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Optimizing Production Costs by Redesigning the Treatment Process of the Industrial Waste Water

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Abstract

This paper aims at presenting a solution for the treatment of industrial waste water, resulted from the process of chemical pretreatment in the electrostatic painting industry, which can also supply water decontamination, thus preventing environmental destruction. The proposed technological process can be optimized by redesigning the pretreatment process by changing the path of the waste water and redirect it in the system created within the company, based on the observations noted during two years of sampling and testing. The results have been confirmed by the fact that through the implemented system, the waste water, can be efficiently cleaned and re-entered in the work process without affecting the quality of the process the pretreated products. By using this system lower production costs were achieved. This was possible by reducing the amount of water used from the distribution network, as well as by reducing the amount of chemicals needed for the pretreatment of contaminated water.

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Keywords: waste water; chemical pre-treatment; electrostatic field painting; contamination; production costs

1. Introduction

Wastewater is the main source of natural water pollution due to their discharge to receivers. Through water pollution we comprehend the alteration of physico-chemical and biological characteristics of water due to human activities and that makes the waters become unfit for use. Wastewater compositions depend on their origin they may

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be domestic sewage and industrial wastewater. To avoid the pollution of natural waters, wastewater discharge is permitted only after they have been treated so that they reach the parameters that do not endanger the environment [1]. Parameters of discharged waters are regulated by two standards namely NTPA 002/2002 for discharged waters into sewage systems and NTPA 001/2002 for waters that are discharged into natural receptors. To achieve these parameters wastewater treatment differs depending on their origin. Wastewater treatment processes are generally mechanical, physico-chemical or biological: anaerobic or aerobic.

The paper aims to present a solution for industrial waste water treatment as a result of the chemical pretreatment process form the painting industry in electrostatic field both protecting the water and the surrounding environment.

The proposed technological process optimization, involves the re-projection of the pretreatment process with the change of the track of the waste water and redirecting it in a system mad by the firm based on observations realized within two years of tests and samples.

The results have confirmed the fact that with this system we can provide an efficient waste water cleaning and reintroducing them into the working process, without affecting the quality of the process and the pretreated products, also there have been made cost reductions [2] of the production with this system, reducing the used water quantity from the distribution network, also reducing the necessary chemical substances for the pretreatment of the contaminated water.

Electrostatic field painting is a part of the treatment, coating and decorating activity of metal surfaces. A category of the field painting category is powder painting.

Within this painting water is used as an element for making degreasing solutions, pickling, passivation or conversion, without forgetting the rinse before and after the upon mentioned processes.

After these operations waste water appears as a result of the chemical pretreatment process of which the product is put before being paining in electrostatic field.

2. Theoretical foundations

Waste waters are classified into: sewage channel (or municipal) and industrial waste water.

Quantitative waste waters contain 99,95 % water and just 0,05% impurities such as organic or inorganic, soluble or insoluble, degradable or non-degradable substances, substances which if introduced to the natural circuit can rise major problems contaminating the surrounding environment [3].

After the degree of contamination, industrial waters are mixed with municipal waste waters ant treated together, followed by discharging them into the rivers, or they are treated separately and they are reused in the industrial process.

Waste water treatment [4] has three main stages:

- *The primary treatment* consisting of sedimentation or sieving operation to remove more than the size of the colloidal particles. At the same time remove 30-60% of the BOD.
  Primary treatment consists of the collection of the waste water using draining under gravitation. The large objects are removed, this is realized with grills and sieves. Deposits are stored in pits or incinerated. After that waste waters are decanted in decanters, in which are put the smaller solid parts. The bottoms of these decanters are tilted and their flow speed is small, these coagulants are added to remove finer suspensions.
- *Secondary treatment* ensures removing colloidal or dissolved materials, reducing BOD. This process is a biological treatment, the growth of microorganisms using water as food residues.
  Secondary treatment consists of a biological treatment operation, performed in two versions:
  - natural – where the filtrate environment is the soil on which the waste water is spread, on the surface of the soil a biological membrane is formed which retains the substances of the waste water and with the presence of the air and the microorganisms takes place a transformation and elimination process;
  - artificial biological – by different mineral environment flirtation: crushed stone, slag, brick, and cokes. This is the most used biological treatment method or active sludge processes in which the active sludge flocks are suspended in the moving flow. The sludge is collected and removed by rotary filters.
- *Tertiary treatment* is applied to water reuse in the industry.

Tertiary treatment – it is designed for water reuse after treatment; the industrial water may include one or more of the following:

- chlorination in order to reduce bacteria;
- precipitation with chemical agents, insoluble components are formed, and the formed precipitation is separated from the water;
- foam and the separation of the foam based on the ability of the active surface agents, such as ABS, collecting liquid – gas (foam) interfaces;
- active carbon absorption is one of the most important processes of the tertiary treatment with the filtration of the active carbon particles. The organic consistency of the water drops layer by layer;
- oxidizing lacquer in which waste water is discharged and after a suitable stationary, reused;
- treatment of the waste water with ionic change for waste waters that contain organic sulphur compounds, phenols, cyanides, etc. The process takes place with treatment, by passing over ion exchange resins, strong acid compared to the phenols that act as a base, or strong basic anion compared to the phenols that act as acids.

3. Description

3.1. Process description

Depending on the waste water, solutions are physical, chemical or biological waste water treatments. Depending on the nature of these waters, there are different remedies for treating them [5]:

- Neutralization of the Ph – value, controlled dosing of acid/ alkanes;
- The control of the oxygen concentration in the ventilation ponds of the water installation treatments;
- Controlled dosage of agents for reducing / oxidizing decontamination of process water containing for example, chromium or cyanide;
- Phosphate precipitation, determination of iron chloride (III);
- Optimal flocculation of perceptible pollutants: dosing of polymer solutions;
- Removing precipitated pollution from the gravitational filter;
- Sludge dehydration by polyelectrolyte dozing;
- Water desalination by reverse osmosis process;
- Controlled dosing of disinfectants in the subsequent rinsing basin and destruction on the excess amount of disinfectant before the waste water is being flushed into the nature.

Pretreatment process of the waste water within electrostatic field is the following (Fig. 1):

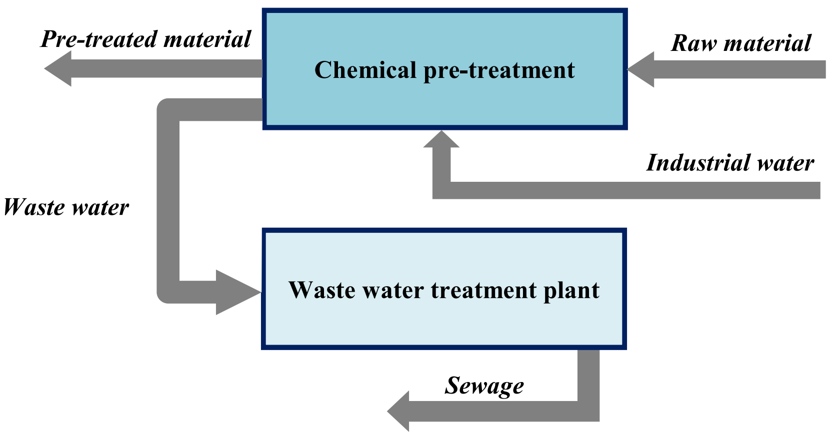

Fig. 1. Technological process of industrial waste water treatment in an electrostatic painting field plant

Raw products are subjected to a chemical pre-treatment which requires a sodium hydroxide attack of the surface, after that pickling with an acid solution, passivation or conversion realized with a Nano ceramic solution. Before and after all these operations is taking place the industrial water demineralization (Table 1):

Table 1. The stages of the pretreatment of aluminum products

Steps	Parameters	Limits
Degreasing (1)	Temperature Time	Temp. 45-60° C 5 min
Tap water rising (2)	Conductivity	Max. 5000 µS/cm Temp. 20-40° C
Tap water rising (3)	Conductivity	Max. 3000 µS/cm Temp. 20-40° C
Etching (4)	Temperature Time	Temp. 20-40° C 5 min
Tap water rising (5)	Conductivity	Max. 2000 µS/cm Temp. 20-40° C
D.I. water rising (6)	Conductivity	Max. 30 µS/cm Temp. 20-40o C
Passivation (7)	Temperature Time	Temp. 25-30o C 5 min
D.I. water rising (8)	Conductivity	Max. 30 µS/cm Temp. 20-40o C

It is noted that some of the rinsing water from the pre-treatment process are filtrated and reused, they are re-entered into the rinsing process from bath 6 and 8, including passivation for completing the demineralized water in case of water evaporation from the passivation solution (Fig. 2):

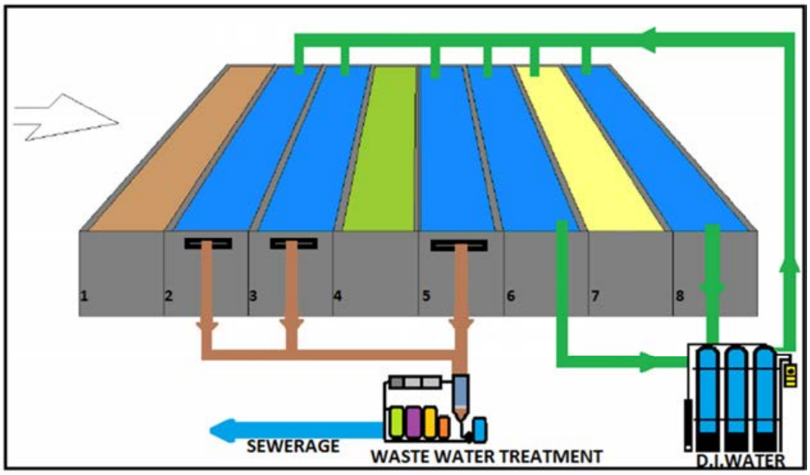

Fig. 2. Technological process of industrial waste water treatment in an electrostatic painting field dipping plant

3.2. New solution implementation

In Fig. 2 we can observe that the rising water from tanks 2, 3 and 5 are continuously discharged from the existent overflow into the conduct system which leads to the waste water pre-treatment station (WWT). Thereby a consistent amount of water approx. 7000 liter/8 hour are discharged daily from the pre-treatment baths, continuous water changes and important costs are required for waste water treatment before eliminating it to the sewage system of the city. After 3 years of testing [6], respectively by simple and ingenious investments, has been created a collecting system of this amount of water, introducing it in an intermediary filtering system and then passing it through a coal based treatment station, treatment with ion exchange, after which the treated water is reintroduced into the pretreatment circuit (Fig. 3). The base of this developed system is the draining filter principle by gravitation used in the primary treatment in combination with the secondary one with artificial cleansing filtration in the mineral environment [7].

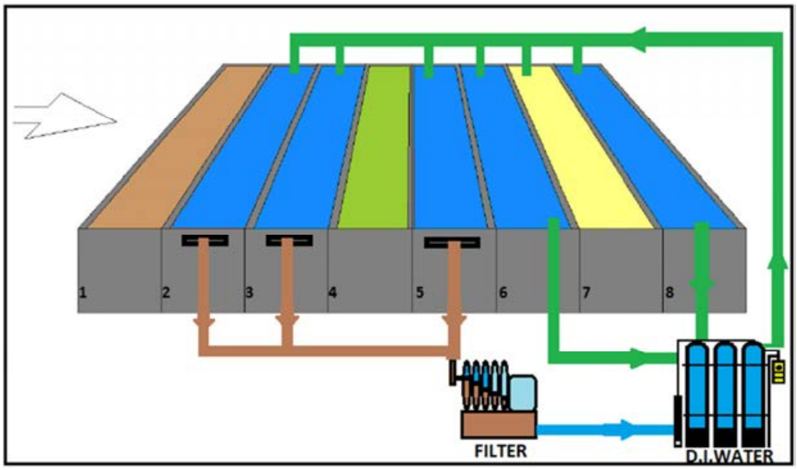

Fig. 3. Optimization of the technological process of industrial waste water treatment

After this the gained water enters in a carbon, resin column purification, succeeding to purify the water so that its load with other elements is almost null, its conductivity is between 0-5 μS/cm^3, being under necessary parameters ($\leqslant$ 30 μS/cm^3) for re-entering it into the chemical pre-treatment flow of the products which has to be painted.

3.3. Treatment process costs of the waste water

Acidic or alkaline waste water must be neutralized before discharge. Acid waters are treated, bringing these waters over a weak basic anion which retains acids [8]:

$2\ ROH + H_2SO_4 \rightarrow R_2SO_4 + 2\ H_2O$ $\qquad$ $ROH + HCl \rightarrow RCl + H_2O$

$ROH + HNO_3 \rightarrow RNO_3 + H_2O$

The regeneration of the shift is made with ammonia solution (NH_4OH):

$R_2SO_4 + 2\ NH_4OH \rightarrow (NH_4)_2SO_4 + 2\ ROH$ $\qquad$ $RNO_3 + NH_4OH \rightarrow NH_4NO_3 + ROH$

$RCl + NH_4OH \rightarrow NH_4Cl + ROH$

Waste waters with chrome, with a content bigger than 30 mg/l are lethal. These waters are the result of chrome baths, passivation. The hexavalent chromium from the waste waters is removed with anion treatment:

$2\ ROH + CrO_4^{\ 2-} \rightarrow R_2CrO_4 + 2\ OH^-$

The regeneration of the anion is made with NaOH solution:

$R_2CrO_4 + 2\ NaOH \rightarrow Na_2CrO_4 + 2\ ROH$

Alongside these elements we do not have to forget the digested sludge which is inert, but still contains a big amount of water. It is dehydrated by heating and filtering, after that it is deposited and will be handed over to specialized companies for destroying them by burning them. All these chemical compounds together with the sludge are parts of the painting process and requires serious costs [9] to achieve the elimination and neutralization of these compounds from the waste water. For example, for the amount of waste water treated within 24 hours, in 3 working shifts we will have the costs presented in Table 2, Table 3 and Table 4.

By total cost we will have a sum of: T1+T2+T3 = 451,10 + 16,47 + 71,05 = 538,58 euro/24 hours.

Costs of a month, 21 days of work, will result a sum of 11,310.10 euro. Therefore, by creating an intermediary filtering and waste water purification system resulting from the pre-treatment process of the products which are painted in an electrostatic field, instead of discharging and letting the water to enter into the final treatment station costs of which are above 450 euro/day, we will have only the costs of the maintenance of the filtering and intermediary purifying system, reaching the amount of 25.70 euro/24 hours.

Table 2. Chemicals cost of 24 hours work for waste water treatment

Chemicals	Quantity (kg/m^3)	Price (euro/kg)	Waste water (m^3)	Total quantity	Costs (euro)
Acid	1	13.60	21	21	285.60
Stabilizing agent	0.50	2.30	21	10.50	24.10
Lime	1.25	2.40	21	26.25	63.80
Flocculation agent	1.50	2.40	21	31.50	76.7
Neutralizing agent	0.01	4.10	21	0.21	0.90
Total T_1 (euro)	-	-	-	-	**451.10**

Table 3. Water consumption in 24 hours work

	Quantity (m^3)	Price (euro/ m^3)	Costs (euro)
Water	21	0.78	16.47
Total T_2 (euro)	-	-	**16.47**

Table 4. Electricity cost for pretreatment of 21 m^3 waste water consumption in 24 hours work

Equipment	Power (kw/h)	Capacity (m^3/h)	Price (euro/kw/h)	Quantity (m^3)	Costs (euro)
Pump A	1.40	21.20	0.80	21	22.61
Pump B	0.09	21.20	0.80	21	1.45
Motor A	0.25	21.20	0.80	21	4.04
Motor B	0.12	21.20	0.80	21	1.94
Pump C	1.27	21.20	0.80	21	20.51
Pump D	1.27	21.20	0.80	21	20.51
Total T_2 (euro)	-	-	-	-	**71.05**

4. Conclusions

This work is a small part of a vast research study carried out with the aim of optimizing production costs of the powder painting in electrostatic fields, so that not only cost should be lowered with necessary chemical solutions of the waste water treatment in long term, but also saving the excess use of water and also protecting the surrounding environment. The accomplished model is based on three types of waste water treatment: primary, secondary and tertiary, but on a small scale, interposed on the path between the chemical pretreatment baths and the whole treatment station of the company in which the concerned innovation is made. The best indicator to demonstrate the successful implementation is the significantly reduced monthly costs compared before putting into operation of the filtering system.

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