International Conference on Advances in Materials, Computing and Communication Technologies
In Association with International Journal of Scientific Research in Science and Technology
Volume 9 | Issue 1 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)

Waste Disposal and Effective Utilization in Footwear Industry

V.Ramar[1], S.Ponsubbiah[2]
[1]The Gandhigram Rural Institute,Dindigul-624302, Tamil Nadu, India
[2]Institute of Leather Technology,Chennai-600113, Tamil Nadu, India

ABSTRACT

The footwear industry is a diverse manufacturing sector which employs a wide variety of materials to make product ranging from different types and styles of footwear to more specialized shoes. Disposal is the management of waste to prevent harm to the environment, injury or long term progressive damage to health. Disposal of waste is where the invention is to permanently store the waste for the duration of its biological and chemical activity. Such that it is rendered harmless. The largest quantity of waste is generated at the cutting process. This work to facilitate industrial awareness and to communicate the key issues with the winder community of stakeholder in the footwear sector. It provides an overview of the scale of post-consumer footwear waste, legislative requirements, existing disposing solutions and the key factors influencing the establishment of a nationwide footwear disposing scheme around the world in coming future and create non-polluting environment.

Figure 1-Shoe and its components

I. INTRODUCTION

Footwear is the sector which "consumes" the major part of leather (60%). Logically, this industry producing the largest quantity of leather wastes. However, in spite of the specific application of their products, these industries have some common points which are described hereafter. The process (and even the machines) involves similar production steps and technologies (except for footwear for which the assembling techniques can be sophisticated).The materials (leather, textiles etc.) are similar.

- Guidelines in order to better anticipate future regulation and deal with them effectively.
- A tool in order estimates the effectiveness of the waste disposal.
- The European standard incorporates such a tool, designed specifically for the footwear industry.
- In order to improve the waste disposal, the footwear manufacturer should perform the following tasks.
- Reduce the quantity of waste.
- Incinerate and recover energy from the waste.
- Treat the waste.

1.1 CURRENT SOLUTIONS FOR DISPOSING OF FOOTWEAR PRODUCTS.

- Economic implications of collecting and disposing of post-consumer shoes.
- Long-term solutions and technology gaps.
- Immediately actions required to set up nationwide footwear disposing scheme.

This document specifies the process steps which are involved in the generation of the waste from footwear manufacture and the usual disposing practices. It also establishment a list of the usual wastes generated during the footwear manufacturing process. It can be applied to one specific product and one specific production technology within the factory or to the whole production of a company. The nature of such wastes produced will depend on manufacturing processes, the type of shoe and the material used.

The tool used to evaluate the effectiveness of the waste management is: Establishment directly from the production process or waste generated, Calculate for a specific product, a specific group of products or a specific production technology which shall be defined or the whole production of the company.

1.2 SHOE

The shoe upper is an assembly of the upper footwear part.it protects the upper portion and sides of the foot. According to the function and location, it is divided into four basic groups:

- Shoe upper parts & components.
- Lining parts & components.
- Reinforcing parts & components.

1.3 SHOE UPPER PARTS & COMPONENTS

They from the external upper part. During production and while worn they are subjected to a lot of stress. The basic shoe upper components are:

- Toe cap
- Vamp
- Quarter
- Counter
- Tongue
- Back strap

1.4 LINING PARTS & COMPONENTS

These parts the following tasks:

- Improve the comfort at walking.
- Enhance footwear appearance.
- Insulate the foot from heat.
- Increase the life of footwear.

During production and when the in footwear is worn the lining is most in the back part and in toe cap, the dividing of lining varies and is dependent on the type of footwear. In most cases it is divided into:

- Vamp lining
- Quarter lining
- Stay facing lining
- Heel grip
- Tongue lining

1.5 REINFORCEING PARTS & COMPONENTS

Their task is to reinforce the upper material in region where it is most stressed to ensure the right appearance and shape of footwear. They are inserted mostly between upper and lining parts. Normally the following parts are reinforced:

- Stay facing
- Toe puff
- Cross piece
- Counter stiffener
- Eyelet
- Back straps
- Buckle
- Velcro
- Saddle
- Quarter stay joining

II. MATERIALS USED FOR MANUFACTURING OF SHOES

2.1.1 LEATHER

Leather is a wonderful and primary material for shoe upper. Is unique properties and characteristics make it the ideal choice for many different applications Here we will discuss some of the most useful properties of leather. It has a high tensile strength and is resistant to tearing, flexing and puncturing. This helps leather items last for a long time while retaining their look and feel. It is a good heat barrier and provides excellent heat insulation. Leather contains a large amount of air and air is a poor conductor of heat. This makes leather a very comfortable item for the human skill. It is able to hold large quantities of water vapor such as human perspiration and then dissipate it later. This makes leather a comfortable item to wear or sit on. Leather's thermostatic properties make it warm in the winter and cool in the summer. This makes leather comfortable to wear. It can be made to stiffen or can be made to be flexible. It can be molded into a certain shape and then remolded into another shape later. Leather is resistant to abrasion in both wet and dry environments. This makes leather an excellent protector of human skin. It is resistant to heat and fire. It is also resistant to fungal growth such as mildew. It consists of many fibers that are breathable. This breath ability makes it very comfortable to wear in any climate. Leather can be dyed many different colors that makes it attractive in the production of that makes it attractive in the production of leather clothing, as a cover for furniture and for many other color sensitive application. It is can be soft and supple. Leather clothing becomes a literal second skin. It warms to your body temperature. It is not itchy and does not scratch. It is non-irritating to the skin. Leather is a fantastic material with excellent physical properties that enable is to be used in much diverse application from shoe upper to soling.

Figure 2- Leather and its texture

2.1.2 TEXTILE FABRICS

Fabric, or cloth, is a supple artificial material which is made up of a network of artificial or natural fibers (yarn or thread) formed by knitting (textiles) or weaving, or pressed into felt. The terms material and fabric are frequently used in the weaving assembly trades such as dressmaking and tailoring, and are synonyms for cloth.

Fabric is most often used in the manufacture of shoe as upper materials. Before woven cloth made its appearance, the roles of textiles had been fulfilled by leather and furs.

There are a large number of different types of fabric, each has its own unique fabric properties such as strength and degree of durability, color hue and color intensity. The thickness, one of the fabric properties, is estimate in deniers. The term "micro-fiber" denotes fibers that are made of strands with the thickness less than one denier. Here are some types of fabric followed by a short description of a few most used types: cotton, wool, silk, polyester, nylon, viscous, rayon, acrylics, jute etc.

Figure 3- Textile fabrics and its texture

2.1.3 RAYON

Rayon is a manufactured regenerated cellulose fiber. Because it is produced from naturally occurring polymers it is neither a truly synthetic fiber nor a natural fiber; it is a semi-synthetic fiber. Rayon is known by the names viscose rayon and art silk in the textile industry. It usually has a high luster quality giving it a bright sheen.

Rayon is a very versatile fiber and has the same comfort properties as natural fibers. It can imitate the feel and texture of silk, wool, cotton and linen. The fibers are easily dyed in a wide range of colors. Rayon fabrics are soft, smooth, cool, comfortable, and highly absorbent, but they do not insulate body heat, making them ideal for use in hot and humid climates.

The durability and appearance retention of regular rayon are low, especially when wet; also, rayon has lowest elastic recovery of any fiber. However, HMM rayon is much stronger and exhibits higher durability and appearance retention. Recommended care for regular rayon is dry- cleaning only. HMM rayon can be machine washed.

- It is strong and durable.
- It is extremely absorbent.
- It is soft and comfortable.
- It is breathable.
- It is easily dyed on vivid colors.
- It is abrasion resistant.
- It resists insect damage.
- It does not pill.
- It drapes well and does not have a problem with static.
- It wrinkles easily.
- It loses 30% to 50% of its strength when wet.

Figure 4- Rayon and its texture

2.1.4 COTTON

Cotton is a soft, fluffy, staple fiber that grows in a boll around the seeds of the cotton plant. It is a native to tropical and subtropical regions around the world, including the Americas, India and Africa. The fiber most often is spun into yarn or thread and used to make a soft, breathable textile, which is the most widely, used natural-fiber cloth in clothing today.

- It is soft
- It "breathes"
- It absorbs body moisture
- It is comfortable
- It is strong and durable
- It is versatile

- It performs well
- It has good color retention
- It is easy to print on
- It wrinkles easily
- It is easy to care for, easy to wash
- It is a natural resource that is fully renewable

Figure 5- Cotton fabric and its texture

2.1.5 NYLON

Nylon is a generic designation for a family of synthetic polymers known generically as polyamides and first produced on February 28, 1935 by Wallace Caruthers at DuPont. Nylon is one of the most commonly used polymers.

- Variation of luster: nylon has the ability to be very lustrous, semi lustrous or dull.
- Durability: it is high tenacity fibers are used for seatbelts, tire cords ballistic cloth and other uses.
- High elongation.
- Excellent abrasion resistance.
- Highly resilient (nylon fabrics are heat-set)
- Paved the way for easy-care garments.
- High resistance to insects, fungi, animals, as well as molds, mildew, rot and many chemicals.
- Used in carpets and nylon stockings.
- Melts instead of burning.
- Used in many military applications.
- Good specific strength
- Transparent under infrared light (-12dB)

Above their melting temperatures, T m, thermoplastics like nylon are amorphous solids or viscous fluids in which the chains approximate random coils. Below Tm, amorphous regions alternate with regions which are lamellar crystals. The amorphous regions contribute elasticity and the crystalline regions contribute strength and rigidity. The planar amide (-CO-NH-) groups are very polar, so nylon forms multiple hydrogen bonds among adjacent strands. Because the nylon backbone is so regular and symmetrical, especially if all the amide bonds are in the configuration, nylons often have high crystal clear depends on the details of formation, as well as on the kind of nylon. Apparently it can never be quenched from a melt as a completely amorphous solid.

Nylon 6,6 can have multiple parallel stands aligned with their neighboring peptide bonds at coordinated separations of exactly 6 and 4 carbon for considerable lengths, so the carbonyl oxygen and amide hydrogen's can line up to form inter chain hydrogen bonds repeatedly, without interruption. Nylon 5, 10 can have coordinated runs of 5 and 8 carbons. Thus parallel (but not ant parallel) strands can participate in extended, unbroken, multi –chain pleated sheets, a strong and tough super molecular structure similar to that found in natural silk fibroin and the sequential –CO-NH- groups). Nylon 6 will form uninterrupted H-bonded sheets with mixed directionalities, but the sheet wrinkling is somewhat different. The three-dimensional disposition of each alkenes hydrocarbon chain depends on rotations about the 109.47◦ tetrahedral bonds of singly-bonded carbon atoms.

Block nylon tends to be less crystalline, except near the surfaces due to shearing stresses during formation. Nylon is clear and colorless, or milky, but is easily dyed. Multithreaded nylon cord and rope is slippery and tends to unravel. The ends can be melted and fused with a heat source such as a flame or electrode to prevent this.

1. It is strong and elastic.
2. It is easy launder.
3. It dries quickly.
4. It retains its shape.
5. It is resilient and responsive

Figure 6- Nylon fabrics and its texture

2.1.6 POLYESTER

Polyester is a category of polymers which contain the ester functional group in their main chain. Although there are many types of polyester, the term "polyester" as a specific material most commonly refers to polyethylene terephthalate (PET). Polyesters include naturally-occurring chemicals, such as in the certain of plant cuticles, as well as synthetic though step-growth polymerization such as polycarbonate and polyester. Natural polyester and a few synthetic once are biodegradable, but most synthetic polyesters are not.

Depending on the chemical structure polyester can be a thermoplastic or thermo set, however the most common polyesters are thermoplastics.

Fabrics woven from polyester thread or yarn are used extensively in apparel and home furnishing, from shirts and pants to jackets and hats, bed sheet, blankets and upholstered furniture. Industrial polyester fibers, yarns and ropes are used in type reinforcements, fabrics for conveyor belts, safety belts, coated fabrics and plastic reinforcements with high-energy absorption. Polyester fiber is used as cushioning and insulating material in pillows, comforters and upholstery padding.

While synthetic clothing in general is perceived by some as having a less-natural feel fiber (such as cotton and wool), polyester fabrics can provide specific advantages over natural fabrics, such as improved wrinkle resistance. As a result, polyester fibers are sometimes spun together with natural fibers to produce a cloth with blended properties. Synthetic fibers also can create materials with superior water, wind and environmental resistance compared to plant-derived fibers.

Polyesters are also used to make "plastic" bottles, films, tarpaulin, canoes, liquid crystal displays, holograms, filters, dielectric film for capacitors, film insulation for wire and insulating tapes.

Liquid crystalline polyesters are among the first industrially-used liquid crystalline polymers. They are used for mechanical properties and heat-resistance. These traits are also important in important in their application as an abatable seal in jet engines.

Polyesters are widely used as a finish on high-quality wood products such as guitars, pianos and vehicle/yacht interiors. Burns guitars, Rolls Royce and sun seeker are a few companies that use polyesters to finish their products. Thixotropic properties of spray-applicable polyesters make them ideal for use on open-grain timbers, as they can quickly fill wood grain, with a high-build film thickness per cost. Cured polished to a high-gloss, durable finish.

The properties of polyester fabrics include: inexpensive cost: superior strength and resilience; lightweight; hydrophobic (it feels dry or moves moisture effects away from touch); it has an unusually high melting point; is resistant to dyes, solvents and most chemicals; stain resists stretching and shrinking; quick drying; wrinkle, mildew and abrasion resistant;

retains heat-set pleats and creases and is easy to launder.

The fabric can also develop small fuzz balls or pills, which may be related to friction, abrasion resistance, and stiffness and breaking strength, according to a university of Tennessee, Knoxville paper. Polyester is sensitive to alkalizes and resistant to most conventional textile bleaches. Which means that it is difficult to remove oil stains from the fabric? It exhibits static cling tendencies and it is frequently used in fabrics that give the appearance potentials and are texturally more similar to the luster and feel of silk. It has good fade resistance, particularly when protected from UV radiation and it is noted to retain its shape. Not all polyesters have the same properties and characteristics but they will share most of them.

1. It is resists wrinkling.
2. It is easy to launder.
3. It dries quickly.
4. It is resistant to stretching and shrinking.

Figure 7- Polyester fabric and its texture

2.1.7 JUTE

Jute is a long, soft, shiny vegetable fiber that can be spun into coarse, strong threads. It is reduced from plants in the genus, family.

Jute is one of the most affordable natural fiber and is second only to cotton in amount produced and variety of uses. Jute fibers are composed primarily of the plant materials cellulose (major component of plant fiber) and lignin (major components of wood fiber). It is thus a lignocelluloses fiber that is partially a textile fiber and partially wood. It falls into the best fiber category (fiber collected from past or skin of the plant) along with knave, industrial hemp, flax. The industrial term for jute fiber is raw jute. The fibers are off-white to brown, and 1-4 meters (3-12 feet) long.

Jute fiber is often called hessian; jute fabrics are also called hessian cloth and jute sacks are called gunny bags in some European countries. The fabric made from jute is popularly known as burlap in North America.

- Jute fiber is 100% bio-degradable and recyclable and thus environmentally friendly.
- It is a natural fiber with golden and silky shine and hence called the golden fiber.
- It is the cheapest vegetable fiber procured from the best of the plant's stem.
- It is the second most important vegetable fiber after cotton, in terms of usage, global consumption, production, and availability.
- It has high tensile strength, low extensibility, and ensures better breath ability of fabrics. Therefore, jute is very suitable in agricultural commodity bulk packaging.
- It helps to make best quality industrial yarn, fabric, net, and sacks. It is one of the most versatile natural fibers that have been used in raw materials for packaging, textiles, non-textile, construction, and agricultural sectors. Bulking of yarn results in a reduced breaking tenacity and an increased breaking extensibility when blended as a ternary blend.
- Unlike the hemp fiber, jute is not a form of cannabis.
- Advantages of jute include good insulting and antistatic properties, as well as having low thermal conductivity and moderate moisture regain. Other advantages of jute include acoustic

insulating properties and manufacture with no skin irritations.

- Jute has the ability to be blended with other fibers, both synthetic and natural, and accepts cellulose dye classes such as natural, basic, vat, sulfur, reactive, and pigment dyes. As the demand for natural comfort fibers increases, the demand for jute and other natural fibers that can be blended with cotton will increase. To meet this demand, it has been suggested that the natural fiber industry adopt the Reiter's elite system, in order to modernize processing. The resulting jute/cotton yarns will produce fabrics with a reduce cost of wet processing treatments. Jute can also be blended with wool. By treating jute with caustic soda, crimp, softness, pliability, and appearance is improved, aiding in its ability to be spun with wool. Liquid ammonia has a similar effect on jute, as well as the added characteristic of improving flame resistance when treated with flame proofing agents.
- Some noted disadvantages include poor derivability and crease resistance, brittleness, fiber shedding, and yellowing in sunlight. However, preparation of fabrics with castor oil lubricants result in less yellowing and less fabric weight loss, as well as increased dyeing brilliance. Jute has a decreased strength when wet, and also becomes subject to microbial attack in humid climates. Jute can be processed with an enzyme in order to reduce some of its brittleness and stiffness. Once treaded with an enzyme, jute shows an affinity to readily accept natural dyes, which can be made from marigold flower extract. In one attempt to dye jute fabric with this extract, bleached fabric was mordent with ferrous soleplate, increasing the fabric's dye uptake value. Jute also responds well to reactive dyeing.

Figure 8- Jute fabric and its texture

2.2.1 MATERIALS AND CHEMICALS PROCESSED DURING FOOTWEAR MANUFACTURING

The materials and chemicals used during the process of footwear manufacturing are tabulated below

MATERIAL / WASTE	USE AS OR PRODUCED BY	REDUCTION
Leather, textile(cotton, polyester, nylon), coated fabrics (PU and PVC)	Upper and lining	The cutting ratio in leather is generally being optimized by the Operators. With less expensive material, the ratio can vary from one country to the other: the only criterion of the footwear manufacturer is the optimization between labour cost and material cost

Natural rubber/ poly-isoprene, Reaction Injection Moulded (RIM) Poly Urethane (PU) Poly Vinyl Chloride (PVC) and blends, Ethylene Vinyl Acetate(EVA) and blends, Styrene Butadiene Rubber (SBR) Thermoplastic Poly Urethane (TPU) Thermoplastic Rubber(TR), Leather	Outsole	The mould must be as tight as possible The design of the mould reduces the quantity and sizes Worn moulds generally produces more wastes
Leather board, cellulose board, non-woven(polyester), leather	Insole	This cutting rate can be reduced with the use of automatic cutting machines (water, laser etc.) with leather, the cutting ratio can be reduced by 2-3 points.
Leather, coated fabric (PU and PVC), Foams (EVA, PU, PE, NR), textile (nylon).	insocks	This cutting rate can be reduced with the use of automatic cutting machines (water, laser etc.) with leather, the cutting ratio can be reduced by 2-3 points.
Thermo plastic sheet type (polyamide, ABS, Styrene, EVA) Impregnated fabrics, Fabric(polyester, cotton, nylon), Leather, Fibre-board	Reinforcement	This cutting rate can be reduced with the use of automatic cutting machines (water, laser etc.) with leather, the cutting ratio can be reduced by 2-3 points.
Roughing dust and sludge	Cementing	The only reduction is to avoid the collection in water. This is possible when the upper has no nail or metallic part.
Bottom filler(cork/resin, foam), Shank (metal, wood, plastic), Heels (polystyrene (PS), Acrylonitrile Butadiene Styrene (ABS)).	Miscellaneous	Two options are possible The footwear manufacturer knows a footwear component retailer. The leather can often take most of the components and sell them to another country The footwear manufacturer purchases most of its components on an order to order(just in time

III. QUANTITY OF WASTE DURING FOOTWEAR MANUFACTURING

Category of waste	TYPE OF FOOTWEAR (waste/million pairs)					Average shoe
	Men's town	Women's town	Children	Casual and general sport	Safety shoe	
Upper and lining materials- leather (chrome and veg)	96.2	70.6	46.9	32.9	176.0	84.5
Upper and lining materials- other materials	23.1	24.4	20.2	36.2	133.9	47.6
Upper manufacturing waste	0.6	0.6	0.3	0.3	0.6	0.5
Insole and reinforcement materials- all materials	72.6	45.7	50.4	58.1	32.3	51.8
Outsole preparation & cementing (footwear)	20.2	68.7	21.8	32.1	15.1	31.6
Injection wastes	0.0	12.8	1.0	14.1	144.8	34.6
Adhesives, oil, solvents	7.3	6.1	1.1	2.6	6.1	4.6
Household type waste	13.1	12.7	10.5	6.8	10.9	10.8
Total	233	242	152	183	520	266

IV. EXISTING DISPOSAL METHODS IN INDIAN FOOTWEAR INDUSTRIES

4.1 LEATHER MATERIALS:

Wastages from shoe manufacturing often reused in sandal manufacturing. Small pieces are used to make leather goods.

4.2 PAPER:

Paper disposals are often used as filler between insole and outsole. For this they cut into small pieces.

4.3 SYNTHETIC MATERIALS:

Paper industries take charge of these disposals which includes different fabrics and fabric materials, foam, thread, etc.

4.4 LASTS:

Damaged PU lasts cannot be used to produce new lasts as they result is low durability.

4.5 STORAGE OF WASTE LEATHER IN INDIAN FOOTWEAR INDUSTRY:

- Waste leather is stored on level, impervious ground, away from water sources
- Storage areas are kept free of weeds, fuel tanks and other combustible materials
- Non confirming products should be immediately identified, separated and stored in COLD area for disposal
- The main things to remember for proper disposal of waste are listed below and the operator should ensure these guidelines are followed properly.
- Segregate the waste as hazardous (oil spill, chemicals etc) non-hazardous waste (leather,

paper etc) and disposed them at the designated places in daily basis.

- Waste bins must have tight fitting lids
- Bins must be kept clean and washed after they are emptied

V. POSSIBLE UTILIZATION OF SHOE WASTES

The possible ways are mentioned below

5.1 LEATHER MATERIALS

Leather trimmings from the shoe manufacturing often reused in sandal manufacturing. Average pieces are used to make leather goods. But small scraps and trimmings are disposed without effective use; this can be used for the following By products

1. Leather board making
2. Leather threads making
3. Clothing making
4. Preparation of parchment like materials
5. Leather like materials
6. Glue and Gelatin

5.2 PAPER

Paper disposals are often used as filler between insole and outsole. The cut pieces of papers can be recycled and may be converting into paper boards. So that the waste can be reduced.

5.3 SYNTHETIC MATERIALS

Fabrics and fabric materials, foam and threads are the main synthetic materials used in the fabrication of shoe. The waste trimmings of synthetics are disposed without any effective use. The synthetic wastes can be convert into value added composite materials such as

1. Paper weights
2. Floor mats
3. Mid soles
4. Insoles

5.4 LASTS

Normally lasts are manufactured through High density Poly Ethyl materials. The recycling of poly ethyl materials is very easy and easy to convert again last mistrials.

VI. CONCLUSION

The waste generated from the footwear industry is unavoidable, but sustainable way of making use of the waste generated by the footwear industry helps to reduce the pollution caused by the materials used in the process and will reduce the production cost. Hence, it may be concluded that efficient use of the non-leather materials and trimmings would avoid the environmental problem, and could be a source of sustainable value-creation from these wastes.

VII. REFERENCES

[1]. Manuals from Footwear Design and Development Institute (FDDI).
[2]. Manuals from Central Leather Research Institute (CLRI).
[3]. www.leathersscorg.in
[4]. www.assignmentpoint.com
[5]. www.worldwidescienceorg.in
[6]. Manual from Leather Sector Skill Council
[7]. William Handley, industrial safety handbook, McGraw Hill Book Company, 1969
[8]. H.W, Heinrich, P.E. Dan Peterson and Nester, road industrial accident prevention, McGraw Hill Book Co.1980
[9]. R.P. Balak industrial safety. Prentice Hall inc., New Jersey, 1963.
[10]. EN- 344 standards