of 0.3m/s was measured. Therefore, the accepted clogging degree was exceeded during the dyeing process although, at the beginning of the operation, the clogging degree was an accepted one.

The remedial measure consists in changing the frequency of mechanical filters replacement but not higher than the one specified in the maintenance program developed by the terotechnic department.

Nonconformity 2: When this nonconformity was found, humidity was measured with a humidity meter.

The proposed remedial measure is to install a humidifier/dehumidifier to keep moisture inside the DDB under control.

Nonconformity 3: The DDB temperature, at the time of nonuniformity was found has been measured with temperature sensors mounted inside the booth.

The remedial measure is to recover heat from the flue gases to preheat the air introduced into DDB. For this purpose, through the activities of Project 74BG/2016, experimental researches are carried out to quantify the reduction of energy consumption by using the heat exhausted with the flue gases.

5. Conclusions

Following the Criterion 5 analysis, which represents a maximum of 9%, it has been found that this is fulfilled at a rate of 4%. The identified weaknesses are due to incomplete manufacturing records, the existence of unqualified processes as a result of the parameter changes, and poor record-keeping. However, the observed and presented nonconformities indicate that there are still chances to increase the obtained scores.

The observed nonconformities are due both to the modification of the operating parameters of the DDB during their operation and to the human operator error.

In conclusion, the article proposes three main actions to solve these nonconformities, which will result in the creation of new operational procedures or working instructions for the spraying process in order to ensure the control of the operating parameters.

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