Takestan Institute of Higher Education

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UCT Journal of Research in Science, Engineering and Technology

UCT. J. Resea. Scien. Engineer.Techno. (UJRSET)

Volume 3,Issue3

36-40 (2015)

ISSN 2382-977X

Waste minimization in paint manufacturing plants: cost saving and environmental protection

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ABSTRACT

Paint manufacturing wastes are mostly hazardous and toxic. The cost of proper treatment and safe disposal of these wastes is high. Implementing waste minimization management system reduces both waste generation and resource consumption. Furthermore it can result in environmental preservation and operational cost saving. The purpose of this study was evaluation of the effectivness of waste minimization performance in the paint formulating industries. So we determined the amount of waste generation, raw materials usage, water and energy consumption in a paint manufacturing plant called"Rang Afarin" in Tehran, Iran. There were three major sources of waste in this factory: solid wastes, wastewater, and air pollutants. We focused on wastewater because according to our researches we found that the main waste in this plant is wastewater and we can reduce about 20% of generated wastewater at the plant. Also, results showed that by implementing waste reduction program, the amount of raw materials, energy, and water usage can reduce respectively down to 0.114%, 22%, 9.8%. The whole of these waste reduction equal to 87288$ saving in production costs annually. Waste minimization plays key role to achievement sustainable development and economic profits in industries.

Original Article:

Received:30 June2015
Accepted :28 Aug 2015
Published :30 Nov 2015

Keywords:
Paint industry; Energy and water consumption; Raw materials saving; Waste minimization

Introduction

Waste minimization is an aspect of pollution prevention. It includes source reduction and recycling (California department of toxic substances control, 1992). Waste prevention is a business strategy from which any company can benefit. In addition to cost savings, it can also help you improve worker safety, reduce liability, and enhance your image in the community (USEPA, 2001). In today's competitive business environment, saving energy, reducing waste and improving productivity are more than just buzz words; they are vital for a business to be successful (EPA, 2002). The major driver for waste reduction is cost (Jewell et al., 2004). If a firm wishes to minimize its total cost, it is obvious that boath disposal costs and waste amounts are a good place to start cutting costs (Higgins, 1989). Waste encompasses wastage of energy or water in producing or using a product (Bishop, 2000).

The amount of wastes disposed of by paint manufacturers is high and reducing waste is a high priority for them (USEPA, 1990). Paint formulators generate a variety of hazardous wastes in their operation. Tank cleaning is the principal source of waste generation (California department of health services, 1989). The majority of conventional paints contain organic solvents. These chemicals are classified as hazardous due to toxicity, ignitability or boath (WMRC reports, 1992). Waste sources of the plant are classified into three main categories: wastewater, solid waste, and air pollutants. Significant attention is given to wastewater since laboratory results indicate that wastewater contains significant quantity of solvents (Dursun, & Sengul, 2006). Waste generation reduction leads to saving in rawmaterial, energy, and water as well as less waste disposal. This means cost saving in production process and environment protection. It is true that pollution prevention is prefer to pollution treatment.

This study examines quantitative results of waste minimization Implementation in paint formulating industries. Our selected plant for researching is located in Tehran, Iran (see Fig. 1). This plant produces 30 kton/year of products such as industrial paints, marin paints, thinner.

Materials and methods

Our research was done at some steps. First we estimated the quantity of wasted raw materials, energy waste, water waste as well as the amount of wastewater generated in the factory. Then it was determined that what percentages of all aforementioned items could be stored by implementing waste minimization management system in the plant. Finally, the sum of production cost saving was calculated through the price of purchasing raw materials and energy as well as annual production capacity of the plant.

Raw materials

We selected seven different batches in seven days randomly to estimate raw materials wasting. For each batch, the type and quantity of raw materials recorded from weighing and mixing stage to the end of production process. Paint is composed of pigment, solvent, resin and additive but the most wastage in raw materials is related to pigments and solvents. we measured total weight of used raw materials and total weight of produced paint. Differences between these two amounts indicated raw materials wasted. By the percentage of pigments and solvents in each batch the waste of pigments and solvents determined.

Energy

For measuring the quantity of energy consumption, first we listed all of the electrical equipments and facilities in the plant. At three periods of time we recorded the hours of energy consumption for all of electrical devices. According to the registered used power (total watt) on the devices by the manufacturers, the quantity of energy consumption were calculated. Compare between calculated amount and electricity bills which sent periodically by the power organization showed the waste of energy in the factory.

Water and wastewater

Total water consumption except for drinking water was supplied by a well at the plant. The volume of water which pumped daily into water reservoir was measured . Then we specified all of the water consumers in the plant. At the production area we determined the amount of water applied for cooling process equipments, washing the floor of production area. At the domestic area we estimated the volume of water used to daily shower for people who worked at production area (because of the contact with pigments and powder rawmaterials) and water consumption for sanitary and kitchen purposes of all domestic and industrial workers as well as water use for irrigation of plants and lawn of the plant.

Whit due attention to waste minimization approaches at water consumption segment in the plant, it was estimated that how much water could be reserved.

There were three major sources of waste in the factory: solid wastes, wastewater, and air pollutants. We focused on wastewater because according to our researches we found that the main waste in this plant was wastewater. So we examined wastewater of the plant at two portions. Cleaning solvents used for removing paint from process equipments accounted for the most volume of the hazardous waste stream. The used solvents were collected into barrels and sent for off-site management. The other waste stream we focused on was composed of paint spills mixed with solvent residue plus floor washing waters which contained low concentration of pigments.

The quantity of both waste streams were measured in our research. The amount of used solvents and wastewater could be recycled and reused were also estimated.

Results

The results of measuring the quantity of raw materials usage, product produced, and raw materials waste in seven different batches in seven days have been shown at table 1.

Table 2 shows the list of electrical devices in the plant and their electric power. The estimated amount of energy consumption, the true amount of energy consumption according to electricity bills, and the quantity of energy waste are shown at table 3.

The water reservoir was pumped 50m 3 of well water in the factory every day. Daily usage of water by water consumers in the plant and reservable amount of water are given at table 4.

It was also estimated that 2.5m^3/d of used cleaning solvents were collected into barrels. Colected used solvent are sent to off-site recovery and then is recycled in process. The other wastewater composed of floor washing and inadvertently paint spills with cleaning solvents which generated at the production area was determined 6.5m^3/d.

Table 1 The amount of used raw materials, produced paint, and raw materials wastes

Batch No.	Used raw materials (Kg)	Pigments content (%)	Solvents content (%)	Produced paint (Kg)	Raw materials waste (Kg)	Waste pigments (Kg)	Waste solvents (Kg)
1	1064.965	28.3	23.47	1061.165	3.8	1.075	0.892
2	1069.965	28.16	20.09	1066.265	3.7	1.042	0.743
3	894.7	26.89	42.36	891.4	3.3	0.887	1.398
4	1267.6	22.92	11.44	1263.4	4.2	0.963	0.48
5	850.452	25.91	12.93	847.252	3.2	0.829	0.414
6	1214.4	21.28	12.35	1210.3	4.1	0.872	0.506
7	969.575	28.09	8.25	966.075	3.5	0.983	0.289
Average	1047.379	25.94	18.7	1043.69	3.69	0.95	0.674

Table 2 List of energy consumption sources in the plant and their power

Electric device	Number	Power (Kwatt)
Mixer	1	40
Mixer	6	3.5
Mixer	2	15.2
Mixer	3	6.6
Purl mill	5	30
Purl mill	4	24
Filter	3	0.37
Feeding and discharging electro pump	1	4
Feeding and discharging electro pump	1	2.5
Dissolver	4	30
Dissolver	1	11
Sand mill	4	24

Table 3 The estimated amount of energy usage, the electricity bill value and the energy waste value

Course No.	Length of time (day)	Electricity bill value (Kwh)	Estimated value (Kwh)	Energy waste (%)
1	29	24827	18620	25
2	31	30967	22451	27.5
3	41	36585	25975	29
Average		915	664	27.2

Table 4 Daily water usage in the plant and reservable amount

Consumption source	Consumption rate (m^3/day)	Saveable amount (%)
Cooling water	32	2.5
Washing water for production area floor	6	50
Plants and lawn irrigation	1	50
Kitchen and sanitary uses	3	10
Shower	3	10

Discussion and conclusion

There is average 3.69kg (0.35%) waste of raw materials in each bach during production process. One portion of these wastes is related to solvents evaporation and other portion is due to pigments waste. According to table 1, nearly 0.064% of total wasted raw materials in one batch, results from solvents waste. Changing the technology in the plant is one way to minimize the quantity of waste (Dursun, & Sengul, 2006). Since most process equipments are open design, some of used solvents vaporize in the form of volatile organic compound (VOC). We can save approximately 50% of solvents wasting. The production capacity is 3Kton /Year and 9686.784 Kg of solvents can be stored per year which equals to 24217$ cost saving. This goal can be achieved in this plant through designing close system for production process. This system can be performed by:

1. Putting cover over the mixing tanks and other open processing equipments.
2. Pouring small plastic balls over containers.

By the table 1, 0.091% of pigments waste in each batch. The most important reasons for pigment wastes in the plant are as follows:

1. Waste of pigments when loading in bags and unloading in mixing tanks manually.
2. Suction through ventilators in loading and unloading areas.

We can automate loading and unloading pigments by using facilities such as vaccum and hopper system and save nearly over 90% of pigments wastage. By the production capacity, 3Kton /Year, we are be able to save annually 24576.26 Kg of pigments and 61441$ in operational costs. Improved quality control during manufacturing process with employee training can be significant factors in reducing wastes particularly the reduction of material losses through spills. Thus by performing waste minimization program in the factory 0.114% of total rawmaterials will stored each year which equal to 85658$ cost saving in operational costs of the plant. It must be mentioned that there is about 50Kg leftover paint in mills in every batch. If the next batch is same colour with previous, it will be discharged as production. Otherwise, it must be cleaned and removed as waste. In this research we didn't consider this kind of rawmaterials wasting.

Table 3 showes that there is about 27.2% energy waste in the plant. It was found that the most share of energy consumption belongs to mills, ventilators, dissolvers, and mixers respectively. For production of one ton paint, mills work approximately 18 hours.

The main causes of this wasting can be:

1. Low efficiency of the process equipments resulting from oldness and fatigue of devices
2. Inappropriate program for maintenance and repair of electrical devices.

Process equipments in this plant have been instaled since 35 years ago. So they probably work with around 50% efficiency or less. For instance, in order to supply 30kw power, a mill with 80% efficiency consumes 37.5kw energy while a mill with 50% efficiency uses nearly 60kw energy. Differences between these two number is equal to 22.5kw (75%)energy waste. Therefor, if we replace electrical equipments at production process with newer ones, the energy consumption will approximately decrease as much as 22% . If plant works 300 days per year, then 1630$ will nearly saved yearly. Unfortunately because of low price of energy in our country , there is no incentive to save it . In fact, regulatory approvals and really price of energy are good instruments to natural resources conservation.

With due attention to this point that 50 m3 of water is pumped to rservoir every day, as well as by findings at table 4, it is found that there is 5 m^3/day (10%) waste of water in the factory. Most of this wasting results from lack of pay attention to resource conservation and incorrect consumption pattern, because the water is free in this factory. In this research we noticed that through accomplishment of some easy option, we can save about 4.9 m^3/day (9.8%).

By closing floor drains and discouraging employees from routinely (i.e. needlessly) washing down areas, som facilities have been able to achieve a large decrease in wastewater volume (USEPA, 1979). Other effective ways to reduce water use include employing volume-limiting hose nozzles, using recycled water for cleanups, and actively involved supervision (USEPA, 1990).

Moreover aforementioned options, we recommend other waste minimization options as follows:

1- Employee training to correct consumption and environmentaly sound thought.
2- Control and check the leakages and defaults especially water pumping system providing cooling water.
3- Use of shower and valves equipped to electronic eyes.
4- The wastewater results from washing floors has low contamination, so by slight treatment to reduction COD, it can be reused for irrigation of the plants and lawn and floor cleanup purposes. This waste stream plus spills cleaning residue generate as much as 6.5 m^3/day and we can reduce it down to 3 m^3/day

Spent cleaning solvent is a hazardous waste commonly generated by the paint manufacturing industry. Spent solvent should always be kept separated from other wastes, so that it can be reused. Spent cleaning solvent can often be reused as a process ingredient in batches of compatible formulation (Department of toxic substances control, 1997). Over 1/2 of the paint manufacturing hazardous waste contained solvents (USEPA, 1992). Installation of a distillation unit can provide at least 70% solvent recovery from wastewater (Dursun, & Sengul, 2006). In 1985 a survey showed that over 82% of the respondents recycled all of their solvent waste either on-site or off-site (USEPA, 1990). Waste minimization options for decreasing solvent waste are: Scheduling batch production runs from light to dark colors, use high pressure wash systems, reuse equipment cleaning wastes, clean equipment immediately, use alternative cleaning agents,use mechanical wipers on mix tanks,use countercurrent rins methods. By performing mentioned options the solvent waste generation in the plant decreased to 2 m^3/day and 20% of solvent waste stream generated in the plant will reduce.

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