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LIFE CYLE ANALYSIS FOR DENIM FIBER RECYCLED COTTON INSULATION

Prepared for BluePoint Marketing

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Applegate Insulation in partnership with BluePoint Marketing manufactures and markets the Cotton Armor line of household furnishings and insulation using a yarn spun from cotton waste recovered from the fabric manufacturing process. Applegate Insulation processes pre-consumer denim cotton waste and recycled denim products into insulation that can be used in housing and commercial buildings. This technology dismantles the cotton jean fabric and re-spins it into a soft, fluffy insulating cotton fiber material.

Cotton Armor denim cotton fiber insulation provides all of the insulating and noise reduction benefits of conventional fiberglass insulation products. The use of cotton waste material in the production of insulation provides significant reductions in key Greenhouse Gas (GHG) emissions, energy, and water use compared to insulation manufactured from 100 percent fiberglass. The purpose of this study is to utilize a Life Cycle Assessment (LCA) approach to quantify the environmental impacts from a specific production process. The LCA identifies, quantifies and evaluates the environmental impacts (inputs and outputs) of a product, service or activity, from cradle to grave and has four main components.

1) Goal and scope definition - this step defines the purpose of the LCA, identifies assumptions and boundaries and defines the scope (i.e. what processes, elements and activities associated with the product/process/activity will be assessed).

2) Analysis - the impacts of energy, materials, emissions, etc are identified, classified and quantified. An inventory table listing all environmental impacts is one outcome of this process.

3) Assessment - the environmental impacts of the product/process/activity are assessed.

4) Interpretation/evaluation - the results are interpreted or evaluated. Opportunities for environmental improvement identified and value judgments made. Products/services/activities are compared.

Goal Definition

The objective of the study is to determine and compare the Greenhouse Gas (GHG) emissions, water and energy required to produce $1 million of output of fiberglass insulation produced by the mineral wool industry (NAICS 327993) with insulation produced from yarn spun from recycled waste cotton. The LCA describes the manufacture of insulation product and does not assess the use and disposal by the final consumer.

Analysis

The production process of fiberglass insulation is illustrated in Figure 1 and consists of the following major steps or stages.

A. Conventional fiberglass insulation[1]

1. Collection of raw materials. The basic raw materials for fiberglass products are a variety of natural minerals and manufactured chemicals including silica sand, limestone, and soda ash. Silica sand is used as the glass former, and soda ash and limestone help primarily to lower the melting temperature. Other ingredients are used to improve certain properties, such as borax for chemical resistance. The insulation industry also uses a significant quantity of recycled materials such as waste glass as a raw material.

[1] http://www.enotes.com/how-products-encyclopedia/fiberglass

2. Melting. Once the raw materials batch is prepared, it is fed into a furnace for melting. Once the glass becomes molten, it is transferred to the forming equipment via a channel located at the end of the furnace.

3. Forming into fibers. Several different processes are used to form fibers, depending on the type of fiber. Textile fibers may be formed from molten glass directly from the furnace, or the molten glass may be fed first to a machine that forms glass marbles. The primary processes are the continuous-filament process, staple-fiber process, chopped fiber process and glass wool process. Each of these differ in how the molten glass is turned into filament which is then either processed into yarn or into batts or boards for finishing and production of end-use products.

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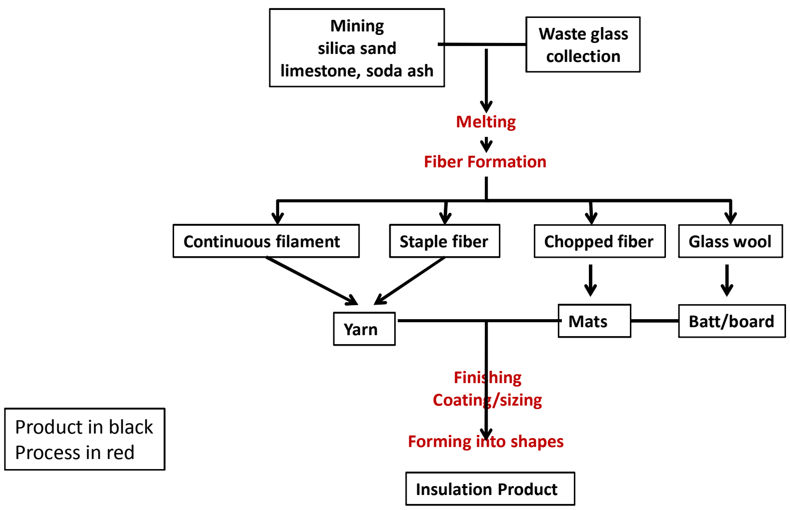
4. Protective coating and sizing. Coatings are required for fiberglass products to reduce fiber abrasion and provide anti-static protection. Sizing is any coating applied to textile fibers in the forming operation, and may contain one or more components (lubricants, binders, or coupling agents). Coupling agents are used on strands that will be used for reinforcing plastics, to strengthen the bond to the reinforced material.

5. Forming into shapes. Fiberglass products come in a wide variety of shapes, depending on end use. These range from loose insulation that is blown into spaces to rolls, mats, and boards used in construction.

Figure 1
Fiberglass Insulation Production Process

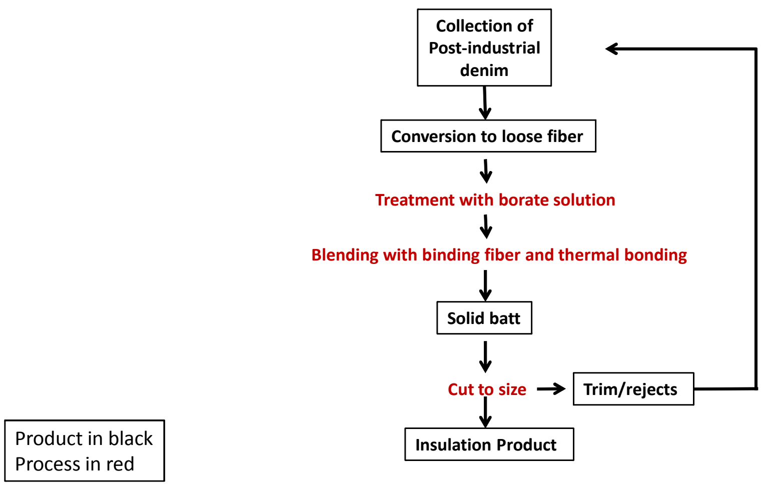


Interpreted from Aubourg et. Al. "Glass Fibers, Ceramics and Glasses,"
Engineered Materials Handbook, Vol. 4. ASM International, 1991

B. Cotton Armor Recycled Denim Cotton Insulation

The manufacturing process for the denim fiber insulation is illustrated in Figure 2 and consists of the following major steps or stages.

Figure 2
Denin Fiber Insulation Production Process



1. Collection of the scraps and clippings from the manufacturing of blue jeans. The material is known as post-industrial recycled denim.

2. The denim waste is processed to achieve its original loose fiber form. The denim is now ready to be baled and transported to the manufacturing plant for transformation into insulation.

3. The processed denim is first treated with a borate solution. This process imparts a Class A fire rating and mold/mildew resistance, as well as acting as a non-toxic pest inhibitor.

4. After treatment and blending with our binder fiber, the recycled denim is deposited onto the manufacturing line and ready for thermal bonding.

5. After passing through the bonding ovens, the recycled denim is now formed as a solid batt. This large batt is then cut to size to meet the specifications of our various products.

6. The denim fiber manufacturing process is a zero-waste process. All edge trim and any product that does not pass quality control is once again shredded and returned to the raw material supply.

7. After cutting and cooling, the finished cotton fiber insulation is transported to the packaging area and ready to insulate a home or business.

The denim fiber process differs from conventional fiberglass insulation is several key areas. First, the process uses virtually 100 percent recycled raw materials. The environmental impacts for production of denim are embodied in that product. The only impacts from denim fiber material are associated with processing. Energy use is significantly lower since no production of glass from silica sand or melting of glass is required.

Assessment

Methodology

There are two commonly used approaches for LCA analysis: the process-based LCA approach and the Economic Input-Output approach. The LCA tool used for this analysis is the Economic Input-Output Life Cycle Assessment (EIOLCA) Model maintained by the Green Design Institute at Carnegie Mellon University.[2] This model uses Economic input-output (EIO) model framework that expresses the monetary transactions between industry sectors in mathematical form. EIO models indicate what goods or services (or output of an industry) are consumed by other industries (or used as input). As an example, consider the industry sector that produces textiles. Inputs to the textile manufacturing industry sector include the outputs from the industry sectors that produce cotton, synthetic fibers, dyes and other process chemicals, looms and other machinery, as well as computers (for designing textiles and

[2] Carnegie Mellon University Green Design Institute. (2008) Economic Input-Output Life Cycle Assessment (EIO-LCA), US 2002 Industry Benchmark model [Internet], Available at http://www.eiolca.net. Accessed June 22, 2011.

controlling weaving), electricity, water, etc. In turn, cotton farmers, machinery, and chemical producers require inputs for their operations that are outputs of other sectors, and so on. Each of these requirements for goods or services between industry sectors is identified in an EIO model.

In a process-based LCA, the inputs (materials and energy resources) and the outputs (emissions and wastes to the environment) for a given step in producing a product are assessed. So, for a product, such as fiberglass insulation, one might list the silica sand, limestone, soda ash and waste/recycled glass used as the raw material, as well as electricity or natural gas for firing the furnaces to melt the glass and running machinery to produce the fiber and end use products.

However, for a broad life cycle perspective, this same task must be done across the entire life cycle of the materials for the yarn and the use of the final textile produced from the thread or yard. So, one needs to identify the all of the inputs, such as mining for sand and other minerals and other non-organic chemicals used in the production process. Similarly, the analysis needs to include inputs and outputs for packaging the insulation product for shipment to the wholesale of retail store, and the trip to the store to purchase the product

A process-based LCA approach raises two main issues that are simplified through the use of an EIO approach. The first of these is defining the boundary of the analysis. One of the first steps in a process-based LCA is defining what will be included in the analysis, and what will be excluded and ignored. Establishing the boundary limits the scope of the project and the time and effort needed to collect information on the inputs and outputs. While a necessary step in the LCA process, this limits the results and creates an underestimate of the true life cycle impacts.

The second major issue with process-based LCA methods is known as circularity. Circularity means that it takes a lot of the same "stuff" to make other "stuff." For example, machinery made from steel is used to spin yarn and weave cloth. But to make the steel machinery requires other machinery and tools made out of steel. And to make the steel requires machinery made out of steel. Consequently a life cycle assessment of all materials and processes must be completed before a life cycle assessment of any material or process can be completed. As a result, completing a broad life cycle assessment requires many assumptions and decisions that increase the complexity of the analysis and restrict the results.[3]

This EIO approach eliminates these two major issues. First, since transactions and emissions of *all* industry sectors among *all* other industry sectors are included, the boundary is very broad and inclusive and even small transactions and emissions are included. Second, since the transactions of the target industry sector are included, circularity effects are included in the analysis.

The EIO model assesses greenhouse gas emissions, energy, and water uses associated with the purchase of inputs from supplying industries to produce output from specific industries. For purposes of this analysis the input-output industries were matched up to the specific process stages of towel manufacture. Table 1 provides a correlation between the NAICS industry sectors in the EIOLCA model to the process stages described above.

Table 1
Industries for LCA Analysis

NAICS	Industry	Process
212390	Other nonmetallic mineral mining	Raw material supply
313100	Fiber, yarn & thread mills	Filament/yarn production
327993	Mineral wool manufacturing	Fiberglass production
31321	Broad woven Fabric Mills	Denim manufacturing

The output of the EIOLCA model is expressed in units of environmental impact per million dollars of output of the specific industry. The functional unit for analysis is the quantity of inputs and outputs measured in dollars. That is, the emissions of greenhouse gasses are measured in kilograms of CO_2 equivalents (CO_2e) per million dollars of fiberglass insulation output; liters of water per million dollars of output; and mega joules (MJ) of energy per million dollars of output. Insulation output in physical units was not available. Commerce Department statistics report the value of shipments and inventories in currency units.

Results

[3] "Approaches to Life Cycle Assessment". http://www.eiolca.net/Method/LCAapproaches.html.

The environmental impacts of the production of conventional fiberglass insulation and denim fiber cotton insulation are summarized in Table 2.

- Consistent with the LCA approach described above, the production of denim fiber cotton insulation generates 2,021 kg of all greenhouse gas emissions (measured in CO_2 equivalents) for $1 million of output produced. This is a measure of the global warming potential of the product production process and is a weighted average of all major greenhouse gasses. This represents a 54 percent reduction compared to the emissions of insulation made from 100 percent fiberglass. The most significant savings come from two areas. First, the use of 100 percent recycled denim as a raw material compared to the mining of silicate and other mineral raw materials for traditional fiberglass. The second, and largest, impact is from the use of electricity and fossil fuels (mainly natural gas) needed to fire furnaces needed to turn silicate to glass.

Table 2
Cotton Armor Recycled Denim Fiber Cotton Insulation LCA Results

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Stage of Processing	Total CO2 Conventional Fiberglass kg CO2e	Total CO2 Denim Fiber Cotton kg CO2e	Total Energy Conventional Fiberglass MJ	Total Energy Denim Fiber Cotton MJ
Raw materials	856.0	181.4	18.8	4.6
Melting/glass fiber	937.0		12.3	
Fiber production	1,670.0	1,252.5	23.7	17.8
Finishing to final product	890.0	587.0	16.3	10.3
Total	4,353.0	2,020.9	71.1	32.7
Denim Fiber Savings		-53.6%		-54.0%

Stage of Processing	Water Use Conventional Fiberglass Liters	Water Use Denim Fiber Cotton Liters
Raw materials	1,120	237
Melting/glass fiber	15,705	
Fiber production	188,000	141,000
Finishing to final product	13,195	13,437
Total	1,525	1,299
Denim Fiber Savings	219,545	155,973
Denim Fiber Savings		-29.0%

- The production of recycled denim fiber cotton insulation results in significantly less water use than conventional fiberglass insulation (155,973 liters per $1 million of output compared to 219,545 liters for conventional insulation), a 29 percent reduction. The primary savings come from reduced requirements for raw materials and no need for melting furnaces.

- The production of recycled denim fiber cotton insulation also is significantly less energy intensive than conventional fiberglass insulation since it has no need for furnaces to melt silica and glass.

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