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A Study on Incineration from the Wastages of Footwear Industries in Bangladesh

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Abstract-In Bangladesh footwear industries are a promising sector for rapid increase of export earnings. There are about 5000 small, medium and large scale footwear industries in Bangladesh. The production of Energy from Waste is not a new concept, though it is a field that requires serious attention. Leather, footwear industries are producing a bulk amount of scrape material, in this project we tried to recover energy from waste leather and allied materials through Incineration, the combustion of organic material such as waste with energy to recover the energy. Leather is one of the most widely traded commodities in the world. The leather and Footwear industry plays a prominent role in the world's economy, with an estimated global trade value of approximately US$100 billion per year. Leather raw materials have increasingly become available in the developing world. Now, more than half of the world supply of leather raw material comes from the developing world and, increasingly, those countries with large supplies are seeking to process them through to finished leather articles. This report assessed the prospects of the leather and footwear industry in the coming decade in Bangladesh & so about the estimated wastage. In its attempt to provide a thorough picture of the Footwear sector, the project work tried to utilize the waste in brick field and it was found that using leather wastage as a fuel, we can save our valuable gas, coal without deforming the final quality of Brick in brick field. We can substitute coal by wastes leather for burning purpose. In the mean time we can supply half of coal to burn the bricks and on the same time we can give wastes leather in the burning chamber of brick field. Because in the experiment of Bomb Calorimeter we have found the calorific value of Oily Nubuck Leather(dried) 6096.997* which is equivalent to coal. 4 (Four) Ton Coal is required per day when the traditional Brick Field run its operation in winter. Total Production capacity per day=40,000 pieces of Brick. The amount of coal per Ton price =10,000 BDT. If we use leather wastes as fuel the production cost will be minimized in Brick field and it will be more ecofriendly. As we have the power crisis so it will be great achievement if we are able to get renewable energy such as gas, heat, electricity etc. as a byproduct.

Keywords- *Waste Management, Energy Recovery, Incineration, Waste to Energy Technologies, Re-cycling*

I. INTRODUCTION

Using renewable energy sources is not only highly beneficial from energetic point of view but also from ecological point of view because by utilizing the renewable energy we can save our environment for our future generations. Currently the most talked about renewable energy sources are wind and sun, and many people see these two energy sources dominant in years to come. Leather and cotton production require significant inputs of water, land, fertilizer, and pesticides while leather tanning releases chromium and other harmful chemicals into the environment. In addition to an environmentally harmful production process, many footwear companies have worldwide supply chains in which products are transported across the globe while burning fossil fuels, thus contributing to global warming. One of the items of leather product -footwear, the global footwear market is expected to reach $500 billion by 2020, according to research from Global Industry analysis, with volume sales exceeding 25 billion pairs by 2016.Waste- to –Energy is the process of generating Energy in the form of electricity and/or heat from the primary treatment of the waste. WtE is a form of energy recovery. Most WtE processes produce electricity and/or heat directly through combustion, or produce a combustible fuel commodity, such as methane, methanol, ethanol, or synthetic fuels [1]. Energy recovery from waste is the conversion of non-recyclable waste materials into useable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolization, anaerobic digestion, and landfill gas (LFG)recovery. This process is often called waste-to-energy (WTE) [2]. Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat. Renewable energy replaces conventional fuels in four distinct areas: electricity generation, hot water/space heating, motor fuels, and rural (off-grid) energy services. The National Renewable Energy Laboratory projects that the levelized cost of wind power will decline 25% from 2012 to 2030[5]. Renewable energy technologies are getting cheaper, through technological change and through the benefits of mass production and market competition. A 2011 IEA report said: "A portfolio of renewable energy technologies is becoming cost-competitive in an increasingly broad range of circumstances, in some cases providing investment opportunities without the need for specific economic support," and added that "cost reductions in critical technologies, such as wind and solar, are set to continue." Hydro-electricity and geothermal electricity produced at favorable sites are now the cheapest way to generate electricity [6]. Renewable energy costs continue to drop, and the levelized cost of electricity (LCOE) is declining for wind power, solar photovoltaic (PV), concentrated solar power (CSP) and some biomass technologies. Renewable energy is also the most economic solution for new grid-connected capacity in areas with good resources. As the cost of renewable power falls, the scope of economically viable applications increases. Renewable technologies are now often the most economic solution for new generating capacity. Where "oil-fired generation is the predominant power generation source (e.g. on islands, off-grid and in some countries) a lower-cost renewable solution almost always exists today". A series of studies by the US National Renewable Energy Laboratory modeled the "grid in the Western US under a number of different scenarios where intermittent renewable accounted for 33 percent of the total power." In the models, inefficiencies in cycling the fossil fuel plants to compensate for the variation in solar and wind energy resulted in an additional cost of "between $0.47 and $1.28 to each Mega Watt hour generated"; however, the savings in the cost of the fuels saved "adds up to $7 billion, meaning the added costs are, at most, two percent of the savings [7]. It is very difficult to determine the ratio for each nature of waste. On the contrary it was possible to know the global quantity of waste. Leather goods process stages are comparable to footwear. The footwear process has been taken as a reference for the leather goods process stages except for lasting. The proportion by nature of waste known in the footwear process has been applied to the global quantities of waste declared by the leather goods manufacturer. The ratios provided hereafter can be considered as acceptable [12]. The footwear industry seems to be generating the largest quantity of dry leather and finished wastes. This means that footwear is the sector on which actions (if any) should apply first. It is very difficult to provide a global image of the costs related to each practice; each country has its own costs and regulations [3]. The major common point is: the costs regarding land filling is the lowest everywhere. In France, the global land filling cost (container renting, transportation, land filling) is approximately 100 Euro/ton and is rising under the pressure of lobbies and regulations. On the other side in Europe, the treatment of hazardous solid wastes costs about 300-400 Euro/ton. The recycling of material like cotton, cardboard, metallic parts can be profitable or not. This business depends very much on the world market. If the prices are low, the finished product manufacturer in Europe can pay up to 30-50 Euro/ton [4].

Incineration in a special furnace: Bubbling fluidized bed

Before being introduced into the furnace, the leather wastes are ground down to 10-12 mm[8]. Then a special pneumatic feeding system introduces the scraps at the right place into the furnace. A fluidized bed is created by blowing air under pressure through sand set in the base of the combustion chamber. The upward flow of air via distributor plates set at the bottom of the bed creates a movement maintaining the grains in suspension. As the grains are continuously moving in the chamber, a constant temperature (400-500 °C) is easily maintained across the whole bed. A post combustion chamber at 850°C and an average dwell time of 2 seconds forces the organic gases to burn completely [15].

II. MATERIALS AND METHOD

A. *Sample collection*

Sample materials such as Oily Nubuck Leather, Nappa leather, Semi-Aniline Finished Cow Leather, Shoe upper cow Leather, Skiving Dust of shoe upper leather, Polyester Fabric Lining (SLG & MLG) and mixture of all waste materials were collected from three footwear industries in Bangladesh, ABC Footwear Industries Ltd, F.B Footwear Ltd and Apex Footwear Ltd.

A Bomb-Calorimeter was used to measure the heat created by a sample burned under an oxygen atmosphere in a closed vessel, which is surrounded by water, under controlled conditions. For this study, samples were analyzed to find out calorific value using standard ASTM D5865 method, Ash content using standard ASTM D297, Moisture content using standard ASTM D6403 method and determination of Chromic Oxide (Cr_2O_3) Content From Ash using ASTM D2807[14].

III. RESULTS AND DISCUSSION

TABLE I. DETERMINATION OF CALORIFIC VALUE (METHOD: ASTM D5865)

S.N	Sample ID	Sample Material	Calorific Value (Kcal/Kg)
01	ILET-A/02 (With Moisture)	Oily Nubuck Leather	5876.140
02	ILET-A/02 (Without Moisture)	Oily Nubuck Leather(dried)	6096.997*
03	ILET-A/06	PVC	3227.975
04	ILET-A/10	Nappa leather	4244.2105
05	ILET-A/13	Semi-Aniline Finished Cow Leather	4997.875
06	ILET-A/15	Mixture of all samples	4063.152

TABLE II. ASH CONTENT (METHOD: ASTM D297) DETERMINATION OF ASH CONTENT

S.N	Sample ID	Sample Materials	% ash
01	ILET-A/01	Shoe upper cow Leather	4.838
02	ILET-A/02	Oily Nubuck Leather	4.126
03	ILET-A/03	Cellulose Shank Board	8.10
04	ILET-A/04	Cellulose Taxon Board	4.794
05	ILET-A/05	Skiving Dust of shoe upper leather	5.7203
06	ILET-A/06	PVC	12.8697
07	ILET-A/07	Synthetic Fur Lining (Footwear)	13.7081
08	ILET-A/08	EVA Micro	27.8217
09	ILET-A/09	Pattern Paper	14.4502
10	ILET-A/10	Nappa leather (Bag Upper)	5.827
11	ILET-A/11	Adhesive Tape	8.501
12	ILET-A/12	Tricoat (PU,Foam,Net) Cellulose	9.505
13	ILET-A/13	Vegetable Tanned Cow Leather	4.692
14	ILET-A/14	Polyester Fabric Lining (SLG & MLG)	0.788
15	ILET-A/15	Mixture of all samples	11.116
16	ILET-A/16	Thread (Nylon)	0.629

TABLE III. ASH ANALYSIS, DETERMINATION OF CHROMIC OXIDE (Cr_2O_3) CONTENT FROM ASH (METHOD: ASTM D2807)

Sample ID	Weight/ Quantity	Burette Reading			Calculation	%of (Cr_2O_3)	Result in mg/L
		Initial	Final	Accurate			
ILET-Z/02	25ml	0.0	64 ml	64ml	64×0.00253×100 / 25	0.6476%	=6.476 mg/L
ILET-Z/10	25 ml	0.0	66ml	66 ml	66×0.00253×100 / 25	0.66792%	6.6792 mg/L
ILET-Z/13	25 ml	0.0 ml	82.8 ml	82.8 ml	82.8×0.00253×100 / 25	0.8379%	8.3793 mg /L
ILET-Z/15	0.9372 gm	.9372 gm	0.0 ml	18.5 ml	18.5×0.00253×100 / 0.9372 gm	4.9941%	-

TABLE IV. DETERMINATION OF MOISTURE CONTENT (METHOD: ASTM D6403)

S.N	Sample ID	Sample Materials	% Moisture
01	ILET-A/01	Shoe upper cow Leather	10.988
02	ILET-A/02	Oily Nubuck Leather	9.6265
03	ILET-A/03	Cellulose Shank Board	9.3432
04	ILET-A/04	Cellulose Taxon Board	6.472
05	ILET-A/05	Skiving Dust of shoe upper leather	11.943
06	ILET-A/06	PVC	1.7366
07	ILET-A/07	Synthetic Fur Lining (Footwear)	0.4154
08	ILET-A/08	EVA Micro	0.9946
09	ILET-A/09	Pattern Paper	6.8134
10	ILET-A/10	Nappa leather (Bag Upper)	10.0744
11	ILET-A/11	Adhesive Tape	6.259
12	ILET-A/12	Tricoat (PU, Foam, Net) Cellulose	1.7674
13	ILET-A/13	Vegetable Tanned Cow Leather	16.4672
14	ILET-A/14	Polyester Fabric Lining (SLG & MLG)	0.9286
15	ILET-A/15	Mixture of all samples	3.667
16	ILET-A/16	Thread (Nylon)	0.4053

TABLE V. DATA COLLECTION ON WASTES FIELD SURVEY IN DIFFERENT INDUSTRIES. THIS DATA IS CALLED NON-COMMERCIAL IN FACTORY LANGUAGE

S.N	Name of the factory	Location Of Factory	Manufacturing items	Production capacity (pairs per day)	Mostly used Materials	Total Discharge of solid waste (per month in Kg.)
01	Papella Footwear Ltd.	CEPZ,Chittagong, Bangladesh	Footwear	2000	PU, Mesh	3200
02	Patenga Footwear (PVT.) Ltd.	CEPZ,Chittagong, Bangladesh	Footwear	2200 in 2 Lines	Leather	4200
03	Excelsior Shoe Ltd.	CEPZ,Chittagong, Bangladesh	Footwear	6500 in 3 Lines	PU	10400
04	M.S Shoe Ltd.	CEPZ,Chittagong, Bangladesh	Footwear	700-800	Jute	1280
05	Bon Shoe BD Ltd.	CEPZ,Chittagong, Bangladesh	Footwear	2200-2400	Leather	3600
06	CosMos Shoe Ltd.	CEPZ,Chittagong, Bangladesh	Footwear	850-900	PU	1440
07	UFM BD Ltd.	CEPZ,Chittagong, Bangladesh	Footwear	2000	PU, PVC	3000
08	Maf Shoes Ltd.	Chadgaon, Chittagong	Sports Shoes, Leather Shoes, Flip-Flop/Beach Sandals	8500	PU, EVA	13600
09	Karnafuly Shoe Industry (KSI) Ltd.	KEPZ, Anowara, Chittagong	Footwear	20000	PU, PVC	29500
10	Bengal Shoe Industries Ltd.	Raipur, Luxmipur	Footwear	3500	Leather	4850
11	SonaliAnnsh Industries Ltd.	Daudkandi, Comilla.	Footwear	1000	Jute	1480
12	ABC Footwear Industries Ltd.	Zirabo, ashulia, savar, Dhaka.	Footwear	15000	Leather	24500
13	F.B Footwear Ltd.	KaliakoirGazipur Bangladesh	Footwear	6000	Leather	9800
14	Rimex Footwear Ltd.	Savar, Dhaka	Footwear	2000	Leather	2600
15	Bay Footwear	Mouchak, Gazipur	Footwear	2500	Leather	3650
16	Apex Footwear Ltd.	Mouchak, Gazipur	Footwear	32000	Leather	48600
17	LonglaLeatherex Limited	Hydrabad, GazipurSadar, Gazipur	Wallet, Ladies Bag, Office Bag, Jacket, Shoes & Sandal	6600	Leather	9600
18	Fortuna Shoes Ltd.	Kunia, Gazipur	Footwear	4500	Leather	6450
19	Jennys Shoes Ltd.	ShayampurKadamtali I/A, Dhaka	Gent's & Ladies Leather Footwear.	2000	Leather	2800
20	Landmark Footwear Ltd.	Mouchak, Gazipur	Footwear	1000	Leather	1520

TABLE VI. HEAT OF COMBUSTION TABLES

Higher (HHV) and Lower (LHV) Heating values of some common fuels				
Fuel	HHV MJ/kg	HHV BTU/lb.	HHV kJ/mol	LHV MJ/kg
Hydrogen	141.80	61,000	286	119.96
Methane	55.50	23,900	889	50.00
Ethane	51.90	22,400	1,560	47.80
Propane	50.35	21,700	2,220	46.35
Butane	49.50	20,900	2,877	45.75
Pentane	-	-	-	45.35
Gasoline	47.30	20,400	-	44.4
Diesel	44.80	19,300	-	43.4
Kerosene	46.20	19,862	-	43.00
Paraffin wax	46.00	19,900	-	41.50
Wood (MAF)	21.7	8,700	-	-
Peat (damp)	6.00	2,500	-	-
Coal (Lignite)	15.00	8,000	-	-
Coal (Anthracite)	32.50	14,000	-	-

In the experiment of Bomb Calorimeter we have found the calorific value of Oily Nubuck Leather (dried) 6096.997* Kcal/Kg 7 which is 25.5269070396 MJ.

We know that, 1 kcal = 0.0041868 MJ

Way to burn wastes leather in Brick Field in a hygienic way: Now there are 2 types of brick fields

- Auto Bricks using Gas
- Traditional Brick Field using Coal

We can substitute coal by wastes leather for burning purpose.

In the mean time we can supply half of coal to burn the bricks and on the same time we can give wastes leather in the burning chamber of brick field. Because in the experiment of Bomb Calorimeter we have found the calorific value of Oily Nubuck Leather(dried)6096.997* which is equivalent to coal. So by using leather wastage as a fuel in here we can save our valuable gas, coal without deforming the final quality of Brick.

In the ash analysis we have found the ash content of supplied samples of in its first burning.

TABLE VII. ASH CONTENT OF SUPPLIED SAMPLES OF IN ITS FIRST BURNING

S.N	Sample Id	Materials	%of (Cr_2O_3)
01.	ILET-A/02	Oily Nubuck Leather	0.6476%
02.	ILET-A/10	Nappa leather (Shoe Upper)	0.66792%
03.	ILET-A/13	Vegetable Tanned Cow Leather	0.8379%
04.	ILET-A/15	Mixture of all samples	4.9941%

But in the brick field it will burn continuously and the ash will also burn again and again so after repeated burning there is little scope for existing large amount of harmful elements. Beside this we know that today the leather wastages are also crushing and finally mixing in Poultry feed, Fish feed as a great source of Protein, but which is totally hazardous and dangerous for human health because they are strongly entering into our food chain.

From Field Survey we have found the proved data from Brick Field authority that they have already practiced for many times the burning of wastes leather in their brick fields & also satisfied on the color & quality of final product Brick after burning from leather wastes.

- The brick fields run in the winter season, so there is no chance of any acid rain by the mixture of toxic acid produce from the Brick field.
- If we can set a gas filter this will neutralize the toxic oxide and may produce various acids after receiving oxide and mixing them with water.
- Most importantly the Brick Fields burn continuously with a higher temperature 800-1200 C ,so there are few chances of presence of toxic elements if presents it will be trace elements and no harmful for the environment[12].

Calculation of total coal required to burn brick in one day: 4 (Four) Ton Coal is required per day when the traditional Brick Field run its operation in winter.

Total Production capacity per day=40,000 pcs Brick.

The amount of coal per Ton price =- 10,000 BDT.

The traditional Brick Field runs mainly in continuous production 6 months in a year.

Coal & Electricity & Wastes of leather can be used with coal. Modern life is unimaginable without electricity. It lights houses, buildings, streets, provides domestic and industrial heat, and powers most equipment used in homes, offices and machinery in factories. Improving access to electricity worldwide is critical to alleviating poverty. Coal plays a vital role in electricity generation worldwide. Coal-fired power plants currently fuel 41% of global electricity [13]. In some countries, coal fuels a higher percentage of electricity.

IV. CONCLUSION

The quantification of the wastes produced is a difficult task; the production data (number of pairs of shoes, number of gloves etc. are not available on a worldwide basis except for leather and for leather footwear. The calculations for the other products have been made from exportation data which do not represent production. However, with the figures obtained, it seems that Asia is the 1st region regarding the production of the leather sector. It is producing more than 60 % of the wastes in the world [11]. In most cases, internal reduction solutions cannot reduce the quantities of waste very much and internal recycling solutions can only be applied in large scale to thermoplastics. This is why recycling solutions must be found outside the factories. As the recycling technologies need large quantities of wastes (>2000 t/year), the leather sector must organize the collection, the transport and the recycling operations in order to find a solution [10].

Regarding finished leather specifically, it seems that two recycling options are available now:

- As a component for fertilizers (after keeping or removing chromium).
- As a source of chromium after incineration under controlled conditions.

For the other wastes, it will be difficult to find a recycling solution which could be operational rapidly. This is why the valorization solution seems to be the incineration with energy recovery and under controlled conditions (exhaust gazes treatment). In that way, scraps containing PVC will probably become a problem due to the production of chlorhydric acid during the combustion. As a consequence, and unlike the other wastes, waste containing PVC will probably continue to need landfills in the next future. These considerations also apply to worn finished products as contain the same materials. In any case, and in order to start/improve the recycling treatment of wastes, the leather sector will need to develop a new internal organization and new internal responsibilities in the factories as well as a structured organization between the factories which could deal with these new environmental issues. Everyone should emphasis on these topics. Otherwise we will lack behind from the developed and developing part of the world. We need to increase our footwear production under all rules and regulation imposed on footwear, only then we could sustain in the market. For that reason all concerning of this sector should think and work on environment and we can find an eco-friendly use of all resource of the waste generated from leather and footwear industries. Since we have the power crisis so it will be great achievement if we are able to get renewable energy such as gas, heat, electricity etc. as a byproduct. We should save our environment from the pollution linked with the production of footwear. So it will be better if we can introduce wastes management with energy recovery. We can use the leather wastes as well as other wastes those cannot be recycled. We can use those as a fuel with coal for Burning purpose.

V. ACKNOWLEDGEMENT

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