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RESEARCH ARTICLE OPEN ACCESS

Proposed Model for Pre-Treatment Process with Nano-Ceramic Conversion Coating at Surface Coating Industry

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ABSTRACT
This paper mainly focuses on the pre-treatment process in the surface coating industry. There is a lot of time-consuming factors, cost, and the quantity of water, the chemical has been used throughout the existing pre-treatment process at the surface coating industry. To overcome these obstacles, we have introduced an innovative model for the pre-treatment process at the surface coating industry with the help of Nano-ceramic coating process. This proposed model benefits the surface coating industry with less water efficiency, the quantity of chemical, cost, and the time is taken for each process.

***Keywords* –** Nano-ceramic, Surface coating industry, Pre-treatment Process, water efficiency

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I. INTRODUCTION

The present-day world has been running behind developmental activities to an extent that has never been witnessed in human history before. This has led to the exploitation of natural resources resulting in a matter of concern for the industries and public as well. In a world of the growing population, the situation has been further precipitated by increasing urbanization and consequently the use of a large number of natural resources. Therefore, many industries have limited the use of such resources by changing their process methods to reduce the impact on the environment. To achieve the objectives under the sustainability program, a lot of industrial waste that is generated is of great importance. This has given path for the rise of the Clean Development Mechanism. Clean Development Mechanism is one of the mechanisms in which emission reduction projects and cleaner production projects are involved. It helps the industries to opt for projects which will help in reducing the negative impact on the environment by process change.

The Clean Development Mechanism (CDM), which provides for emission reduction projects that produce Certified Emission Reduction Units (CERs) that can be exchanged in emission trading schemes [1], is one of the versatile mechanisms identified in the Kyoto Protocol (IPCC, 2007). It is an arrangement that enables developed countries (Annex I) dedicated to reducing greenhouse gas emissions to participate in or fund renewable technology-based pollution reduction programs in developing countries [2].

Surface coating industries are those industries where the manufacturing processes include pre-treatment, machining, surface finishing, and painting processes. The working process in these industries involves the method as follows, firstly the metal parts are molded in the desired form as per the client requirement and then sent for the pre-treatment process, where the surface is made ready for the coating process which is done either by manual spraying or by automated spray guns. The metal pre-treatment can be done by many methods; one which is commonly done is the phosphating process which is in practice even now in many small scale industries. This phosphating process involved in finishing the metal surface contributes to the discharge of effluent which involves heavy metals and also hazardous emissions. Therefore, these industries are considered to be polluting industries.

In an increasing number of application areas, nanotechnology has rapidly become a scope and has now found its way into industrial coating shops, and precisely in the pretreatment process. A new small-thin coating is applied to metal parts before they reach the paint store. This eliminates heavy metals and phosphates, reduces contamination of equipment, and lowers energy consumption. The Nano-coating is compatible with all commonly-used powder and wet paint systems and can also be used with only minimally modified existing equipment [3].

This proposed model focuses on how to reduce the different stages of the pre-treatment process in the surface coating industry with the help of Nano-ceramic conversion coating

II. REVIEW OF LITERATURE

In [4], the author suggested a mixed-integer bi-level hierarchical programming model (MIBLHP) examine the effect of the implementation of CDM to reduce CO_2 emissions on the optimization of the regional energy-water-carbon nexus in the electricity system of China. The results reveal that the highest satisfaction levels (λ Ό 0.934) are when the level of CO_2 reduction is up to 40%, which means that each part of the device has reached the best state.

In [5], the author conducted a water balancing method for sugarcane crops in the semi-arid zone. The crop evapotranspiration was calculated by the field water balance, reference evapotranspiration (ETo) by the Penman-Monteith approach, while the crop coefficient was computed using the normal FAO-56 methodology. The field research was performed for two consecutive years to determine the evapotranspiration and grain coefficients (Kc). The regular values of Kc from the equation are very helpful for effective irrigation water management in terms of different aspects, such as the Decision Support System, Soil Moisture Dependent Crop Yield Simulation, etc.

In [6], the author evaluated the water balance in the city garden. Regarding the urban infrastructure, an innovative model is developed to improve the use of water efficiency, avoiding water contamination, and restoring natural water streams. This model helps to differentiate with existing and proposed urban city projects.

In [7], studied on Bonderite which results in phosphate-free, and heavy metal free pre-treatment process. The use of Bonderite gives the coating a high quality, which shows good adhesion and excellent corrosion protection. The contribution is devoted to the evaluation of these properties. The experimental results which were obtained thus showed an increased quality of powdery coatings using a modern method of coating chemical pre-modification – a conversion layer Bonderite NT type.

In [8], Nano-ceramic coatings were tested for phosphate-free protective layers on galvanized sheets of steel using an H_2O_2 additive. For the coating morphology, more parameters such as pH solution and H_2O_2 concentration as oxidants were evaluated. Scanning electron microscopy/energy dispersive spectroscopy (SEM / EDS) was used to describe the coating surface morphology. Using DC polarization and salt spray experiments on the treated layer, the corrosion efficiency of the coatings was examined. The corrosion test findings have shown that the efficiency of H_2O_2-treated samples against corrosion is not substantially better than that of other treated samples.

The use of data envelopment analysis techniques with a material balance state was analyzed [9] to determine the inherent trade-offs between cost and environmental efficiency between various forms of energy use in the construction industry in China. This research used the integrated DEA-based MBP model to introduce individual carbon mitigation activities by enhancing the energy usage system and increasing energy quality in the construction sector in China in the short term, rather than implementing very costly CO_2 emission control strategies (e.g. end-of-pipe treatment) or relying on conventional carbon emission control techniques.

Any construction materials absorb natural capital and electricity and release large quantities of greenhouse gases in a report on the manufacture and transport of building materials [10]. To show its efficacy and practicality in lowering carbon emissions, the proposed model was extended to the case of China, where it was observed that the model was capable of efficiently reducing the production of construction materials and transporting carbon emissions, encouraging suppliers of construction materials to take environmental measures by increasing their output and encouraging suppliers of construction materials to take environmental initiatives by increasing their output.

A rigorous technique for the systematic measurement of the water balance in collective irrigation systems (CIS) for pressurized pipelines or open canals [11] has been developed and implemented. The approach allows the measurement of different components of water loss and the estimation of water loss performance metrics that allow identification of the key issues of water loss and provides advice on steps to manage water loss. The outcome underlines the importance of improving the day-to-day operation of these networks and of rehabilitating aging infrastructures.

The corrosive resistance properties of mild steel coated with zinc phosphate were examined for evaluation in [12]. The effect of the phosphate processing parameters on the corrosion resistance of the zinc phosphate conversion coatings and the optimization of the process are explored using the Taguchi system. For both products, the findings are addressed in the testing of the phosphate conversion coatings' corrosion resistance efficiency. SEM Analysis is conducted on the crystalline structure of the material. Based on that, material behavior is discussed. To give a better processing parameter value, the ANOVA table is compared to the Taguchi method performance.

III. EXISTING MODEL PRE-TREATMENT PROCESS

The manufacturing process of Diesel Generating set enclosures to involve the following steps
1. Pre-Treatment process
2. Coating process

The pre-treatment process is followed by the powder coating process. The pretreatment process carried out in the plant is the phosphating process; it is also called as the seven-step process. The detailed flow diagram of the process is as shown in the figure 1 below;

The design criteria of the existing manufacturing process are as follows with the pre-treatment phosphating process with quantity of chemical used, price and the time taken to implement it as shown in figure 2 - 4;

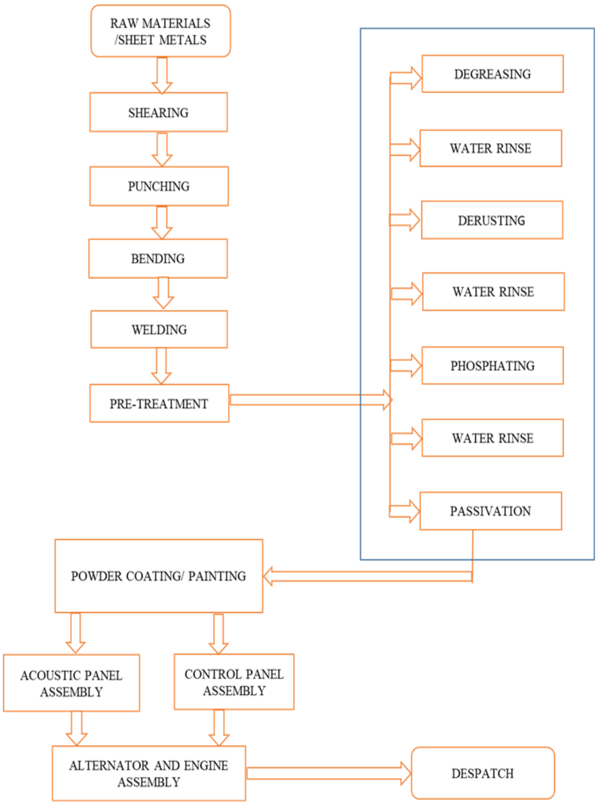

Fig. 1 Existing Model for Pre-Treatment Plant Process

1. ***Degreasing:*** The metal components are coated with oil and grease to protect the surface from corrosion. If the oil and grease are present on the surface of the metal, the coating of the surface becomes difficult. So, to remove this, the components are passed through a degreasing chamber/tank where an alkaline cleaner i.e. Delube-LP is used. The components are mechanically loaded and dipped in the tank with a degreasing solution for 8-10 minutes.
2. ***Water rinse-1:*** To prepare the surface for the de-rusting process, the component is washed with industrial water.
3. ***De-rusting:*** To prevent the rusting of the metal parts, de-rusting is done using an acidic chemical known as Deoxid-120(M).
4. ***Water rinse-2:*** To prepare the surface for the activation process, it is washed with industrial water.
5. ***Activation:*** Here the metal parts are washed with RO water to make the surface fit for the phosphating process. The chemical used for this is Kris Fine-Z, it is a low foaming mild alkaline powder formulated to activate metal surfaces to improve subsequently applied to pre-paint conversion coatings.
6. ***Zinc Phosphating:*** The process coats the surface of the metal with a polycrystalline framework containing phosphates of iron, manganese, nickel, and zinc, which provides excellent adhesion to powder coatings, electrophoretic or liquid coatings and provides superior protection against corrosion [13]. The chemical used for this is Phibond-D25 which is diluted with RO water and a chemical called TC2 and Catalyst- RT is also added along with Phibond D-25. It is a Nickel, Manganese modified Zinc phosphate process operative at a low temperature designed to treat steel surfaces for smooth, uniform Zinc phosphate coating. The process is used by a dip application.

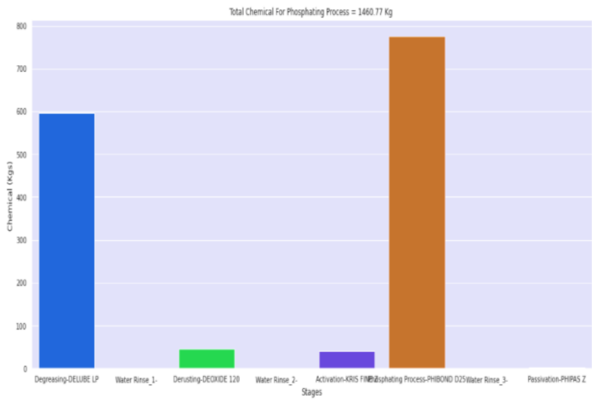

Fig. 2 Total chemical for Phospating process

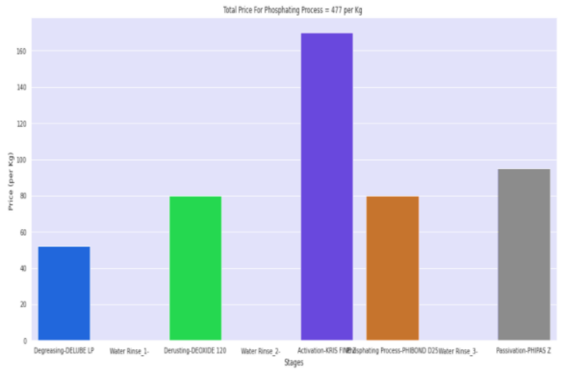

Fig. 3 Total Price for Phospating process

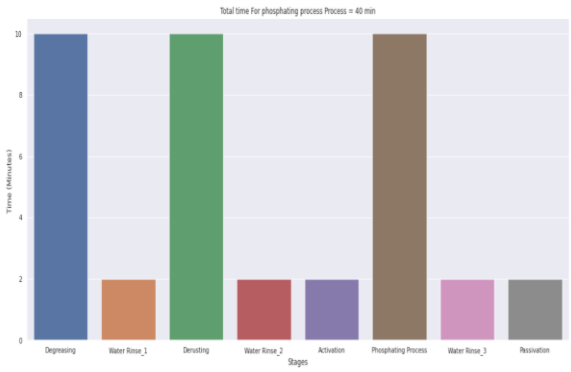

Fig. 4 Total Time for Phospating process

7. ***Water rinse-3:*** The metal components are now again washed with industrial water to make the surface fit for the passivation process.
8. ***Passivation:*** It is a process by which a metal is handled or coated to reduce its surface's chemical reactivity, i.e. to remove free iron from the metal's surface utilizing an acid solution to prevent corrosion. For this purpose, RO water is used. The acid-based chemical used here is Phipas- Z.
9. ***Drying:*** After the seven tank pre-treatment process the components are passed through the oven maintained at a temperature of 190-210℃ as per the material used. It is cured for 12-20 minute accordingly
10. ***Final Air Cleaning:*** Now the parts are cleaned by using an air dryer so that no moisture is present on the parts.
11. ***Powder coating:*** Now the components are ready for the powder coating process, in this industry mechanical sort of spraying/coating is done. The percentage of powder waste generated is further given to the vendors for the recycling/disposal.
12. ***Oven Curing:*** After the powder coating the components are passed through the oven to dry the surfaces. Temperature is maintained at 190-210℃ as per the material used. It is cured for 12-20 minutes accordingly.

IV. THE PROPOSED MODEL PRE-TREATMENT PROCESS

Nano-ceramic conversion coating process; it is also called as the five-step process. The detailed flow diagram of the process is as shown in the figure 5 below;

The design criteria of the proposed manufacturing process are as follows with the pre-treatment Nano-ceramic conversion coating process with quantity of chemical used, price and the time taken to implement it as shown in figure 6 - 8;

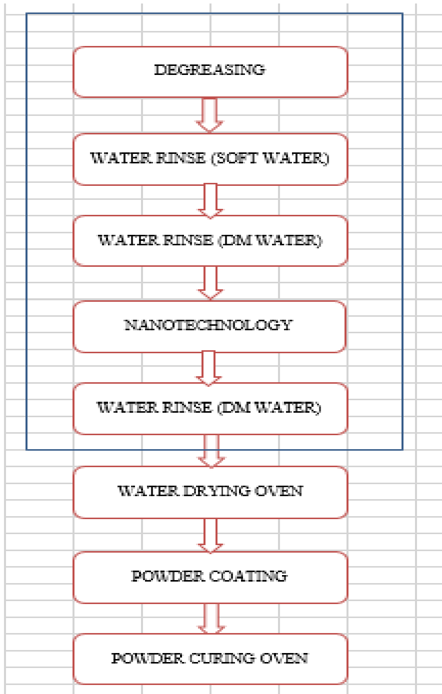

Fig. 5 Proposed Model for Pre-Treatment Plant Process with Nano-Ceramic Conversion Coating

1. ***Degreasing:*** The metal components are coated with oil and grease to protect the surface from corrosion. If the oil and grease are present on the surface of the metal, the coating of the surface becomes difficult. So, to remove this, the components are passed through a degreasing chamber/tank where an alkaline cleaner i.e. Delube-LP is used. The components are mechanically loaded and dipped in the tank with a degreasing solution for 8-10 minutes.
2. ***Water rinse-1:*** To maintain the efficiency of Nano-coating on the metal surface, the components are washed with soft water. It is immersed in the bath for 1-2 minutes or 2-3 dips.
3. ***Water rinse-2:*** In this tank demineralized water (DM water) is used. For Nano-coating, the surface should be free from minerals. So, after spraying the parts with raw water it is again

sprayed with DM water, to make the surface free of minerals. It is immersed in the bath for 1-2 minutes or 2-3 dips.

4. ***Nano-ceramic Coating:*** To increase the adhesion of the powder coat onto the metal surface, it is sprayed with nanomaterial i.e. Bonderite M-NT. The nature of the chemical is alkaline. Immersed in the bath for 1-2 minutes or 2-3 dips.

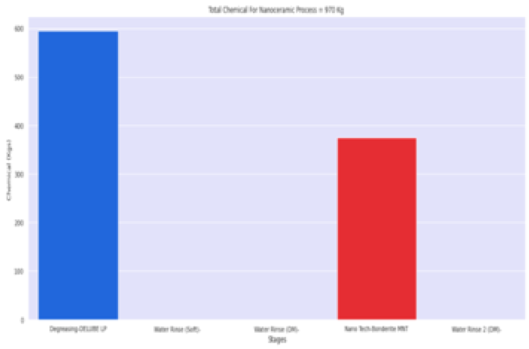

Fig. 6 Total chemical for Nano-ceramic process

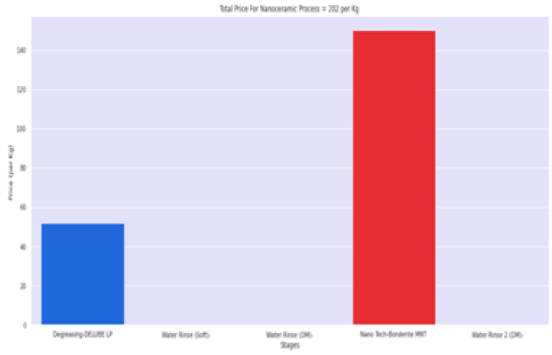

Fig. 7 Total Price for Nano-ceramic process

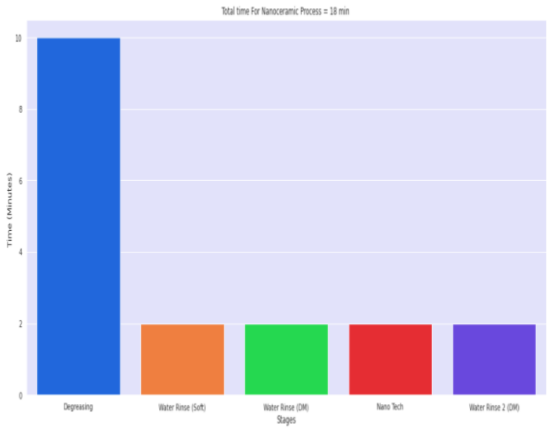

Fig. 8 Total Time for Nano-ceramic process

5. ***Water rinse-3:*** now again the parts are sprayed with DM water. To remove the excess chemicals adhered to it. It is immersed in the bath for 1-2 minutes or 2-3 dips.
6. ***Water drying oven:*** After the 5 tank pre-treatment process the components are passed through the water drying oven maintained at a temperature of 80-120℃. It is passed at the rate of 0.9-1 m/minute.
7. ***Powder coating:*** Now the components are ready for the powder coating process, in this industry mechanical sort of spraying/coating is done. The percentage of powder waste generated is further given to the vendors for the recycling/disposal.
8. ***Powder curing oven:*** After the powder coating the components are passed through the oven to dry the surfaces. Temperature is maintained at 180-200 ℃.

V. DISCUSSION

In the existing system, there are seven stages to implement the pre-treatment plant process in the surface coating industry. By using this methodology, the time is taken for each stage, also the quantity of the chemical at each stage, quantity of the water at each stage, and cost of the chemical at each stage is very high. When compared to the existing system, the proposed model has only 5 stages, to implement the pre-treatment plant process with Nano-Ceramic conversion coating at the surface coating industry. By using this proposed model, the time is taken for each stage, also the quantity of the chemical at each stage, quantity of the water at each stage, and cost of the chemical at each stage will be very less.

VI. CONCLUSION

The pre-treatment process with Nano-ceramic conversion coating at the surface coating industry will reduce the negative impact on the environment by this proposed model. This proposed model will help in the use of water efficiency, the number of chemicals to be used as less, and the time take at each stage will be reduced and cost-efficient in the process changes.

REFERENCES

[1]. Clean Development Mechanism, 2020. Available at https://en.wikipedia.org/wiki/Clean_Development_Mechanism

[2]. Mayuri R. Naik, Anju Singh, Seema Unnikrishnan, and Neelima Naik, Role of the Clean Development Mechanism (Cdm) in the Development of National Energy Industries, *Energy & Environment*, 25, 2014, 325-342.

[3]. Paul L. Caszatt and Terry Giles, Pretreating Metal with Nanotechnology, *Paint and Coating Industry Magazine*.
[4]. Qinliang Tan, Yuan Liu and Qi Ye, The impact of clean development mechanism on energy-water-carbon nexus optimization in Hebei, China: A hierarchical model based discussion, *Journal of Environmental Management*, 264, 2020.
[5]. S.K Dingre and S.D Gorantiwar, Determination of the water requirement and crop coefficient values of sugarcane by field water balance method in semiarid region, *Agricultural Water Management*, 232, 2020.
[6]. María RocíoRuíz-Pérez, M. Desirée Alba-Rodríguez and Madelyn Marrero, The water footprint of city naturalisation. Evaluation of the water balance of city gardens, *Ecological Modelling*, 424, 2020.
[7]. Dagmar Draganovská and Róbert Moro, Influence of chemical surface pretreatment on adhesion properties and protective effect of coatings, *Machines. Technologies. Materials.*, 14(3), 2020, 110-114
[8]. Ali Payami-Golhin, Morteza Amrooni Hossaini, Reza Eslami-Farsani and Hamid Khorsand, Phosphate-Free Protective Nanoceramic Coatings for Galvanized Steel Sheet with H_2O_2 Additive, *Advanced Material Research*, 829, 2013, 436-440.
[9]. Yujiao Xian, Kexin Yang, Ke Wang, Yi-Ming Wei and Zhimin Huang, Cost-environment efficiency analysis of construction industry in China: A materials balance approach, *Journal of Cleaner Production*, 221, 2019, 457-468.
[10]. Jiuping Xu, Yawen Deng, Yi Shi and Yidan Huang, A bi-level optimization approach for sustainable development and carbon emissions reduction towards construction materials industry: a case study from China, *Sustainable Cities and Society*, 53, 2020.
[11]. Henrique Cunha, Dália Loureiro, Gonçalo Sousa, Dídia Covas and Helena Alegre, A comprehensive water balance methodology for collective irrigation systems, *Agricultural Water Management*, 223, 2019.
[12]. E Gurunathan and A Senthilkumar, Optimization of Zinc Phosphating Process using Statistical Tool, *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 4, 2019, 19-28.
[13]. BONDERITE M-ZN - Zinc Phosphate Technology, 2020, Available at https://www.bonderite.hr/en/technologies/pretreatment/zinc-phosphating.html