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Shoes polish production using the concept of chemical engineering process

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ABSTRACT

The popularity of shoe polishes started in mid-19th century and continued throughout the 20th century leading to the rise of leather and synthetic shoe manufacture. Substances like wax and tallow have been used as starting materials for shoe polish hundreds of years ago, and these material combinations are still in use today. Modern shoe polish production employed a mixture of natural and synthetic materials that include wax, lanolin, naphtha, ethylene glycol; turpentine, oil soluble dyes, and gum Arabic were processed by straight forward chemical engineering method. Flow charts are drawn to show typical industrial process; the material balances are conducted through accumulation in which 70% and 30% feed solutions of M_A and M_B streams contained 2kg and 1kg respectively were mixed then fed into the heater unit at 100°C. The batch process showed that the law of mass conservation exists where input is equal to output. Laboratory determination of product quality was carried out, the shoe polish showed density ≤ 0.99kg/L, specific gravity of 1.01, flash point >93°C using setaflash closed cup, 84-89% of kiwi liquid wax shoe polish was volatile, shoe polish was dispersible in water. Appearance: liquid wax shoe polish can be neutral, black, brown, blue, or red.

1. Introduction

The World Wars witnessed a surge in demand for polish products in order to polish army boots. Shoe polish is a waxy paste, cream, or liquid used to polish, shine, waterproof, and restore the appearance of leather shoes/boots, thereby protecting the footwears against abrasion. Shoe polish can be made of a waxy colloidal emulsion, a substance composed of a few partially immiscible liquids and solids mixed together. It is usually made from ingredients including some or all of naphtha, lanolin, turpentine, wax (often carnauba wax), gum arabic, and ethylene glycol, and if required a colourant, such as carbon black or an azo dye (such as aniline yellow) [1]. The high amount of volatile substances means that the shoe polish will dry out fast, and harden after application, while retaining its shine [2]. Due to surface tension forces, a glossy surface is created after polishing, dries up to give the shoe the required luster. The polish should be resistant to abrasion, smooth, transparent, uniform in colour, be adhesive and thin. Most polishes depend on wax or oil for their polishing properties. Wax polishes are more long lasting [3]. Shoe polish can be manufactured using large heaters and air conditioners. There is no set method of manufacture, although most methods use pressures of two atmospheres to ensure that naphtha does not boil off, and temperatures of up to 85ºC [4]. In the manufacture of shoe polish, wax is reacted with resins which provide the thin film on the shoe after polish has been applied and shined, volatile solvents are used to give it a quick drying effect. Water acts as a solvent while different dyes can be used to give it the colouration [3]. But, a chemical process is any single processing unit or a combination of processing units used for the conversion of raw materials through any combination of chemical and physical treatment changes into finished products; and the process employed in this research work is a straight forward chemical engineering process [5], using simple equipment in the chemistry laboratory.

In the 18th century leather with a high natural veneer and glossy surface finish was used for shoes and boots making, which required in most cases variety of homemade polishes like lanolin to provide shine surfaces [6]. In the 19th century many forms of shoe polish were available often called 'blacking' and dubblin when animal by product tallow is mixed with lampblack, being that 82% of the meat consumed in the United States was processed in Chicago, Illinois stockyards, these cities turned out to be major shoe polish producing areas [6]. The popularity of shoe polish lead to the rise of leather and synthetic shoe production, which started late 19th century, then continued throughout the 20th century, the World Wars witnessed a surge in demand for polish products that were used for army boots [7]. An American war correspondent Walter Graeber wrote for TIME magazine that shoe polish was found everywhere Allied troops ventured [8], and that in 1942 "old tins of British-made KiWi polish lay side by side with empty bottles of Chianti" [9]. Scottish boot polish makers in Melbourne, Australia made polish in a small factory and their formula was a major improvement on previous brands, it preserved shoe leather, made it shine, and restored colour of shoes [10]. KiWi was the first shoe polish to resemble the modern varieties aimed primarily at inducing shine, the practice of shining people's shoes grew up in city streets as many shoeshine boys offer shoe shines using a basic form of shoe polish along with polishing cloth [9] [11]. The popularity of KiWi shoe polish spread throughout British Commonwealth Nations, United States of America, rival brands began to emerge which include Shinola and Cavalier (United States), Cherry Blossom (United Kingdom), Parwa (India), Jean Bart (France) and many others [9] [12]. In recent years, there are numerous brands of shoe polish available and the demands are declining due to gradual replacement of formal foot wears with sneakers for everyday use [13]. The two chief areas of shoes polish sales to the general public, specialists, and trade are through the shoe repairers and cobblers, the sales percentages between the two outlets are roughly comparable [14]. The physical definition of wax comes from a substance between resins and fats, chemically it is defined as an ester of a long chain aliphatic acid with a long chain aliphatic alcohol [15]. A better definition also state that wax is the collective name for a series of natural or synthetically produced substances that possess the following properties, kneadable at 20ºC, brittles to solid, coarse to finely crystalline, translucent to opaque but not glass like, melts about 40°C without decomposition, of relatively low viscosity even slightly above melting point, not tending to stringiness, consistency and solubility depending on the temperature and capable of being polished by slight pressure [16]. Shoe polish produced is flammable, toxic, if misused it can stain skin; it is applied to shoes in a well-ventilated area taking care of clothes, carpet and furniture.

2. Methodology

The materials used were bought from chemical stores and local livestock market, lanolin hydrophilic grease (fat) obtained from slaughtered cow, distilled water, gum arabic a substance from sub-Saharan species of acacia tree, oil soluble azo dye, turpentine, paraffin was made by Sigma-Aldrich

(M) Solution, BDH, ethylene glycol 99+%, MW 62.07 was made by Aldrich Chemical Co. Ltd., England, UK., Ohaus AR2130 Adventurer electronic laboratory balance, USA. Water bath HH-2 B-Scientific, USA.

2.1. Preparation of Samples

The carnauba wax known to be thickener was weighed and heated to melt at 85ºC on electric water bath, then if necessary, all other waxes may be added by descending order of melting point. The lanolin (fats) and paraffin of known weights were mixed with some measured quantity distilled water to form emulsion, which was poured and stirred into the molten wax at 85°C. Measured volume of turpentine, ethylene glycol, gum arabic and oil soluble dye were mixed together then poured into the mixture and further heated to 80ºC; in addition, gum arabic increases viscosity of the molten polish. If neutral polish is desired no azo dye (such as aniline yellow) should be added to the batch mixture. This mixture slowly forms molten mass of shoe polish on continuous stirring for 15 - 30 minutes on water bath at 50°C, then it is finally poured into flat round tins often use as shoe polish.

2.2. Product Quality

The laboratory experimental methods involving density, relative density, flash point, volatility, water solubility and appearance were employed to determined physical properties of the shoe polish produced: Relative density known to be specific gravity: Kiwi liquid wax shoe polish specific gravity is 1.01. Flash Point: Kiwi liquid wax shoe polish is flammable in air at temperature >93°C using setaflash closed cup. Volatility: 84-89% of kiwi liquid wax shoe polish is volatile. Water solubility: this test show that kiwi liquid wax shoe polish is dispersible. Appearance: liquid wax shoe polish can be neutral, black, brown, blue, or red. Kiwi Brands Inc. (1990) [1],

2.2.1. Determination of Shoe Polish Density

Weight of dried empty nickel crucible (W_o) in air and weight of nickel crucible and a quantity of shoe polish were recorded (W_1) in air, then record apparent weight of empty crucible (W_2) immersed in a 250mL beaker containing water placed on the chemical balance. At the end of 30min remove crucible containing sample from bath at test temperature; weighed (W_3) to 0.001g at 60ºC. The density is calculated from the mass of the shoe polish sample and its apparent mass when weighed in water.
Wo = mass of empty crucible in air, W_1 = mass of crucible containing sample in air
W_2 = apparent mass of empty crucible in water, W_3 = apparent mass of crucible containing sample in water. W_T = density of water (ρ_{water}) at test temperature observed at 15ºC and 25°C, taken as 0.9991kg/L and 0.997kg/L respectively).

$$\text{Relative density} = \frac{W1 - w0}{(W_1 - W_0) - (W_3 - W_2)} \text{ g/cm}^3 \quad (1)$$

$$\text{Density} = \text{Relative density x } W_T \quad (2)$$

Fig. .1: Types of Shoe Polish in Round Tins.

Source: Chicago Historical Society. Accessed November 27, 2007 [3].

2.3.1 Method of Application

Clean and dry footwear before vigorous rub of shoe polish using rag, cloth, or brush on it, further buffing with clean dry cloth or brush provide good results [1]. Sometime slight polish with few drops of water rubbed on footwear gives mirror-like, high-gloss finish surface on leather; this method is known as spit shine or bull [1], [11], [14].

3. Results and Discussion

3.1. Results

70% and 30% feed solutions of each batch material contained 2kg and 1kg in M_A and M_B streams respectively were mixed then fed into the heater unit at 100ºC; conversion ratios in problem statement was performed to determine values for the water vapour X_{WV} removed and product M_{SP} which were the two unknown variable streams.

INPUT: Total Mass Balance on Mixer Unit ($\sum MT$) (3)

$$\sum MT = \sum(M_{A1} + M_{A2} + M_{A3} + M_{A4}) + \sum(M_{B1} + M_{B2} + M_{B3} + M_{B4})$$

$$\sum mMT = M_{A(TOTAL)} + M_{B(TOTAL)} \quad (4)$$

$$\sum MT = 3000g$$

OUTPUT: Water Balance ($\sum MT \times X_{WV}$) (5)

$$\sum MT \times X_{WV} = \sum(M_A) \times \sum(70\% \text{ product/kg feed solution}) + \sum(M_B) \times \sum(30\% \text{ product/kg feed solution})$$

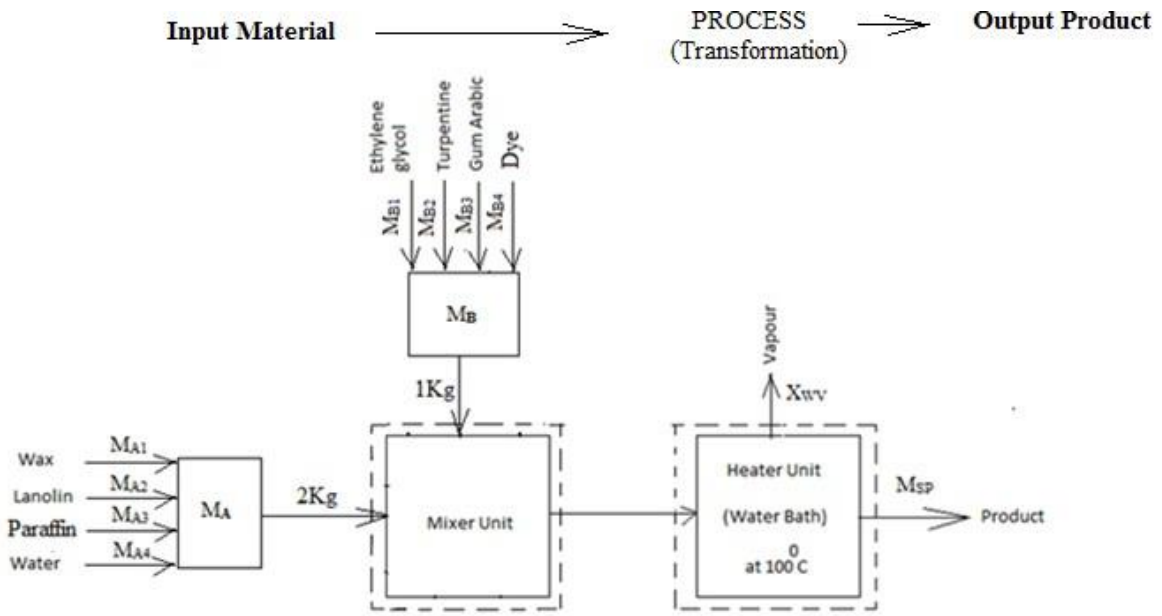

Fig. 2 : Flow Chart of a Typical Industrial Process showing stream of materials for shoe polish production.
The dotted lines represent boundary.

Table 1: 70% Feed Solution of Batch M_A in 2kg Stream

Serial Number	Material used	Material Measured weight (g) and Volume (cm^3)	Ratio Conversion units in (g/kg) and cm^3/kg	70% Product Solution per kg Feed Solution
M_{A1}	Wax	1000	0.50	0.350
M_{A2}	Lanolin	300	0.15	0.105
M_{A3}	Parafin	600	0.30	0.210
M_{A4}	Water	100	0.05	0.035

Table 2: 30% Feed Solution of Batch M_B in 1kg Stream.

Serial Number	Material used	Material Measured weight (g) and Volume (cm^3)	Ratio Conversion units in (g/kg) and cm^3/kg	30% Product Solution per kg Feed Solution
M_{B1}	Ethylene glycol	250	0.250	0.075
M_{B2}	Turpentine	350	0.350	0.105
M_{B3}	Gum Arabic	300	0.300	0.090
M_{B4}	Oil Soluble Dye	100	0.100	0.030

By substituting into Equation 3, value for water lost as vapour (X_{WV}) is obtained.

$3000(X_{WV}) = 2000*0.700 + 1000*0.300$

$(X_{WV}) = 0.567g/kgH_2O$

Since the Law of Conservation is obeyed, it follows that input is equal to output [18], [19], [20].

Amount of Feed Stream = Amount of Product Stream [18], [19] (6)

By substitution,

$$2000\{\sum(70\%\ \text{product/kg feed solution})\} + 1000\{\sum(30\%\ \text{product/kg feed solution})\} = 3000(Xwv)$$

It follows that,

$$1700 = 1701$$

The stream product obtained containing gum Arabic increases viscosity of the melt, wax acts as water proof, bonding agent, giving the shoe polish its greasy feel and texture and it also provides prolong reflective surface of the leather shoe. Turpentine and ethylene glycol being volatile at high temperature are tapped within the shoe polish cavity thereby decreasing its average density calculated to be 0.89kg/L; also, trapped volatile materials further enhance the fast drying, improve the surface shoe shine. Shoe polish contains chemical substances which can be absorbed through the skin, or inhaled, it should be handled with hand gloves, and in a well-ventilated area. Shoe polish should be kept out of reach of children and animals. It can stain the skin for a protracted period, and it can cause irritation to the eye if there is direct contact [2].

4. Conclusion

In chemical process involving shoe polish production, the amount of input materials equals that of output streams which indicate existence of law of mass conservation. The engineering method of processing shoe polish is viable for small and large scale productions; because negligible amount of the input materials was lost as steam (vapour) and compared to the little gain in the output production. In this system accumulation of materials is positive, as holdup of materials are within the system, there is no steady state; the net accumulation is not zero. This method is also relatively simple processing technology couple with cheap and easily accessible raw materials to make small/larger volume production for market demand.

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