Closing the Loop for clothing **March 2013**

Closed loop fibre recycling - current status and future challenges

What is it?

Closed-loop recycling takes post-consumer clothing and uses it to produce a fibre or yarn that can be used to make new clothing, with the main fibres of interest being cotton, polyester and wool. The processes of closed-loop recycling can be mechanical or chemical. Complications and difficulties arise with blends, particularly with other speciality fibres such as elastane.

Today the dominant form of recycling is open loop, which cascades the fibre into non-clothing applications. These are often industrial applications, such as insulation, sound-deadening, oil absorbents and spring-cushioning. In these processes the original yarn is usually down-cycled into a textile of lower value.

This paper considers only post-consumer textiles and does not consider post-industrial fibres such as cuttings, where incorporation of a percentage of this material into virgin yarns has long been practised.

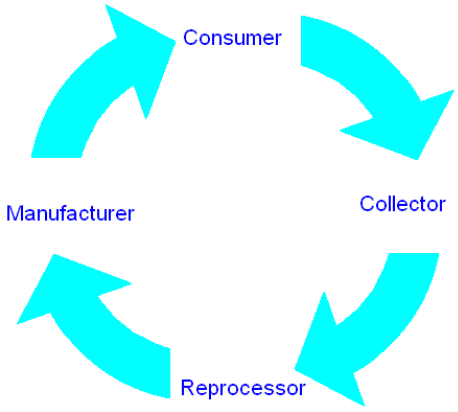

Figure 1. Closed-loop recycling of clothing takes post-consumer clothing and refibrises it. The fibres are then re-spun and made into new clothing.

Why is closed loop important now?

Brands and retailers are aware that consumers are increasingly interested in the environmental impact of clothing. They are also aware that the current recycling story given to consumers is a complex one and shows mainly indirect benefits - clothing is collected by charities, sold at a profit mainly for re-use, and the proceeds used to finance those charities' actions. The story is complicated by a perception that such second hand reused clothing may have a negative impact on developing countries' own textile industries (although research indicates that low priced virgin fibre imports are more to be blamed). A far simpler and environmentally compelling story to consumers is that clothing is collected by a retailer, and is then recycled into new clothing in a closed loop. This requires fibre-to-fibre recycling.

In high clothing-consuming countries, there is a general growing awareness of the significant environmental impact of clothing manufacture and use. This has led to country level initiatives to ameliorate these effects through greater re-use and recycling. Currently underway are actions to increase collection of clothing, or (particularly in Nordic countries) to divert clothing from incineration to other more resource-efficient purposes.

Another reason for the current emphasis on closed-loop is the likely increase in the quantities of re-use/recycling grade clothing collected. Although consumers in many countries are familiar with clothing collections operated (usually) by companies controlled by charities, currently disposal is often only of clothing that the consumer considers suitable for reuse[1]. However, we expect a gradual increase in the proportion of re-use and recycling grades of clothing as collection rates increase through a combination of factors including greater consumer awareness and greater opportunity, such as M&S Schwopping and H&M's in-store collection arrangements with I:Co. As clothing collection increases, it is reasonable to expect that the quality of the clothing will decrease, as consumers send for re-use or recycling clothing that they would otherwise have disposed of in municipal waste.

Lastly, closing material loops has been given high profile through the actions of the Ellen McArthur Foundation (at a policy level) and the Cradle to Cradle approach (at a design level).

Economics

Financially speaking, from the perspective of a textile collection and sorting operation, recycling of clothing is much less attractive than re-use. The price of recycling grades obtained by textile sorters is usually less than the cost of the collection and sorting, but obviously better than paying for disposal, which is the only other option. Hence recycling is cross-subsidised by the higher prices obtained from the sale of garments for re-use.

Figure 2. Shoddy production, India (Photo: Tim Mitchell)

The perspective of organisations using recycled textiles is different. In developed countries most recycled fibre is sent to open-loop recycling into industrial products such as mattress flocking or automotive sound deadening. Prices of these products are highly competitive and the manufacturers rely upon cost-effective recycled raw materials to give them an advantage over virgin raw materials which may have superior performance or appearance. There is potential for more recycled fibre to be absorbed by these applications, but only at the right price. In early 2013 in the UK this means below £100 per tonne.

Closed loop recycling methods are already available for some textiles and depend on the fibre type and the end product. Technologically mature processes such as shoddy production in India, Morocco or Tunisia recycle used garments, while technologically advanced methods such as Teijin's or Toray's polyester recycling use chemical recycling to produce new yarns. There are also other processes under development, particularly for fibre mixes.

[1] See "Public Understanding of Sustainable Clothing" Research Report for Defra No. EV0405, 2008

History

Closed loop recycling of clothing pre-dates the industrial open-loop applications that now dominate. Wool has historically been the most recycled fibre, partly due to its previously high market share in clothing, and partly the greater ease of fibrising the knitted products in which woollens have tended to predominate. The UK West Yorkshire woollen industry actually used around 40% recovered wool at its height, with shoddy mills manufacturing a lower quality cloth often used in workwear or in carpet underlay.

Figure 3. The recycling of wool to make shoddy was once a thriving part of England's textile industry (Photo: Mike Townend/Maggie

In Sweden Stena Recycling employed over 100 people in the fibrising of cloth, to be re-spun and made into blankets or other products. All of these operations disappeared over 20 years ago due to reduced demand and lack of competitiveness. The industry now resides primarily in India, but also in some North African countries, with blankets the main product. These may be low quality emergency blankets for relief operations, or more stylish patterned blankets of greater value.

Some small scale fibrising and res-pinning of yarn still exists in Europe. In Prato, Italy, there is a network of companies that use the post-industrial cuttings from primary clothing manufacture, together with some clothing, to re-spin yarn. Usually this is from worsted or woollen clothing. There exist other isolated examples of small companies carrying out respinning in Europe.

Little historical evidence exists for closed loop chemical recycling of cellulosics, although cotton linters (byproducts of cotton ginning) are used in the production of cuproammonium rayon.

Chemical recycling of polyester *per se* has been long known and a number of possible routes exist. Chemical recycling of polyester clothing was established commercially around five years ago in Japan by Teijin.

Current state of play

Mechanically recycled fibre from post-consumer clothing is being used in a range of small scale initiatives. For example, a coat recently launched by M&S contains fibre from "schwopped" clothing collected in M&S stores. [2] The Dutch Jeans for Jeans[3] project was able to incorporate a percentage of recycled denim from clothing into new denim yarn.

A number of corporate clothing projects have created new clothing such as hoodies or scarves from used uniforms. In this case, the fibre mix is often polyester-wool. Although not clothing, there have also been a number of projects producing bags and similar accessories from corporate clothing[4].

The supply chain for these products is often small scale involving pulling and re-spinning operators working on intermittent or one-off projects. Working at a small scale with modest machinery sizes and/or slower speeds can help to retain fibre length and improve the quality of the product compared to the fibre obtained from machines set up to produce large volumes of non-wovens for industrial

[2] http://social.marksandspencer.com/fashion-2/sustainable-fashion-the-shwop-coat/
[3] http://kici.nl/en/innovate/non-wearable-textiles/recycled-jeans
[4] http://www.wornagain.co.uk/blogs/media

applications. Even so, there is often a degree of quality reduction in the re-spun yarn, hence the use in scarves and coats using weave patterns where small imperfections may be more successfully hidden.

Chemical recycling

In chemical recycling of polyesters, Teijin have successfully extended their Eco Circle scheme to over 100 customers in Japan, mainly corporate clothing suppliers, who send uniforms for recycling and receive back Teijin fibre for further use. The company has now established a joint venture with Jinggong Holding Group to establish polyester recycling in China using Teijin's process, so further growth is expected in the Far East of this business model. In addition other Far Eastern polyester manufacturers such as Toray are developing competitive recycling processes. Some work is also occurring in Western Europe, although this is currently only at the laboratory scale.

Cellulosic recycling is still at the developmental stage, with R&D projects at Manchester University, Renewcell[5], Chalmers University[6] and Saxion University aiming to recycle used cotton clothing into either a chemically modified (e.g. viscose) or pure cellulosic (e.g. lyocell) fibre. These projects are mostly based on pulping of the cotton and its dissolution in solvents associated with these fibres. The Chalmers project will also consider the recycling of polycotton blends through the recycling of the polyester component.

Other parts of the recycling supply chain are gearing up for fibre recycling. For example, the Textiles4Textiles project has developed a machine which sorts used clothing according to composition. This will be able to feed recycling processes for specific fibre types rather than end-use applications, as is the case at present.

The Future

The volumes of clothing collected for re-use and recycling across Europe are likely to increase due a number of factors:

- Continuing high prices for used clothing, in turn driven by steady demand from outside the EU (and for the best quality clothing, within the EU)
- Possible landfill ban extensions
- Possible extension of producer responsibility and a drive towards recycling away from energy recovery in Nordic countries
- Increasing collection rates of clothing from government and retailer initiatives such as Schwopping, H&M/I:Co, Jack Jones/I:Co and Puma in-store collection.

As collection rates increase, so the percentage of lower grade clothing only suitable for recycling will also increase, since it is known that consumers are more likely to treat as rubbish clothing that they would not wear themselves. The rate of increase may only be slow, since countries with high collection rates such as Germany appear to have retained high levels of re-use. The retailers and brands involved in in-store collection are keen to make new clothing from old, in order to communicate a much simpler environmental message than the current recycling model, which is driven by financial advantage to a charity (although not wishing either to disadvantage charities who currently benefit).

The challenges to closed loop recycling are substantial. Mechanical recycling faces the problem of colour and fibre segregation currently only addressed by the (offshore) shoddy industry. In addition the suitable scale of processing in clothing is not high enough for volume recycling. Higher percentages of recycled fibre might also lead to consumer resistance owing to perceptions of reprocessed fibres being unclean. We foresee mechanical fibre-to-fibre recycling continuing to be a niche sector, with limited projects in corporate clothing recycling and also taking a small proportion of the market for larger clothing areas

[5] http://renewcell.se/hem/the-process.html
[6] http://www.mistrafuturefashion.com/en/research_program/project5/Sidor/default.aspx

such as denim. Useful projects can be carried out to bring together small fibrisers and spinners to create a more integrated offering to retailers and brands for a wider range of products.

We are optimistic that the development issues in cellulosic fibre recycling will be solved with the application of further research funding. Since most of the problems relate to the pre-treatment of cotton-containing fibres to deal with dyes, finishes and mechanical objects, we expect that this technology will start to be established with the simpler end of life cotton products that do not contain these. Beyond this, there is a need for funding of demonstration plants that will scale up the processes towards the 5,000-20,000 tpa that will start to be commercially interesting. The problem of blends will continue, and the economics of combining separation and recycling will make such operations difficult to establish even after technical solutions are achieved. The economics of polyester recycling will also continue to be difficult, given the scale economies and relatively low price of virgin polyester production.

As the industry continues to develop, the role of automated composition analysis will become greater. Based on current recycling markets, the demand for compositional analysis is limited, but if closed material loops can be established, machinery such as that developed by Textiles4Textiles will become increasingly relevant.

Although widespread uptake is still a long way off, with continued technical development and judicious re-invention we expect gradual progress towards closed loop textile recycling.

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About Oakdene Hollins:

Oakdene Hollins is a research and consulting company working to support change toward more sustainable and less carbon-intensive products, processes, services and supply chains. The company was started in 1995. The business sectors we work with include food & drink, textiles & clothing, metals & mining, wastes management, chemicals & materials, sustainable innovation and European & UK policy. We have built a strong reputation for integrity, reliability and excellence with public sector and private industry clients alike. We operate at a European scale and manage the Ecolabel scheme in the UK in collaboration with TUV/NEL.

We employ people with science, economics, business administration and manufacturing disciplines, so that within each industry sector we can offer the following core services: market appraisal, technology appraisal, protocol and standards development, economic modelling, lean manufacturing projects, financial impact assessment, management of research projects, ecolabelling advice, carbon footprinting and critical review of life cycle assessments.

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