TURNING ENVIRONMENTAL CONCERN INTO REAL PROFIT

Clive Jeanes

Introduction

For many business people these days, viewing the protection of the environment as a business consideration provides a starting point to the question of waste and its management.

Sadly, there are still a few "unreconstructed backwoodsmen" who are unaware, uncaring and too busy running their business to think about these issues. They accept that textile products cannot be made without incurring waste, and try to go on working in their traditional ways for as long as they can get away with it, paying little attention to the concerns of environmentalists.

Thankfully, more and more people have woken up to the need for careful management of all assets, including waste, and major changes of attitude are being brought about by government legislation which obliges all producers of waste to consider recycling instead of disposal in a landfill site or discharge into air or water. Although some businesses may complain, they will eventually be obliged to comply with new regulations and so join the growing band of environmentalists actively working to preserve our planet's rich assets.

Milliken personnel were in this position for a couple of years, when charts were kept showing progress in reducing the percentage of our solid waste going to landfill. We became increasingly smug as this figure halved itself over that time, and we all had a rosy glow of self-satisfaction that we were doing our bit to preserve the planet for future generations by doing less harm to the environment.

However, we very soon realised that there was more to be gained from waste control than just self-satisfaction. We started to ask ourselves whether we could take waste control measures a step further by generating less waste to begin with. If we did so, could we reduce our need for raw materials, and possibly increase our profits?

We started to challenge each step of our production processes to see whether they could be carried out differently. Studies of all current operations produced some interesting results, leading to the possibility of eliminating between 30% and 70% of our traditional amount of waste.

Waste Minimisation

A prime opportunity for reducing waste was identified in our carpet manufacturing operation in Wigan. One of the processes involved a roll of carpet just over 2m wide, cut into modules measuring 0.5m square to produce carpet tiles. Four tiles per width, and one row at a time were cut. This operation produced two lots of waste - about 1-2 cm of selvedge waste left down the outside of the roll, and another narrow strip the full width of the roll, which was left after each cut to ensure that the next cut would start with a clean line.

It did not take a genius to see that, if the cutting die was changed from a four-tile cut to an eight-tile cut, then the side-to-side waste strip would occur once every eight tiles rather than once every four tiles. A new cutting die was ordered, and tests carried out off-line to ensure that the practice would match the theory. It did, and eight tiles are now cut at one time, with a consequent 50% waste reduction as a result of a very simple and apparently obvious change.

We looked further at the carpet production plant and, in early 1994, no less than seventeen opportunities were identified to eliminate or reduce waste. If successful, the material cost saved would be worth just over three quarters of a million pounds each year, and the full cost of implementing the changes, including any necessary machine modifications or new parts such as the eight-tile cutter, would be just under half a million pounds. A short pay-back period of the investment of about eight months would be realised, and savings would continue year after year.

Most of the identified improvements have been implemented, and the results have been as expected. The reduction in waste varies from process to process but, overall, by the end of 1995, a reduction of waste of 32% will have been achieved compared to that experienced in early 1994.

This figure not only produces a nice cosy glow in terms of protein in the environment, but has a direct impact on improving raw material yield, reducing costs and producing a higher profit figure. This gives an even warmer glow!

Initiatives of this sort are taking place in all of Milliken's manufacturing operations, including reducing water consumption by 90%, reducing end-of-run dye dumps by 95%, and recycling and reclaiming 70% of all process chemical waste.

In addition, the company has a clear policy of total compliance with all legislative requirements, including no illegal discharges or other infractions. In other words, statutory obligations to reduce waste and to recycle, have become part of the company's environmental management process which, in turn, is now part of our total management system.

Can there be an ultimate stage of total waste elimination?

The answer to this is yes, and a few companies have already started to enter it. It will be characterised by a new product development mentality which includes, as one of its priorities, a plan for the minimisation of waste in the production process. It will be characterised by plant and process layouts which focus on keeping waste to a minimum, and recycling whenever possible. It will be characterised by new machinery specifications which recognises the importance of keeping waste to an absolute minimum, and which provide closed-loop recycling processes wherever possible.

In other words, waste is seen as a cost to be minimised and an economic opportunity to be taken right from the start of a process, and not just as a necessary post-installation improvement.

Waste and environmental management will become cost and quality driven. It will not be an activity only undertaken in order to meet legislative standards imposed locally, or from Whitehall, Westminster or Brussels, or to satisfy the focus of the environmental movement. Governmental requirements and green issues will certainly be satisfied en route, but the main motivation for businesses will be the hard-nosed fact that good waste practice, and good management of the environment, are good for reducing costs and, therefore, good for increasing profits!

RECLAIMED FIBRES, THE SOURCE AND USAGE

Andrew Simpson

Raw Material - Its Source and the Reclamation Industry

There are two main types of raw materials that are processed back to their fibres for reclamation.

Synthetic Materials

Wool/Synthetic Mixture Material

Synthetic Materials

Here there are two products available:

i) Acrylic and hosiery clip waste. Both sources come from the clothing industry and, although a new material, it is still regarded as waste.

ii) The purchase of mixed-coloured acrylic jumpers, sweaters, cardigans etc., from the clothing recycling industry. These are discarded garments, that due to the mixture of colours in each garment, cannot be sorted and sold as self shades. There is a large market for the reprocessing of self-shade garments for the reclamation and re-use of their fibres.

There is a third quality, but one, it has lost its market place in recent years, this being the stretchy synthetic garment, which comprises predominantly cheap ladies clothing such as dresses, skirts, etc. Because of their inherent elasticity and poor recyclable characteristics, these garments in recent years have tended to be put more into the industrial wipers market.

Wool/Synthetic Mixtures

The majority of material re-processed back to original fibres is known as flock. Traditionally, the flock produced from this material was manufactured from a simple waste rag cloth. These rags coming again from the clothing re-cycling industry. However, major changes have been forced upon this product in recent years.

During the late nineteen sixties and early seventies, there was a British Standard (now obsolete) for the flock produced from this course of material. It stated that the flock produced should have a minimum wool content of 50%. This was dropped during the nineteen seventies to 40% and was later removed altogether because the ever-changing fashion industry was using fabrics comprising a greater content of man-made fibres. Furthermore, the relatively high cost of wool as a raw material has again precluded its use as a main fibre.

However, the question of "what is a rag?" should be addressed. This can be illustrated as follows by considering the common types of clothing:

jackets
waistcoats
trousers
skirts
overcoats
dresses

The majority of the rags purchased will be a mixture of the above items. The products not required in the rags are shirts, blouses, gabardines, leather coats, blankets, quilts, anoraks, bedspreads, sheets, etc. The rag product that we buy today, however, has changed dramatically, even in recent years. Fashion has changed and this is the major influence. It must be borne in mind that the reclamation industry is always at least 2 - 3 years behind fashion trends and is receiving cast-off goods from clothing that was bought at least 2 - 3 years ago.

Clothes that are purchased today are different from those of several years ago, not only in design but also the fibres that are used. However, the industry has to cope with everything that the fashion industry has generated in order to produce a product economically, and thus enable it to compete in its market place.

There has also been a decline in the clothing recycling industry, particularly in Great Britain. In recent years, it has gone through a very tough period, with two of the largest companies in the industry going out of business.

One of the main reasons for this decline can be found in the prices that it now obtains for its product. It is not many years ago that sorted white woollen knits were able to fetch prices of £2500 per tonne, and these are now down to nearer £1200 per tonne. At the bottom end of the scale, the flocking rag, which is the product that our industry purchases, is still at the same price as it was approximately ten years ago. This has led this industry to look very closely at the materials it sorts, to see if better prices for certain items can be achieved. This is leading to a greater depth of sorting in an effort to maintain business viability.

Finally, recent flammability legislation for upholstered furnishings and protective clothing has influenced the performance of the clothing recycling industry by demanding a higher wool content. To meet the demand, specialist grades of woollen rag have been generated from, e.g. overcoats, jackets, etc., where a high wool content can be guaranteed. Thus, a market has been found for a new product commanding higher prices.

An alternative to the rag material are tailors' clippings. Traditionally of high wool content, these have other advantages in that the fibrous quality is high and the product is trash-free. Trash is very much associated with the use of rag clothing and is typically made up of:

Zips (metal & plastic)
Belt buckles (metal & plastic) spanners/tools (metal)
Coins (metal)

Other (world war medals, rings, watches, bullets etc.,)

However, there are major disadvantages in the use of tailors' clippings, one being the price which can be up to double the price of rags. Secondly, availability is limited due to the demise of the UK clothing industry, where there is only a limited number of firms and the supply of their waste is always going to be restricted.

This company is the largest single user of rags in this country and possibly Europe. However, in recent years we have had to go to the continent for an increasing percentage of what we buy. Presently, the company purchases approximately 90% of all its rags from the continent and this amounts to approximately 9000 tonnes per year.

The move abroad has been brought about for many reasons amongst which price, quality and quantity are foremost:

Price: The UK re-cycling industry tried a few years ago to adopt a cartel approach in order to push up prices.

Quantity: There appears to be a constant supply available from the continent, unlike the UK

Quality: The quality from the continent is generally of a higher standard and tends to be consistent.

European sorters want flocking rag quality clothing to be constantly moved out of their factories, to allow them to bring in more raw material. Essentially, it is the sorting of the 5 - 7.5% of what they call their "cream percentage" where they make their money, and the more that they can sort, the more they will be able to find.

The Reclamation Industry - its Organisation and Markets

The traditional view of this industry perhaps to the layman, is the "rag and bone man" image, collecting old clothes door to door. However, this is now far from the truth.

EU Continental collection: The European industry is very well organised, and is closely involved with the charity collection agencies. Continental sorters purchase the clothing from the charities at approximately £150 - £250 per tonne, depending upon source of collection.

Used clothing is collected by charities, door-to-door, throughout Europe, where they leave at each house in an area, polythene bags printed with the charities' names. These polythene bags are then collected at a future date, and are sold onwards in an unopened condition to the clothing recycling industry. Because of the tonnages involved, both collected and sorted, the largest percentage of the collected clothing is delivered by rail, particularly to the larger sorting factories, where delivery is made directly into the heart of the factories.

The majority of secondhand clothing is collected from Germany, where it is believed that 6 - 7 kgs is collected per head from approximately 60% of the population and it amounts to approximately 200,000 tonnes p.a.

Continental sorting: The main countries and respective outputs are:

Holland 100,000 tonnes per annum
Germany 75,000 tonnes per annum
Belgium 60,000 tonnes per annum
France 30,000 tonnes per annum

The largest sorter is the Boer & Zoon Group (Holland) with about 50,000 tonnes per annum and the second largest is Evedam (Belgium) which process about 12,000 tonnes per annum (member of Boer & Zoon Group). The probable overall sorting output in EU countries is in the range 250,000 - 300,000 tonnes per annum. Currently, East European sorting levels are about 50,000 - 60,000 tonnes which compares with a probable UK sorting level of 50,000 tonnes/year.

Sorted production may be broken down into the following groups:

5% cream percentage
45% secondhand clothing for the third world
25-30% fibre reclamation
10-15% wipers
10% rubbish

Cream percentage: The single most important factor to the industry is the need to receive the collected plastic bags of clothing waste in an unopened condition. In this way, they can be certain of receiving what they call the "cream percentage". This percentage varies from company to company depending upon their expertise, sorting, layout, etc., but is generally between 5 - 7.5%.

For this small percentage, they can receive upwards of £3,000 per tonne. Important markets for the industry are France (particularly Paris), Italy and then London. However, there is a demand for good secondhand clothing throughout Europe, and the general quality of nearly new secondhand clothing sold into Europe, commands upwards of £1,250 per tonne.

Secondhand clothing: The largest market of all, amounting to 45% of all the clothing sorted, is the third world market which is dependent upon where in the world the market is, the category of clothing sold and, of course, its price. An example of one market is detailed below in Table 1, for Africa:-

An important factor in the selling of secondhand clothing, is the political and financial stability of the country purchasing the goods. A market which is very good can be totally finished in a matter of months should there be political changes inside the country. A major example of this is Rwanda, where recent events have had horrific television coverage in this country (UK).

Table 1: Yearly tonnage of common market second hand clothing exports to Africa

Country	Tonnes
Ghana	3000
Togo	2400
Benin	1500
Rwanda	3000
Burundi	1500
Tanzania	3000
Senegal	3000
Gambia	200
Burkino Fasal	500
Egypt	1200
Tunisia	5000
Sierra Leone	200
Zaire	1500
Gabon	400
Kenya	4500
Uganda	2000
	33,900

There are literally hundreds of grades of clothing sorted and sold including ladies' long-sleeved and short sleeved dresses, gents' trousers, gents' shorts, children's trousers, children's shorts, both ladies' and gentlemen's jeans, American Jewish jeans ie. Levi Strauss, American non-Jewish jeans, etc., etc.; bras are divided into large and small size. Large bras go into Africa, small bras go to the Far East, to the Philippines, etc. Net curtains are heavily in demand from areas with mosquito infestation. Items such as handbags, are again sorted into several categories, as well as trouser and fashion belts.

Shoes had one particularly large market, that of Afghanistan, although no direct trade took place between Afghanistan and the industry. Items were smuggled in from Russia, Pakistan and other nearby countries. This market has now switched to Africa, which cannot purchase enough shoes to satisfy demand.

Hong Kong is a very large purchaser of secondhand clothing, taking 2 - 3, 40 - 60 tonne container-loads each month, large percentages of which head onwards to China.

Nigeria does not allow secondhand clothing but large volumes are sold in all neighbouring countries from where smuggling into Nigeria is organised. In fact smuggling is a very important occurrence for the industry, and unusual business practices are a common feature.

Payment, as would be expected, is in European currencies, which, as can be appreciated, is difficult and often delayed. Payment is made often in various currencies, being paid out of Switzerland, Europe and even the USA. Prices for the graded clothing for the third world vary considerably. Depending on who the customer is, the prices seem to be between £500 - £1,500 per tonne. For instance, cotton shirts will demand approximately £1,000 per tonne. Cotton shirts are packed in tens to a bundle, 33 bundles to a 50 kilo bale. At a price of £2,500 per tonne, a shirt therefore, represents £0.40 in value.

In a sealed container there are on average 10-15,000 assorted garments being despatched at any particular time. The majority of secondhand clothing is packed in 50kg bales which are covered with a woven polypropylene scrim. This is a weight able to be carried by an individual to the local market place with the woven polypropylene scrim becoming the "groundsheet" on which the goods are displayed.

One Belgian sorter has one customer in Africa who will only accept 20-30 kg bales. The customer uses camels to move the bales into the countryside, 2 bales each side of the camel. Two 50 kg bales would break the proverbial camel's back!

Fibre Reclamation: The third most important market is that of the fibre reclaiming industry. Here the industry sells its woollen knits and single shade synthetics to be processed back to fibre for their reuse. Prices for these items can range from £100 per tonne for the heather shade synthetics, up to £300 - £500 per tonne for the single shade synthetic and finally, up to £1,000 - £1,500 per tonne for wool knits.

However, one example of the recent problems experienced by this industry is the stagnation and indeed, fall of its selling prices. For example, in this category are the wool knits, where just a few short years ago upwards of £2,000 per tonne could be received for this particular grade; present prices are now between £1,000 - £1,500 per tonne.

A particularly large market in this section is the sale of self-shade woollen jackets/overcoats to India for processing back to fibre, which is used in the production of cheap blankets. There are several problems with this particular product and market place. These are:

> **Price**: Prices are low in India, and like other products, have seen a decline in recent years. This, coupled with the problems of obtaining payments, makes it a very difficult market.
>
> **Processing**: All the items sold to India have to be mutilated due to the Indian government's ban on the sale of secondhand clothing. This of course adds further cost to the operation. Because of the potential risk in obtaining payments, most companies insist on at least a sizeable deposit that covers both carriage out and, if necessary, return carriage costs.

The last two years has seen the Indian government desperately trying to stem the level of imports and thus the demand for foreign currency. One action by the Indian government has been to require up to 2½ times the foreign currency value to be deposited with the government for up to 6 months interest free. For example, for an import value of £10,000 the importer has to deposit £25,000 with the Indian government in addition to finding the £10,000 payment to the supplier.

Industrial Wipers: The fourth most important market for the industry is the industrial wipers market. Traditionally based around engineering industries for cleaning machinery, a major market is the automotive industry for new vehicle cleaning. Again prices can vary tremendously and this is where the expertise of the sorting company is most important. For instance, the following grades and prices are typical:

(i) Lowest grade (flat synthetics); £120 per tonne.
(ii) White cotton sheets/pillows; £600 per tonne plus.
(iii) White cotton wipers; £500 - £1000 per tonne.
(iv) Flannelette sheeting; £600 - £800 per tonne.

Flocking Rags: Finally, the industry is left with its poorest quality percentage - flocking rags which constitute 8-15% of total European sorting and upwards of 25% plus of UK sorting.

The single largest market is our own flocking industry. The whole business of sorting old clothing however, is very differently organised between Europe and the UK.

It has been explained above how the continent is geared around the charity agencies with an essential requirement to receive the plastic bags, directly from the charities, ensuring that the cream percentage is received. In the UK however, the industry is organised on a completely different basis. Firstly, there are very few house collections specifically aimed at the clothing recycling industry. Local charities do collect, but are more geared to the jumble sale or the local charity shop; e.g. Oxfam, Sue Ryder, Help the Aged, Cancer Research, etc.

It is through these charity shops that, in the UK, the cream percentage is lost to the industry. Because of the standing of the above organisations, many people (particularly after bereavements) take their clothing to these shops and in so doing assume that they are directly helping the charity organisations. The charity organisations, however, have to empty their shops on a weekly basis and it is this tonnage that the UK industry relies upon.

Oxfam of course is the largest organisation in the industry, with hundreds of local charity shops, and a national collection organisation clearing the shops as required, delivering the product to local warehouses. Large containers are filled and then delivered onwards to Oxfam's national sorting depot in Huddersfield. Using these carriers, upwards of 250 tonnes per week are delivered to Oxfam at Huddersfield from all over the country.

The weekly 250 tonnes per week that Oxfam sorts are aimed at providing for that organisation a constant supply of secondhand clothing. The quantity of third world quality clothing sorted, is then purchased by Oxfam's central organisation and shipped to the areas in the world where local Oxfam agencies are needing supplies. These supplies are given away free of charge to the needy. Oxfam only involves itself with this level of trade, not wishing to trade openly in secondhand clothing to the third world. Their view is that by openly selling secondhand clothing, they might well compete against and damage any local clothing industry.

Since there is only one central charity-based, clothing resorting centre in the UK namely Oxfam, so other charities such as Help the Aged, Sue Ryder etc., must rely upon Oxfam and the rest of the industry, to clear their shops of unwanted clothing.

Oxfam are the recipients of far greater volumes than 250 tonnes per week, but the extra tonnage they receive is sold on to the rest of the industry at approximately £150 per tonne. Oxfam themselves are charged by the carrier for the collection service from small shops.

The industry has also geared itself up in recent years to collect its own rags either from clothing banks or directly from shops such as Sue Ryder. This is in an endeavour to achieve a better quality of clothing at a lower price.

Because the UK industry loses out on the cream percentage, and because the general quality of what is collected is lower than in Europe, the quantity of reusable products is therefore reduced, and so of course is potential revenue. The quantity of lower value items such as flocking rags, is greater in the UK as a percentage, and therefore leads to the UK industry charging proportionately higher charges for this product.

Finished Product - Reclaimed Fibre End Product Usage

There are three main finished product groups that use regenerated fibres in the UK and Europe;

Mattress/upholstery felts

Automotive components

Traditional carpet underlays

There are, of course, many other products such as shoulder pads, roofing felt, cheap blankets etc., but the three category groups detailed above are by far the main users of regenerated fibres in the UK.

To provide an understanding of the vast tonnages and thus the size of the industry involved, detailed below are the approximate yearly tonnage usages of regenerated fibres purely in the UK in each of the above categories.

Mattress/upholstery felts: This market consumes about 30,000 - 40,000 tonnes per annum which averages 500 - 800 tonnes per week depending upon the time of year (September through to late November being the peak period).

Products manufactured for the bedding and upholstery industry are in both cut sizes and roll-form with weights ranging from 750 gm^{-2} to 1800 gm^{-2}. There is a range of products from layered felt, heavy needled felt through to bonded felt, both unbacked and backed, with a range of different backing materials such as woven polypropylene or Typar (DuPont).

Recent flammability legislation has also resulted in several felt products being developed specifically for use in the UK by both the bedding and upholstery trades, all using regenerated fibres.

Automotive components: This area consumes about 4,000 tonnes per annum.

Finished products are, for example, underdash trim, rear parcel shelves, headliners, bonnet liners, boot liners and undercarpet and bulkhead sound absorbent sheets.

Traditional carpet underlays: Approximately 5,000 tonnes per annum are used here, equivalent to 80 - 120 tonnes per week, again depending upon the time of year (Easter and September through to late December being the peak periods).

It can therefore, be seen that between the above three main category groups, there is a yearly demand for up to 50,000 tonnes of reclaimable material, purely from UK manufacturing companies.

INDUSTRIAL WASTE WATER MINIMISATION AND TREATMENT

Allan K Delves

Introduction

This paper will cover the following topics:

- Production of nylon 6.6 yarn - uses of water
  - problems
- "End of pipe" solutions
- Targets and water/waste management at source
- Water surveys and mass balances
- Waste water minimisation in the textile industry - infinity dyeing
- Planning for continuous improvement

Production of Nylon 6.6 Yarn

The DuPont Gloucester site consumes annually 380,000m^3 (84mm gallons) in the manufacture of 21,000 tonnes per annum (pa) of Grade 1 nylon 6.6 yarn (see Table 1). This equates to 18 litres of water per kilo of product at a total cost of £201,733 pa. The site is one of Severn Trent's largest consumers in the Cotswold area of the UK. With costs of water expected to rise by 15-20%pa, conservation is of paramount importance.

The basic raw material for the manufacture of nylon 6.6 yarn is polymer chip manufactured on DuPont's Teeside Site from hexamethylene diamine and adipic acid. Several batches of different chemicals are blended together and transported by road haulage to the spinning plants.

The polymer chip is transferred to series of hoppers from where it is gravity fed into a screw pressure melter. Here it is melted and kept in equilibrium under a blanket of **steam**.

The molten polymer is pumped through a filtration pack to a number of spinnerets and extruded as molten filaments. After cooling the filaments are brought together to form a threadline and conditioned in **steam**. Steam accounts for 13% water usage.

The threadline is then treated with an oil-in-water emulsion to confer lubricating, antistatic and adhesive properties to the yarn as processing aids. After passing over a system of godets or rolls, the yarn is wound onto cylinders at speeds of 1000-1200 m min^{-1} typical of conventional melt spinning.

Table 1: Water Statistics at DuPont's Gloucester Works	
Current Water Consumption, pa	380,600m^3
Grade 1 yarn, pa	21,000 tonnes pa
Water per Product	18 l/kg^{-1}
Cost of Water, pa	£201,733 pa
Cost of Effluent (6 months)	£29,707
Effluent Volume (6 months)	55,990 m^3
Annual Cost Water & Effluent	£261,147
Cost of Water for GD 1 Yarn, per tonne	£12.43[4]

NB: ABOVE FIGURES EXCLUDE ENERGY REQUIRED TO MANAGE SYSTEM

Table 2: Annual Water Costings for Gloucester Works

		Cost
Water Consumption	380,600m^3	£201,733
Cooling Water Losses	27,300m^3	£14,469
Air Conditioning	172,610m^3	£91,483
Spin Finish Water Losses	1,299m^3	£6,360
Effluent Water Recycle	111,980m^3	£59,414

The yarn takes up 4.5% moisture at 65% RH - the spinning plant atmosphere is humidified to maintain this atmosphere. This humidification is undertaken by water curtain humidifiers which consume of the order of 172,000m^3 pa of water (this constitutes 40% of water usage).

Compressed air is used to entangle the filaments of yarn to strengthen the yarn bundle for further processing. The cooling of the compressors accounts for between 7-10% water usage.

Additionally, the Research and Development Laboratories and the Textile Centre Dyehouse, where consumer support work is carried out, will consume between 10-20% of the total water intake. Table 2 shows the annual water and effluent costs.

"End-of-pipe" Solutions

The main burden on effluent from the nylon 6.6 production process is associated with the application of spin finish. This is a complex cocktail of hydrocarbon, vegetable oils, ethanolamines, ethylene oxide condensates, fatty acids and sulphated oils with small amounts of biocides. Volume and recycling costs are shown in Table 2.

In the late 1980's it was realised that this effluent posed a problem. The Gloucester consent did not include an "oils, fats and waxes" clause; the Severn Trent River Authority proposed a 500mg/litre ceiling; pump blockages and gels in lines caused major effluent sources. Also, because of acid and caustic imbalance from water treatment plants, the works, at best, met the pH consent limit for only 70-80% of the time.

So the Site spent £2,000,000 on an effluent treatment plant comprising the following process sequence:

Chemical cracking - polyelectrolytes
pH correction - hydrochloric acid/sodium hydroxide
Flocculation
Flotation - separation - compressed air
Sludge transfer
Monitoring

The resulting sludge is sent to Wessex Waters Biodrier Systems who produce BIOGRAN, a clean dry odourless soil conditioner which is a valuable organic product.

The strategy achieved the desired goal.

Targets and Water/Waste Management at Source

In 1991 Sir Denys Henderson, then chairman of ICI and before DuPont bought their nylon 6.6 business, issued Group Environmental Objectives for all sites. These were that:-

(i) Compliance with regulatory legislation and standards was to be the minimum basis of the Group's environmental objective reflecting ICI's commitment to meeting relevant regulatory standards throughout all of its businesses worldwide.

(ii) ICI would reduce wastes by 50 per cent by 1995. It would pay special attention to those which are hazardous. In addition, ICI would try to eliminate all off-site disposal of environmentally-harmful wastes.

This second objective referred to all discharges to land, water and air.

It was then and only then that the Company started to tackle the problem at source, i.e. to stop substances (or minimise them) getting into the effluent and to reduce the volume in the first place.

DuPont's environmental goals dovetail with those of ICI and are presented in Table 3.

In order to do this the following stages were undertaken:

(i) Preparations of a drain map.

(ii) The integrity of the drainage system was determined.

(iii) Every drain was marked.

(iv) All effluent was metered and a mass balance prepared.

(v) Measuring/instrumentation (steam, compressed air, surface water and effluent) was installed.

(vi) Water usage/wastage was costed.

The chemical oxygen demand or COD loading per year has been progressively reduced from 1990, 213 tonnes pa to 1993, 129 tonnes pa and suspended solids from 40 tonnes pa to 13 tonnes pa in 1993.

Costing steam at £9 per tonne, the tagging of leaking flanges, pumps, etc, and rectifying at shutdown gives a saving of £11,295 on 1,322 tonnes lost per annum.

Environmental Systems and Auditing

One of DuPont's European corporate goals is to reduce water costs by a defined percentage per pound of finished product. Defined cost reductions would be dependent upon local site conditions and regulations. At Gloucester works, for instance, this figure has been quantified as a 5% reduction over the next two years.

Water management must therefore become part of the quality system involving management and employee commitment. Employees need to be involved not only in detecting problems but also in preventing them from happening. Co-operation occurs only when everyone is working towards a common goal.

Documentation is crucial to any quality system. Water management must be part of the Environmental Procedures, which are daughter documents of the Site Quality Manual.

It must be remembered that the Company is a supplier of waste water to customers including the National Rivers Authority (NRA) and the water companies who have specifications regarding effluent consents. Documentation should define purpose, principles, responsibilities, procedures, recorded documents, training, references and must be subject to periodic review.

Table 3: DuPont Environmental Goals for Europe	
1.	Reduce **hazardous waste** generated from the manufacture of products by 35% from 1990 to 2000.
2.	Reduce **Violative Organic Compounds** (CEFIC List 1) by 50% from 1990 to 1997 (corresponds to the 33/50 priority list of chemicals in the USA)
3.	Reduce **toxic air emissions** (hazardous compounds emitted to the atmosphere) by 30% from 1990 to 1995, including boiler gases (CO, SO_2, NOx).
4.	Reduce carcinogenic air emissions (DEFIC List 2) by 90% from 1990 to 2000.
5.	Eliminate **toxic discharges to the ground** by 2000, or verify that they have become non hazardous; for Europe this means elimination of landfilling of hazardous waste.
6.	Improve **energy** use continuously, as measured in BTU's per pound of finished product (or kJ per kg). This is expected to result in a 15% reduction by the year 2000, relative to 1991.
7.	Reduce water consumption per mass of finished product by X% from 1993 to 2000 (where X% is a locally defined figure).
8.	Cease production of **chlorofluorocarbons** (CFC's) by the end of 1994.
9.	Eliminate emissions of Nitrous Oxide (N_20), a greenhouse gas, by the end of 1996.
10.	Install **double-walled storage tanks** at CONOCO gasoline outlets.
11.	Manage **wildlife habitat enhancement** programmes at all manufacturing sites.
12.	Reduce **packaging waste** by 50% by the year 2000.

Having a procedure and targets allows performance to be measured, and this should be subject to Annual Management Review. However, that alone is not sufficient, we need also to tell people what has been achieved using newsletters, notice boards, annual reports, for example.

Waste Water Minimisation in the Textile Industry

Three examples of water conservation and effluent quality improvement applicable to DuPont and the textile industry in general are :

(i) Infinity Dyeing.

This is a DuPont-developed process which, by careful and continuous dye metering, enables dye liquors to be almost fully exhausted. In doing so, lower levels of auxiliary chemicals, water and energy are achieved, plus improved light fastness and dye uniformity. Figure 1 schematically compares a conventional with an infinity dyeing process and Figure 2 shows the application of the latter to the dyeing of cotton/polyamide blends.

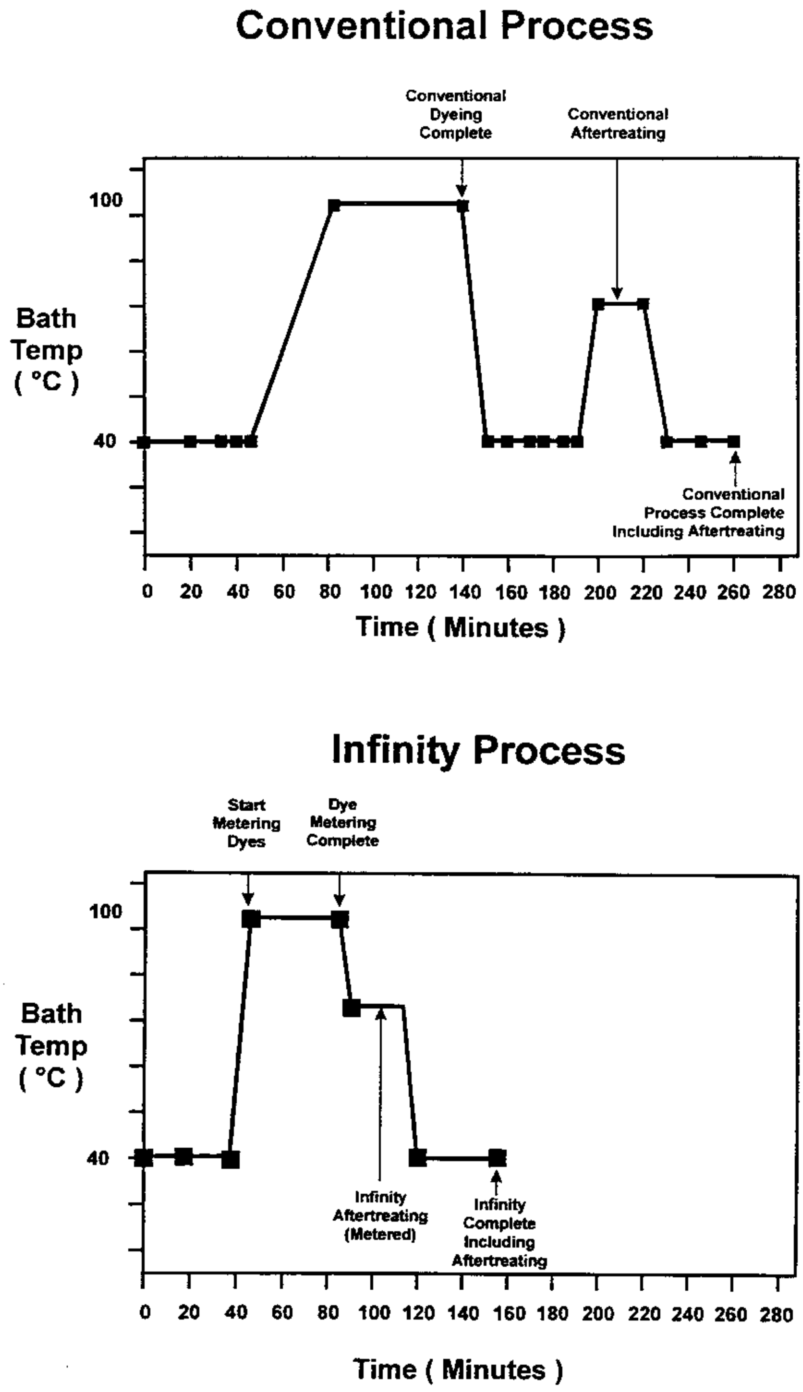


Figure 1: Schematic comparison of conventional and infinity dyeing techniques

(ii) Water scrubbing of effluent gases from waste polymer incineration.

Water Scrubbing at one of our sister sites currently consumes 37,600m^3, £20,000 of water a year, of which 24% is lost to the atmosphere and 76% to trade effluent contributing extensively to COD, toxics and suspended solids. This adds on approx £3/m^3 to effluent costs.

Gloucester has replaced this system with an afterburner which satisfies BEO/BATNEEC and produces natural gases at 16m^3/hr, at a cost of £8,400 pa.

(iii) Rationalisation of water treatment plants and boiler blow down.

For example, one demineralisation plant for the whole site enables bulk regeneration and total system management. In addition, reductions in boiler blow down by 5-10% to the statutory minimum gives a secondary saving and hence reduced effluent discharge.

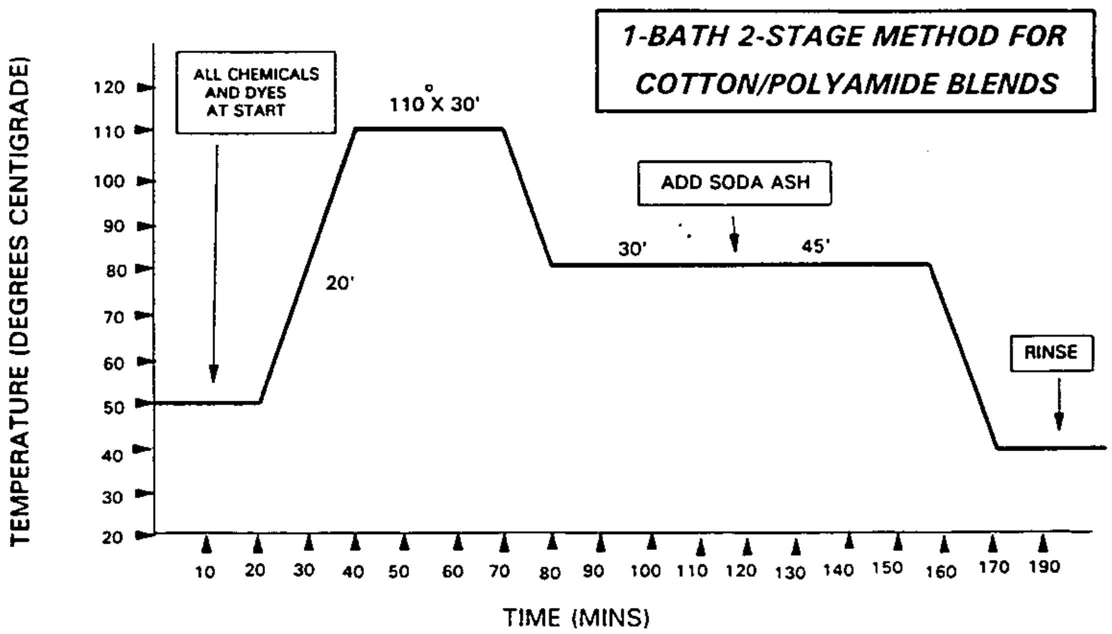


Figure 2: Infinity dyeing process applied to cotton/polyamide blends.

Planning for Continuous Improvement

The quality management system, incorporating measures to ensure progress towards set goals, must be made to work and be subject to frequent audits to maintain the status quo.

Areas to be examined at Gloucester are (expressed annually):

Cooling Water Losses	27,300m^3	£14,469
Air Conditioning	172,61m^3	£91,483
Spin Finish	1,200m^3	£6,360
Effluent Recycling	111,980m^3	£59,414
Steam Losses		£11,895

It is imperative that water supplies are metered at each function - surveys are conducted to address leakages and instigate speedy remediation.

Questions to be answered are: Can water be recirculated to areas not requiring potable supply? Is the effluent being treated effectively to address the best environmental practice? How does water management reflect on energy savings?

These, and many other issues regarding, for instance the challenges to be addressed regarding packaging, require a continuous improvement programme which should include short term, medium term and long term goals, targets and action plans.

FIBRE INDUSTRY AND WASTE MANAGEMENT

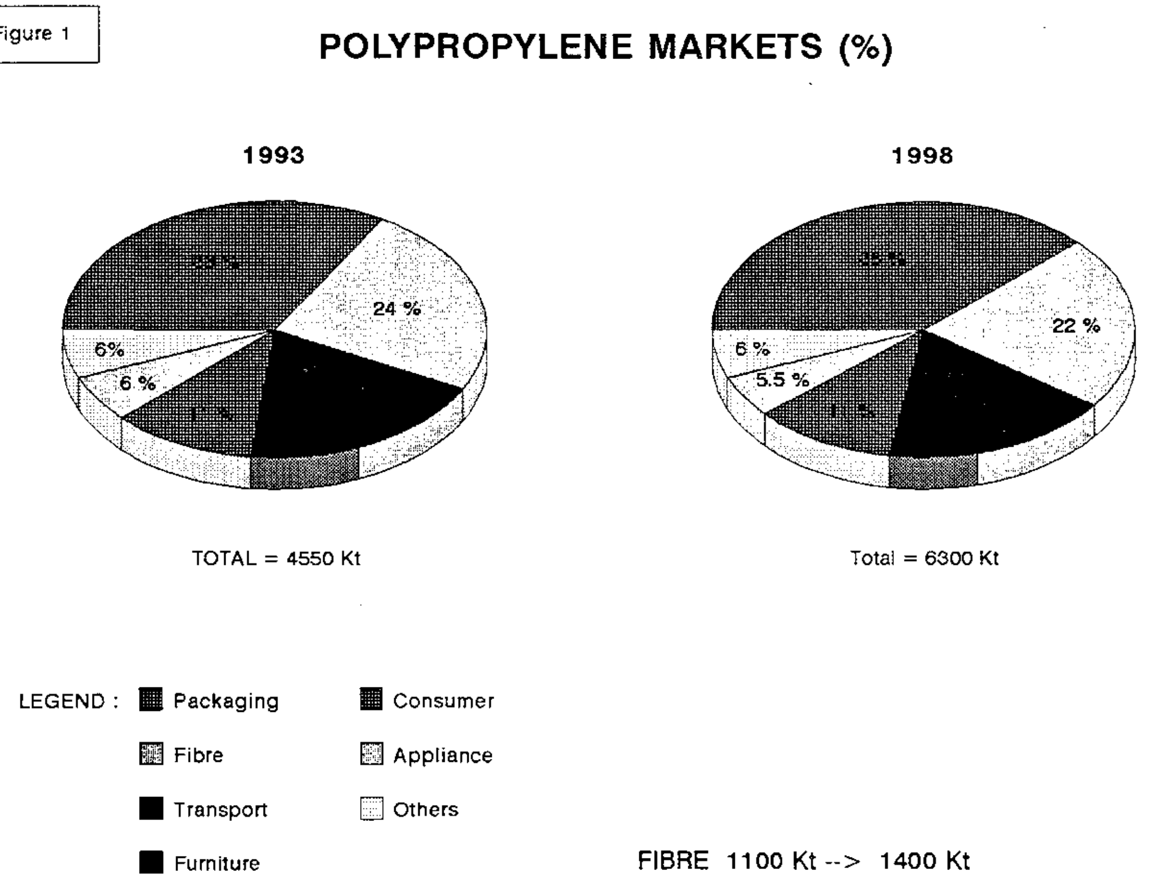
Nello Pasquini

Introduction

The Fibre Market represents an important industry segment for polypropylene (PP), accounting for approximately one quarter of PP consumption; in fact after packaging it is the most important polypropylene application area.

Although a relatively well-established market for polyolefins, recent material developments will revitalize the industry and ensure that a high pace of growth will be sustained in the market. Figure 1 shows the expected growth in PP applications.

Figure 1



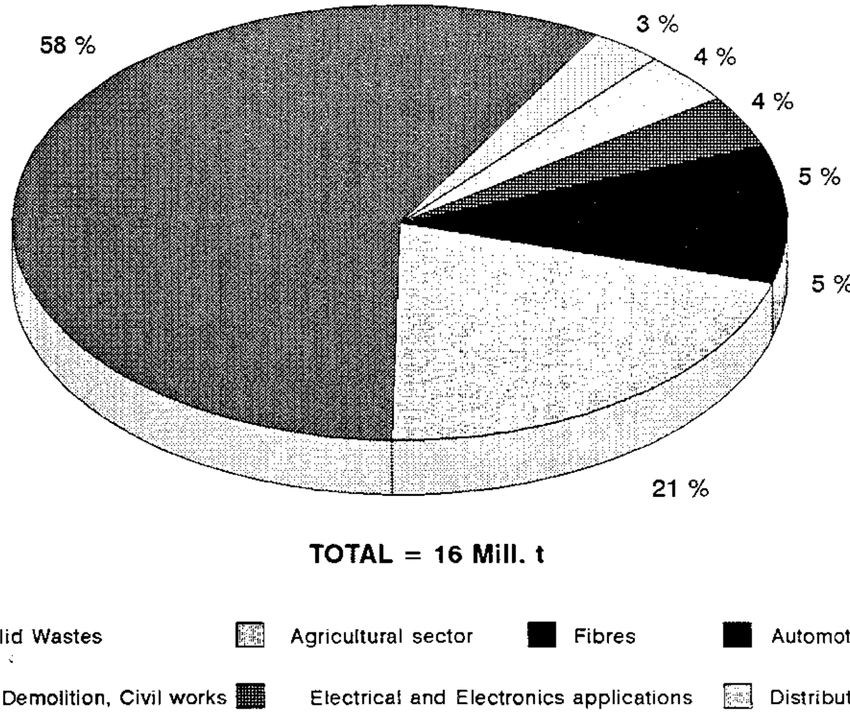
Source : HIMONT

It can be seen from Figure 1 that the PP market is growing in a dynamic way and that the fibre contribution will roughly maintain its percentage share, accounting for 1400 ktonnes in 1998.

Waste from the Fibre Industry

The fibre market generates waste as products complete their useful life cycle. The portion of fibre based waste in the total plastics waste scenario is shown in Figure 2.

Figure 2 **TOTAL PLASTICS WASTE BY SECTOR IN W. EUROPE 1992**



Source : APME and EATP Studies by Sopres Conseil - May 1994

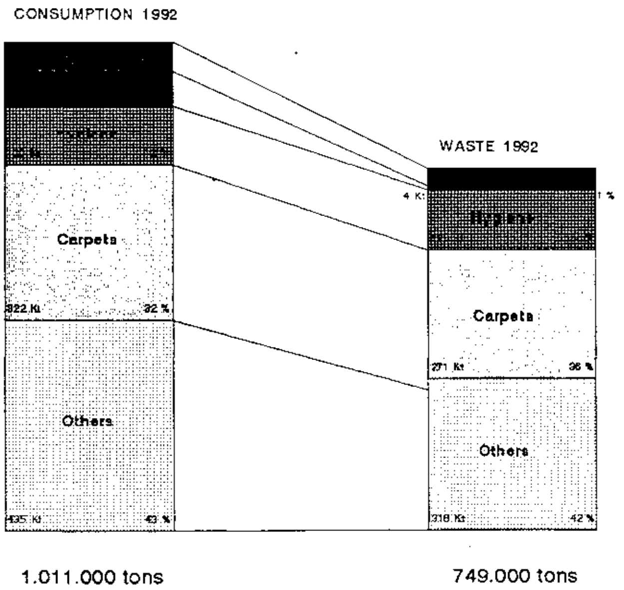
In common with all industrial applications, notably the packaging arena, which has been the focus of considerable attention in recent years, the textiles waste issue needs to be addressed.

Waste level: In 1992 some 750 thousand tons of waste were generated in the fibres sector of the 1.0 million tons of polypropylene consumed that year, see Figure 3.

Figure 3

POLYPROPYLENE TEXTILE CONSUMPTION AND WASTE ARISING IN DIFFERENT APPLICATIONS IN W. EUROPE 1992

Others : twines & ropes, medical, apparels & domestic, strapping, other textiles



Source : EATP study by Sofres Conseil - May 1994

The apparent discrepancy in the figures is explained when the pattern of use of the fibre products and the actual growth in the market are considered.

Table 1 shows the breakdown of uses for fibres and it can be seen that there are four categories of life span.

Table 1 - Approximate life time of polyolefin textiles

Life time (years)	<2	2-5	5-25	>25
Medical	•			
Hygiene	•			
Sacks (*)	•			
FIBC's (**)	•			
Agrotextiles	•		○	
Ropes & twines	•		•	
Carpets	•	○ •	•	
Apparel, domestic	•			
Construction	•		•	
Geotextiles	•		•	

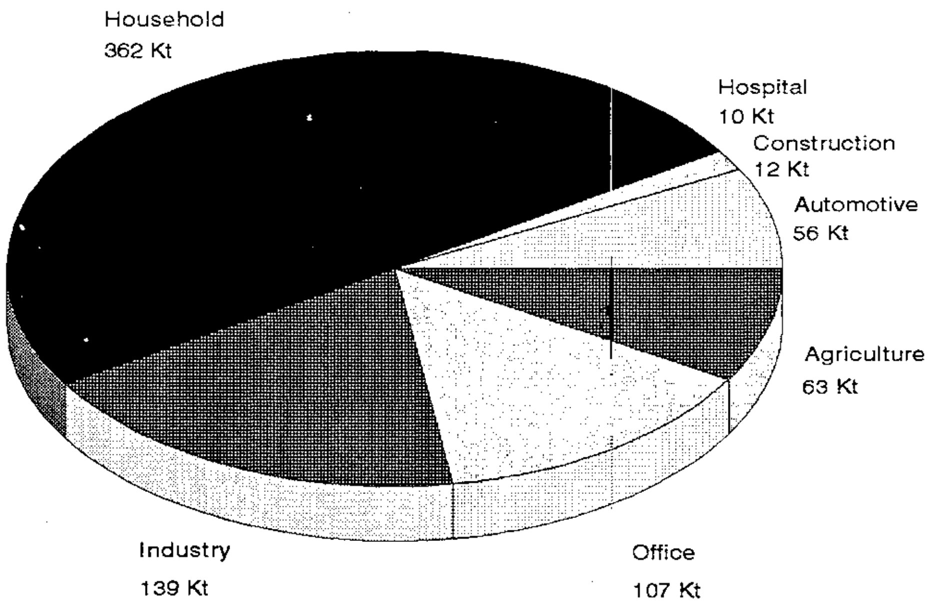
(*) cf. which 50% less than two weeks
(**) Flexible Intermediate Bulk Container
• denotes typical and ○ possible examples
Source : EATP study by Sofres Conseil - May 1994

Textile waste occurs in several industry areas and these are broken down in Figure 4. The situation regarding waste disposal methods, as it stood in 1992, is shown in Figure 5.

Figure 4

OCCURENCE OF TEXTILE WASTES 1992

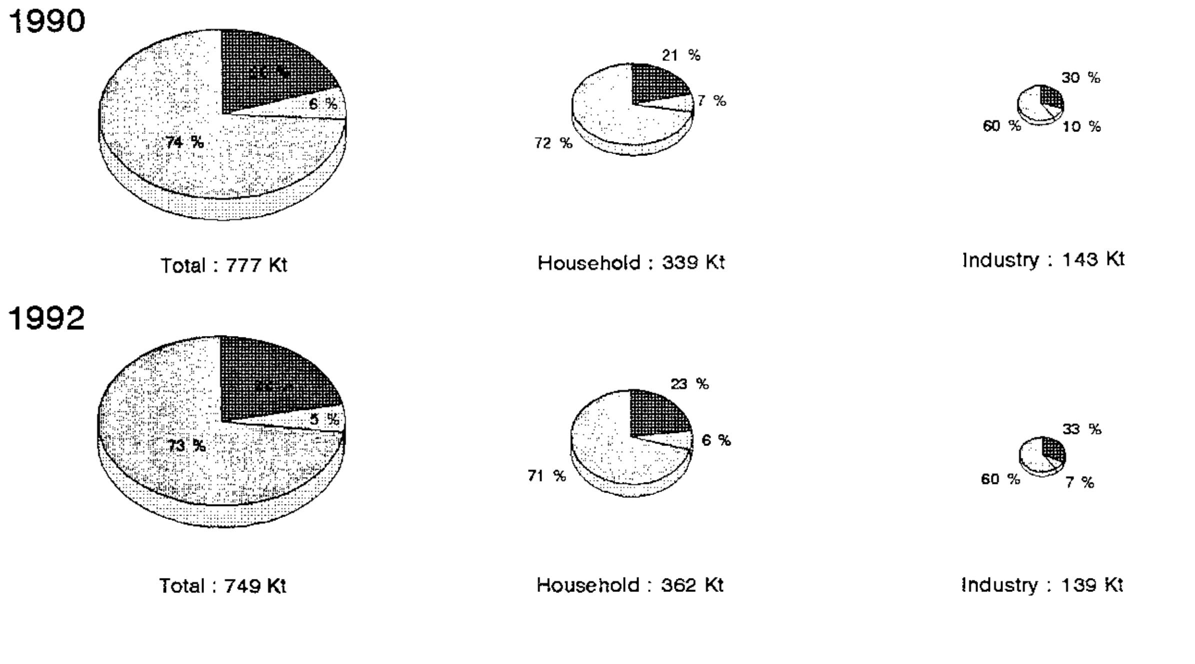
Source : EATP study by Sofres Conseil - May 1994



TOTAL 749 Kt

Figure 5

POLYPROPYLENE TEXTILE DISPOSAL METHODS W.E.



Source : EATP study by Sofres Conseil - May 1994

Figure 5 also indicates that the level of incineration with energy recovery is gradually increasing (from 20% in 1990 to 22% in 1992). The breakdown of the total textile waste disposal systems closely mirrors the fate of household textile wastes, which is the largest area, representing half of the total textile waste generated. The other major contributor is industrial textile waste, which has an even higher percentage (33%) of energy recovery.

The disposal situation today does not suit the legislators as landfill still dominates, and most regulatory bodies consider mechanical recycle as the best option. It is worthwhile evaluating the status of the current legislation and taking as a model for discussion the example of the packaging industry; where some parallels may be drawn.

Legislation: Environmental regulations affecting textiles have already been introduced, and these are listed in Table 2.

Actually, some application areas in textiles fall under the scope of other established regulations. For example packaging legislation affects textiles used in packaging, such as sacks, FIBC's, twines, ropes and strapping.

Packaging and the Environment : An Explanatory Case

So far legislation in the packaging sector has been driven by political expediency and emotional reactions, more than by scientific and practical considerations.

Legislation or draft proposals are in place in almost all the major European countries. A prime example is the Topfer scheme which calls for mechanical recycling levels far in excess of the existing facilities to deal with it. The result is that huge stockpiles of plastics waste have apparently been generated. A further barrier towards the implementation of suitable mechanical recycling schemes is the net cost of recycle which is of the order of DM 3.55 per kilogramme; far in excess of the value of prime materials. In the end the German scheme will need to be drastically reworked.

The German legislators also sought to have their approach adopted by their European neighbours, through the imposition of strict specifications on imported packages. Eventually all the existing legislation will be harmonized under a new EEC Packaging Directive, (the levels of mechanical recycling promoted under this directive are given at the end of Table 2).

However, this approach of attempting to retro-actively introduce an all-encompassing directive which keeps the majority of the diversely opinioned legislators content, is a considerable task. This difficulty should be avoided in the textile sector. For this reason the fibre industry is being pro-active in lobbying for a balanced, rational and attainable approach to waste management and this will be discussed shortly.

We have seen from the packaging experience that wholly inappropriate actions have been followed and regulations imposed for political expediency. Furthermore some of the regulations already in force also have implications for textile waste, such as big bags. It is vital therefore that these punitive regulations and negative experiences are not repeated in other industry segments.

Table 2 - Environmental Regulations Affecting Polyolefin Textile Waste.

Application	Type of Waste	Scope of Regulation
Transportation & Elimination of Toxic Waste	Medical Hospital	Mandatory incineration, most countries - in hospital or MSW incinerator. Transport control also.
Limitation of Cross-border trade	All wastes	Problems arising from German household & contaminated wastes, exported due to ill-fitting regulations, stress need for Community response.
Tax on Polyethylene Packaging (Italy).	FIBC PE Linings	Only becoming effective now.
Packaging Wastes Management	Bags,Sacks, FIBC's,Rope Twines, Strapping	Germany -Topfer ordinance targets 64% material recycle, 36% landfill\energy recovery by 1995. RGK group to manage collection of FIBC, using same type of scheme as failed DSD. France-Conseil d'Etat approved framework for sacks & FIBC - producers exceeding 1100 tonnes weekly to create schemes & pay Austria - 'Altstoff' now effective - based on Germany approach. UK -self-regulation by industry PRIG set up to monitor progress Spain -Discussions but no regulations Portugal,Greece-No regulations or funding systems. E.C.Directive - Management of Packaging Waste; within 5 yrs 50-65 % (wt) packaging recycled with 25-45% of this mechanical with min. of 15% any material stream.

A Better Approach in the Fibre Industry

For this reason the Fibre Chain Forum initially under the leadership of EATP and now COMITEXTIL (Coordination Committee for Textiles Industries in the E.U.)and supported by APME has been created. Its role is:

- To create a platform for intelligent debate.
- To initiate and evaluate appropriate schemes aimed at determining the feasibility of recycling systems.
- To lobby for a cohesive and complete (all encompassing) approach to waste management options and to present a unified single voice to legislators and

consumers alike.

The Fibre Chain Forum (FCF): The precise aims and mandate of the FCF are now laid down in a draft white paper.

The fibre industry has been considering environmental issues for more than 4 years, and therefore several recycle initiatives have already been evaluated. In the area of mechanical recycling it has been shown that it is entirely feasible from a technical standpoint to recycle textile waste. Significant work was carried out in the area of post-user carpet collection and recycling, and in FIBC's, ropes and twines. However, unfortunately, most of these schemes have not been pursued because the economics of recovery and/or the environmental impact of establishing such recycle systems is greater than adopting alternative waste management options.

The floor coverings area is a notable exception, as they currently use industrial scraps such as cutting edges to produce backing in needle-felt which replaces foam or secondary backing for tufted carpets.

Another scheme still being continued sorts floor covering into PVC, linoleum, and textiles; however the appropriate fraction is then used as a fuel.

Projects on life cycle analysis of textiles are in place and will provide the basis for objective debate regarding the environmental impact of articles such as carpets in future.

Feasibility studies into the separation of carpets have also been carried out; and have shown that mixed polymers create a problem. This could be overcome by the introduction of a mono-material polypropylene carpet, and Himont is actively supporting such initiatives by broadening the property profile of polypropylene to enable it to replace other textile materials.

The mechanical collection of FIBC's was also investigated but shown to be unsuitable for two main reasons:

a) Sacks are too widely dispersed geographically

b) Some may have been used to transport dangerous goods.

So it has been shown that the target of the legislators for a high percentage of mechanical recycling of textile waste is impractical and uneconomic.

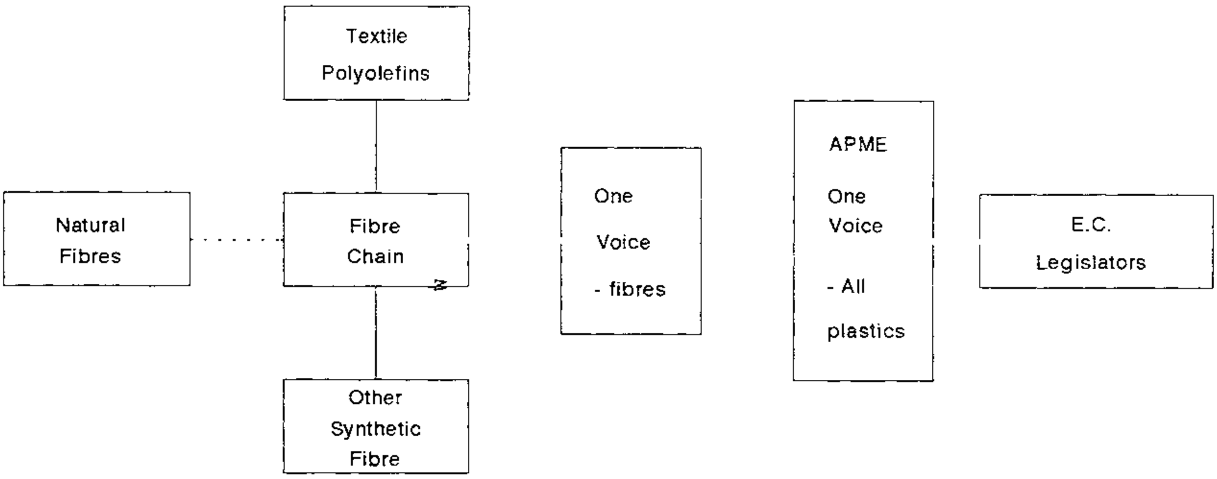
The FCF will champion suitable schemes that aim to reduce the amount of textiles used at source, as this is a rational way of reducing waste. Furthermore the FCF continues to investigate mechanical recycling initiatives, but they believe that the targets need to be properly set to reflect the actual situation and the realistic disposal options.

United under the umbrella of APME, the FCF seeks to promote one voice in representing the interests of the fibre industry (see Figure 6), and ultimately the consumer, through correct and suitable waste management options. Under the coordinating role of COMITEXTIL, the following textile european associations are currently part of the Forum : COMITEXTIL - EATP - GuTT -

CIRFS -EFIBCA - Others. The current legislative position and the desirable approach that we in the industry believe should be followed, are laid out below in Figure 7.

Figure 6

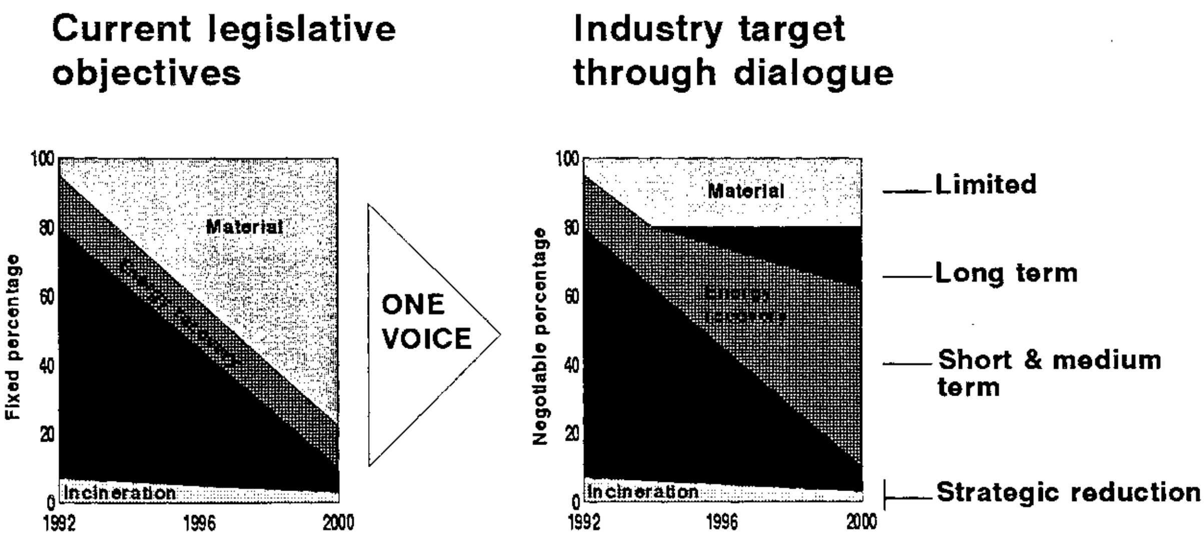
FIBRE CHAIN FORUM - SPEAKING WITH ONE VOICE



- Benefit from APME access to legislators.
- Increase the weight of APME voice.
- Ensure consistency of information and approach within EU.

Figure 7

PLASTICS INDUSTRY GLOBAL TARGET FOR WASTE MANAGEMENT



Energy Recovery

It can be seen from Figure 7, that incineration with energy recovery is believed to be a justifiable and suitable option. This is due to the very high calorific value of plastic materials and polyolefins in particular (their "Locked-In Potential" or LIP). Figure 8 shows the LIP rating for a range of common materials.

Figure 8

LOCKED-IN POTENTIAL (LIP) EXPRESSED AS CALORIFIC VALUE FOR A RANGE OF MATERIAL

Product	**Energy**
Polymer	LIP (MJ/kg)
Polypropylene	46
Polyethylene	46
Polystyrene	41
Polyurethane	24 - 31
Polyester	19 - 30
PVC	20
Conventional Fuels	Energy (MJ/kg)
Diesel Oil	46
Naphtha	42 - 46
Carbon	21 - 33
Wood	16 - 21
Paper	16 - 19

It can be seen from the above figure that the energy of 1 litre of diesel oil = LIP of 1 kgm of polyolefin.

In fact studies have shown that the removal of the plastics component from the Municipal Solids Waste stream, renders the remaining matter (vegetable waste and paper etc.) incombustible, requiring the addition of diesel oil in order to fire the kilns. So the inclusion of plastics components in the form of textiles or packaging, after their primary life, means that a quantity of oil equivalent to the LIP of the plastics matter can be saved. This is in effect extending the useful life of the plastics by using them as a secondary resource or fuel.

So the combustion of polyolefins textiles waste produces a high amount of energy. It may also create a small amount of ash, but this can normally be dealt with easily.

One specific initiative built around carpet waste is to utilize these awkward articles as a fuel in cement kilns. The typically long burning time and large in-feed of these kilns are ideal for accepting bulky carpet waste. Furthermore any residual mineral fillers which generate ash are automatically incorporated into the final cement product.

The Way Forward - A Considered Approach to Waste Management.

APME calls for "equal dignity options", for the generation of a cohesive and comprehensive waste management strategy, which makes sense for the long-term future and not only the short-term objectives of politicians.

Naturally, it is recognized that landfilling must be reduced and that appropriate mechanical recycling schemes should be considered where they may be economically and environmentally viable, as this is a way of extending still further the life time of petroleum based products. However, energy recovery through carefully designed incinerators is an excellent way of dealing with waste matter (particularly contaminated articles).
In addition feedstock recovery schemes, whether as raw polymer or regenerated monomer, are being investigated as they may offer a solution in the longer term.

The FCF and APME will continue to unite all levels of the industrial chain in their struggle to positively influence the legislators of Europe in the derivation of a holistic and sensible approach to the management of plastics waste.

Acknowledgements: I would like to thank T. Mc Cormack (Manager Rigid Packaging & Projects - Himont Europe) and A. Cicuta (Environmental Specialist -Himont Europe) for their kind assistance in the preparation of this paper.

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RECYCLING OF PLASTIC FIBRE AND PACKAGING WASTE

J A(Tony) Horrocks

Introduction

It is practically impossible to avoid producing waste in the manufacturing and use of synthetic fibres, tapes or packaging films and it is essential that this waste is recycled both to improve the economics of the industry and save polluting the environment. For the purposes of this paper scrap can arise from three sources:-

1. In House:- A first priority is to reuse the scrap produced and convert back into the finished product. If this is not possible then every effort must be made to use it in another product which has a higher added value than disposing of the scrap.

The manufacturer can have his own scrap recovery process or he can send the scrap to a trade recycler to be reclaimed into pellet and returned or he can sell it to the trade recycler. Only in rare instances should it be necessary to dispose of it in landfill or incineration.

2. Post Industrial:- This waste is produced when the synthetic fibre, filament or film is used by a customer in another product. It is desirable to recycle as much of this scrap as possible by either returning it to the manufacturer for reuse or by selling to a trade recycler for reprocessing. Only if unusable should disposal to landfill or incineration occur.

Sometimes the material from this source is contaminated with dirt, metal, paper, etc., in which case it will have to be washed first. If not too highly contaminated it can be used without washing to make products such as pallets, composters, garden products directly from scrap.

3. Post Consumer:- This is household waste, and the plastics as packaging are usually mixed and contaminated with other materials such as glass, metal, paper etc.

Material should be manually or automatically pre-sorted and washed before reclaiming - this is being carried out with PET,HDPE,PVC bottles. These reclaimed materials can then be reused in the production of primary products such as fibres, moulded products, etc.

Methods of Recycling

The simplest method of recycling scrap is by granulating but this produces a product which in most cases is impossible to reuse directly into the primary manufacturing process of fibre or film. It is noisy and dirty with much dust; the scrap cannot be filtered to remove impurities.

The standard method of extrusion is by melting, filtering and pelletising. Scrap cannot be fed directly into the extruder and needs to be put through a granulator first. This gives problems because the often light fluffy material is difficult to feed, output is low, different materials sometimes require different screws and dies, material is degraded due to high shear and heat, the process is dusty and noisy and energy usage is high. Semi-or fully automatic aggregators, also termed disc mills, can be used but they have to be fed with granulated material and the final pellet is not uniform in size; it has a lower bulk density, contains fines and has not been filtered. Consequently, it is difficult to feed material back into prime production process.

The Erema Process & Concept

In 1982, three Austrian engineers designed and patented a system which utilised the advantages of all the above and overcame the disadvantages to produce **THE EREMA PROCESS** which is an in-line extrusion process that is dust free, has a low noise level, occupies a small space, has low energy usage and generates low maintenance costs. It can produce clean, full bulk density, filtered pellets with little or no degradation directly from PP, PE, PET film, fibre or scrap bottles at a high output and low operating cost.

This high performance, which is independent of the shape and bulk density of material to be processed, results from the **EREMA** concept of using a shredder drum attached to an extruder (see Figure 1). The shredder drum is continuously fed, with the rate being automatically controlled by the load on the shredder motor which drives high speed rotary knives that not only cut the material but also heat it to just below its melting point. This hot material is then fed into an extruder which melts the material and passes it through a filter to remove contaminants, and then into a water cooled die head to produce pellets which are dried, stored or bagged.

Because the material is fed hot into a short extruder, the screw is designed with deep flights which produces little or no shear. This provides a minimum heat history which results in little or no change in the melt index. Hence quality of material is such it can be used in higher added- value products (see Figure 2). This compares extremely favourably with conventional extrusion where material is heated from cold, primarily by shear from the extrusion screw, which thus causes considerable degradation of polymer, and a high energy usage. See Figure 3 for details of temperatures used for various polymers.

Erema Vented Process

For hygroscopic materials such as PET, polyamide (PA) and materials containing volatile products (foams, fibres with spinning oils, printed material, scrap with more than 4% moisture, etc), it is necessary to have a vented extruder, so that a gas-free pellet can be obtained. With a conventional vented extruder, the screenchanger is normally at the end of the extruder and this can give problems because contaminants such as paper, PVC, etc. can stay on the filter and degrade thus giving an expanded pellet. Erema have overcome this by putting the screenchanger in front of the vents (see Figure 4) which also has the following advantages:-

- It decreases any screw wear and prevents material seeping out of the vent because of high back pressure. Thus material with wood or paper residues, labels, stickers, etc., can be processed.

- A second screenchanger with very fine screens can be fitted to the end of the line if required

- Glass fibres can be added to PA and PET after the filter which protects the screw barrel and glass fibres from damage.

Normally the Erema Process uses a "Hot Die Face" pelletiser but because of their viscosity, it is necessary when processing PET and PA, to use a strand die followed by a water bath at the end of the process. This arrangement will also handle all other polymers.

Screenchangers

Erema have developed and patented two unique types of Screenchangers which are fitted to the Erema process or they can be fitted to other extrusion lines such as fibre production; other scrap processes, etc. The partial backflush screenchanger is shown schematically in Figure 5. Material flows through four filter packs installed in two pistons which provides a very large filtration area. Automatic backflushing of each screen in turn is achieved utilising extrusion pressure, and advantages over conventional screenchangers are:

- lower screen costs since they last between 50 - 200 times longer
- lower labour cost.
- melt temperature and pressure is reduced thus reducing degradation
- materials with a relatively high contamination level can be processed

The screenchangers are constructed from hard precision steel with wide sealing surfaces thus giving many years of operation free maintenance.

The laser filter in Figure 6 is so-called because the specially designed "self cleaning" holes in the hardened steel filter screen have been made by use of laser beams. This allows much smaller diameters than conventional drilling with the ability to have more holes and a finer filtration in a given surface area. It is a "continuous" process whereby the screen is a circular disc through which the contaminated polymer flows and the contaminants are cleaned from the surface by rotating knives to produce a "continuous sausage " of contaminant and plastic in an approximate ratio 1:2. These filters are designed for large quantities of contaminant (5-10%) but this must be a soft material such as wood, paper, aluminium, copper, higher melting plastics.

The optimum filter fineness at present is 150 μm which is sufficient for some purposes; however, a conventional RTF filter could also be added to the line. This arrangement allows material to be recycled which was not possible before.

Use of a Melt Pump: If the scrap is not too mixed and is reasonably uniform in melt flow, then it is possible to produce the finished product direct from the scrap **without** going through the pelletising process. This can be achieved by fitting a melt pump (gear pump) to the end of the Erema extruder and connecting this to an existing or appropriate die. By this method can be produced fibres, films, sheet, tubes, etc.

Use of a Vacuum Shredder Drum (see Figure 7): Even though the Erema process is gentle on processed polymer, the water which is present in PET still reacts to a certain extent and causes a reduction in the viscosity. Whilst the resulting pellets can be used to produce second grade fibres, they cannot be used in high grade bottle or film manufacture. Erema have developed a special shredder drum with a vacuum which removes most water before it enters the extruder so that the IV is changed only a little (see Figure 8). High water contents up to 12 % can also be processed. This allows the recycled PET to be used in high quality products.

Other Processes

Edge Trim Recycling: A recent development which consists of a small two shaft shredder fitted to the extruder allows edge trim from films, sheet, etc., to be processed directly into pellets or returned in a closed loop back into the primary process. Output rates of 20 - 90 kgs/hr are possible.

De-gassing: Polystyrene foam used in bulk packaging can be recycled but until now it has not been possible to re-use it in foam manufacture because a pellet containing gas could not be produced. After two years development, Erema have produced and sell an in-line extrusion process which can introduce a gas and thus provide a pellet containing gas which can be used to manufacture the block foam packaging.

Profile extrusion have developed a special haul-off which can be fitted to an extrusion line to produce profiles from difficult melts (mixed and contaminated scrap) and profiles that cannot normally be calibrated.

Costs

Total operating costs range from £35 to £95 / tonne depending on the machine size which compares extremely favourably with other processes. This, together with the ability to be able to produce higher added value products, provides increased profits for the manufacturer, particularly as the recycled material can often be used instead of virgin polymer with a lighter price of £400 - 600 per tonne.

Advantages

The advantages offered by the EREMA process are:

- low operating costs
- small space requirements
- low noise level and no dust emission
- high quality, filtered, full bulk density pellet with minimum degradation

Applications

These advantages provide financial gains compared to other processes. The low degradation allows the scrap to be reused at high levels (sometimes 100 %) and the quality of the finished product is improved as is the efficiency of the process i.e. not as many filter changes. The film or fibre does not break as often and finished product is improved. It also allows the scrap to be used in applications which were not possible previously.

The Erema process is used in the following applications:-

FILM - all types of film production e.g. LDPE, HDPE, film . With PP film 300 mesh filters can be used which allows film of 12 μm to be produced with over 30 % scrap level and 35 μm film with 100 % scrap
FIBRE - PET , HDPE and PP fibres. A special process was developed to produce PP fibres from polymer with an MFI 600 - 1000.
SHEET - PS, PP sheet production
CARPETS - edge trim and other scrap can be reprocessed.
ROPE - scrap reprocessed and reused
IN LINE - PE films; PP tape; PE tubes; PE sheet are all being produced direct from scrap. Production of fibres and filaments is also possible.
SCREENCHANGERS - these have been fitted to existing film; PET and PP fibre and tape lines
Erema have sold over 700 machines worldwide with 75 in the UK. Over 300 machines are for PP (15 in the UK) and 40 for PET (3 in the UK)

The Remaplan Process (see Figure 9)

Normally it is only with the extrusion process that scrap can be reused because it is not economically or technically viable to put contaminated or mixed scrap through an injection moulding machine.

However, moulded products can now be produced from mixed slightly contaminated scrap using the unique, patented, fully automatic, computer controlled REMAPLAN PROCESS which is basically an Injection / Compression moulding machine connected to an Erema extruder by a special accumulator adaptor.

This process allows finished products to be made direct from scrap in a single operation with only one operator. Consequently operating costs are low; excellent quality products and low capital costs result compared to injection moulding (see Figure 10).

Normally mixed, slightly contaminated scrap is used and there is no need to prewash or sort depending on the finished article. Remaplan have successfully developed the process to use 100% PET scrap from bottles, etc, to produce pallets and other articles which will have technical and economic advantages over other materials.

Applications: Pallets, garden composters, reels and in fact any moulded article with a wall thickness of 4 - 7 mm depending on cleanliness of the scrap.

Two machines are installed in the UK producing Pallets and Geo-block

Ancillary Processes: Sometimes the condition of the scrap requires some pre-preparation and the following processes are also offered by Norplas:-

Tecnofore-washing plants from Italy; several are already installed in the UK and they may be used for prewashing of film, bottles and consumer waste by local authorities. In addition they are used for washing used car carpets from scrap cars; the PP and PET fibres are recycled by extrusion back into reusable pellets.

Pierret cutters - these are special high speed cutters used to precut very thin film, fibres, filaments from baled or loose material. Many are installed throughout the world and Pierret have been given awards for their achievements in the textile industry.

Conclusions

It is essential that scrap in all its forms is recycled wherever possible. By choosing the right technology and process it is possible to reduce costs and to add value to existing and new products. Thus the product quality is improved, profitability is considerably increased and the environment is helped.

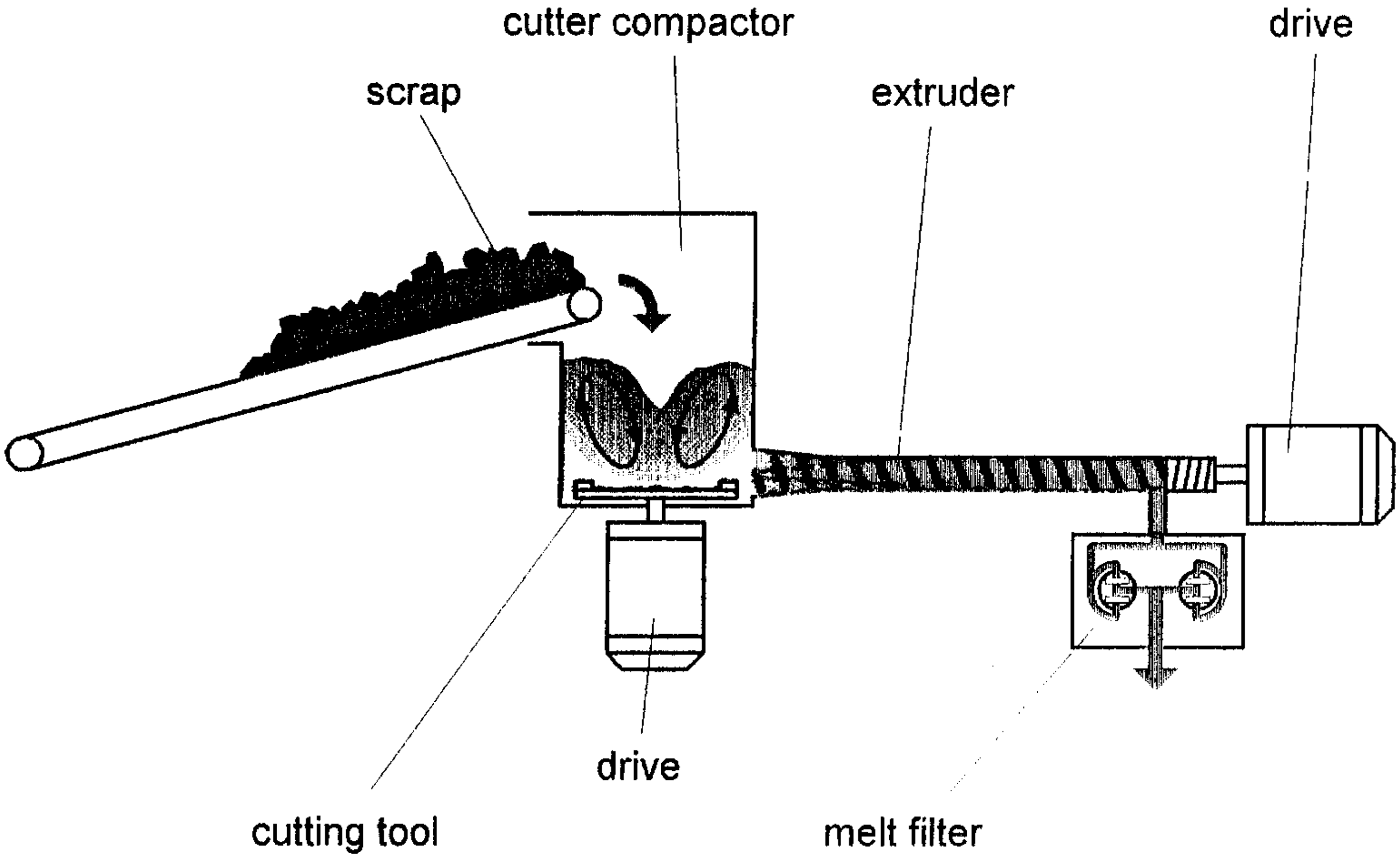

Figure 1: The Erema recycling plant concept

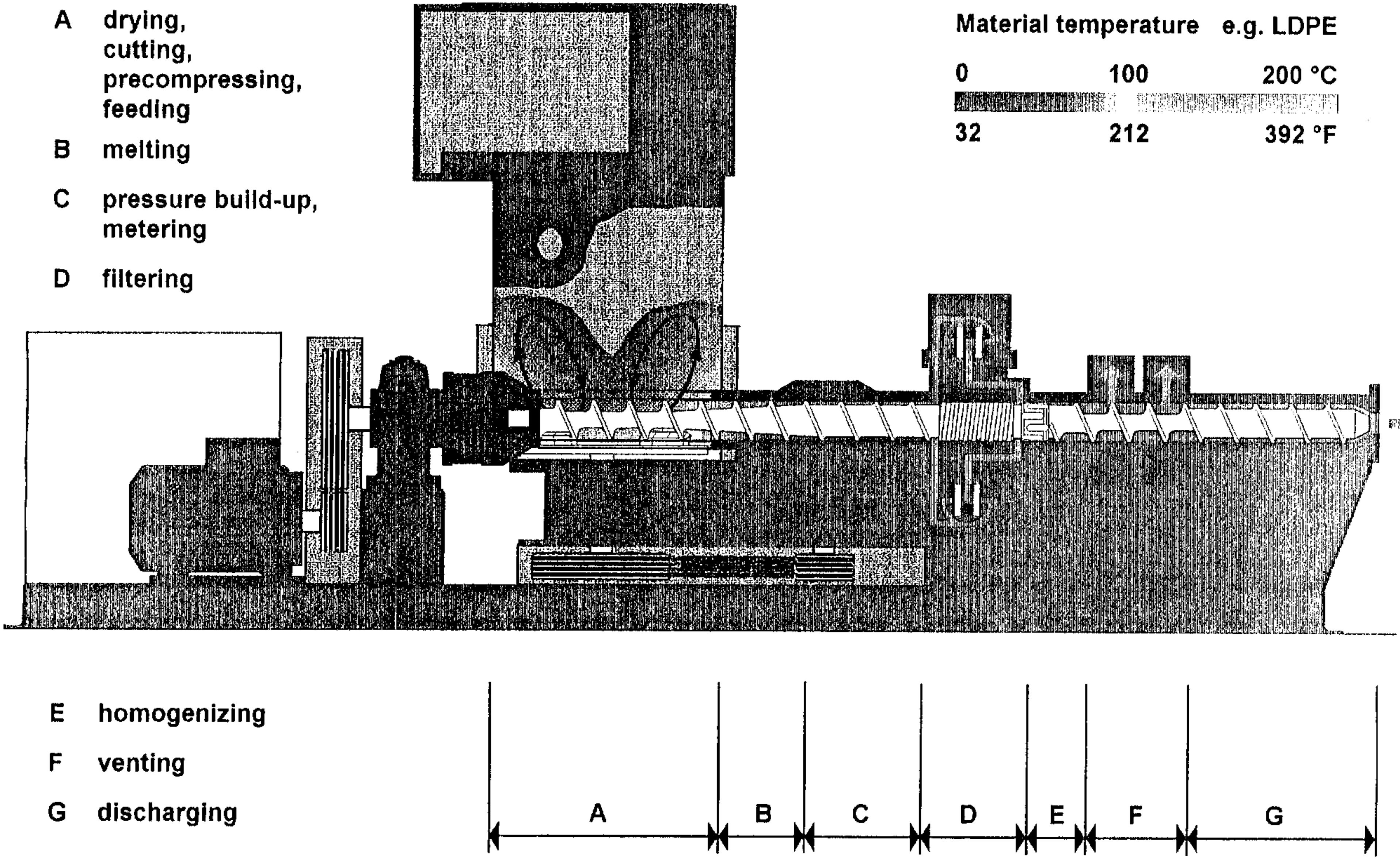

Figure 2: The Erema short extruder system

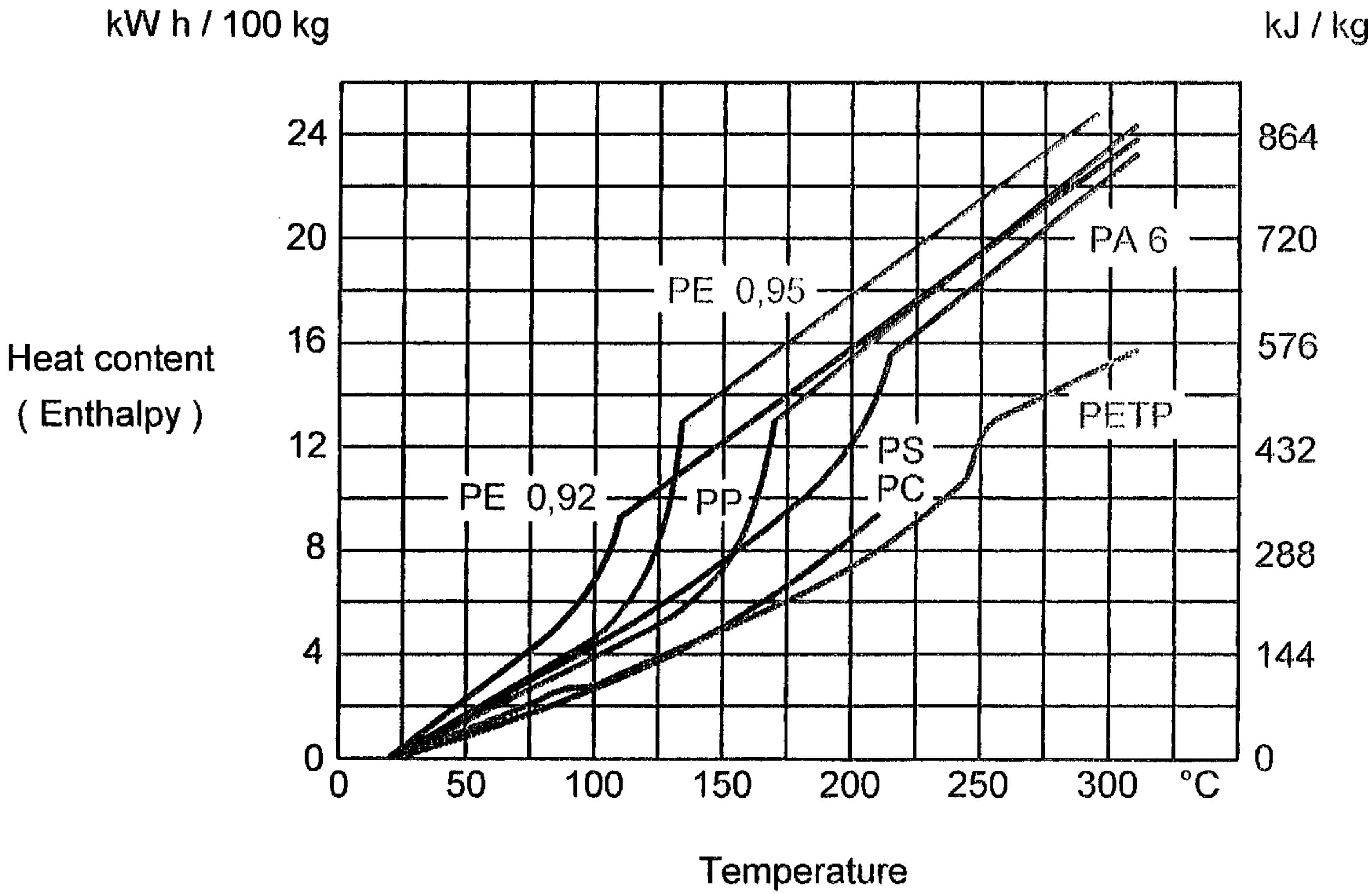

Figure 3: Specific heat capacities of different thermoplastics versus temperature

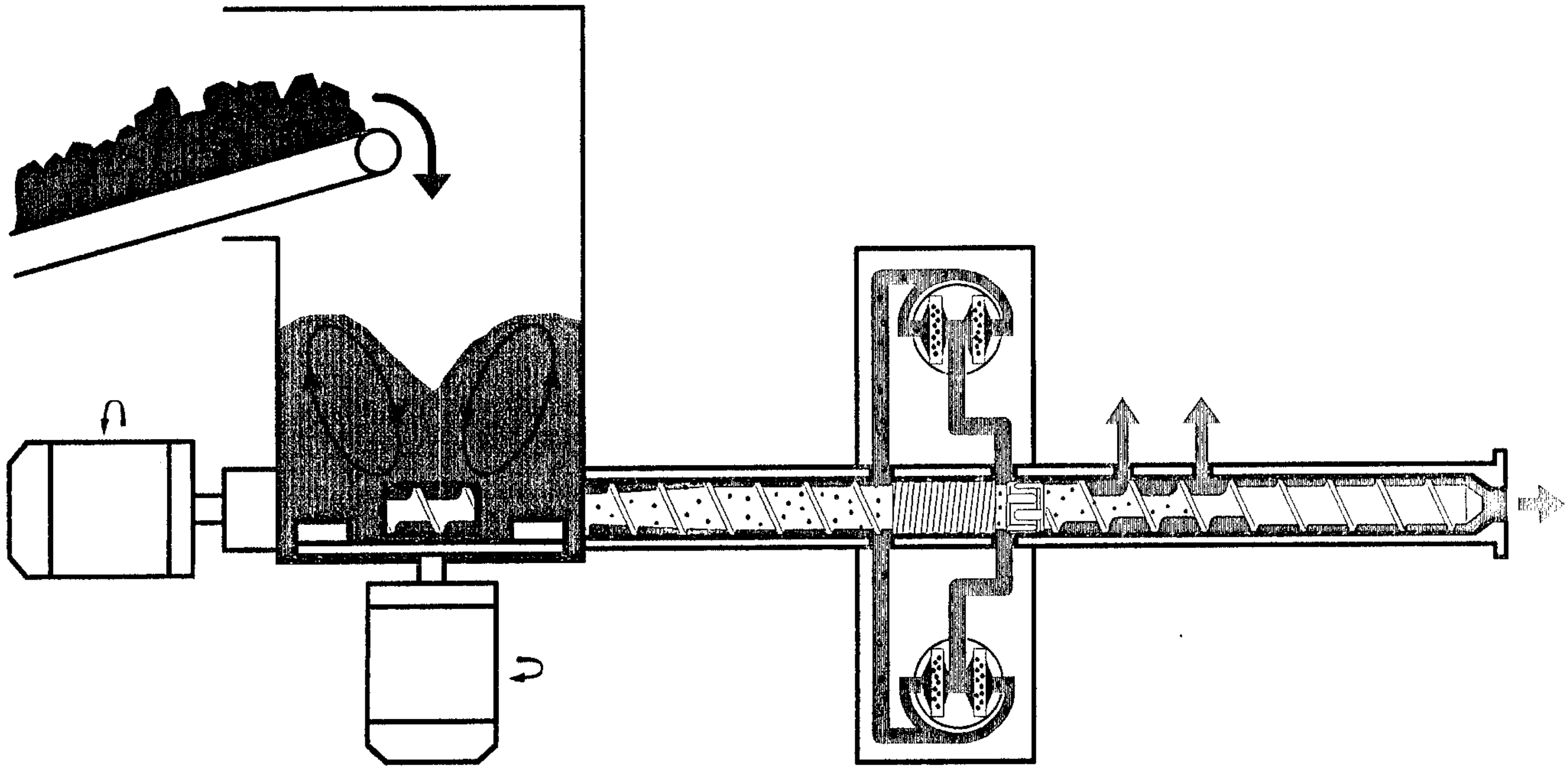

Figure 4: The screenchanger in the short extruder

Cleaning of screen pack II in piston 1

piston 1 in backflush position 2

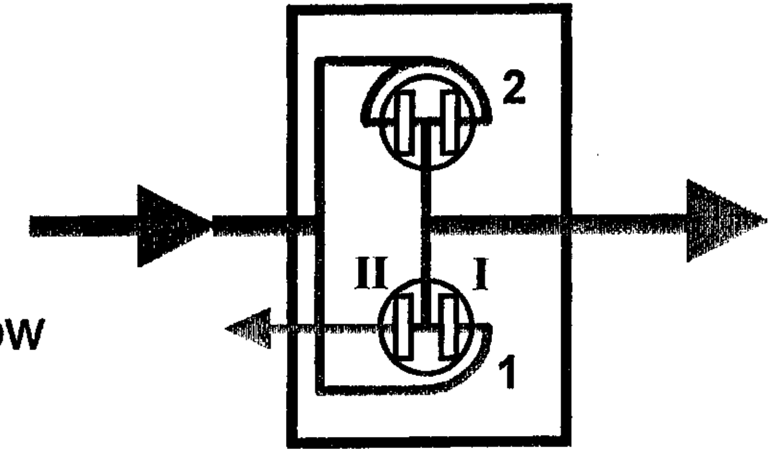

Figure 5: The partial surface backflush action of the screenchanger

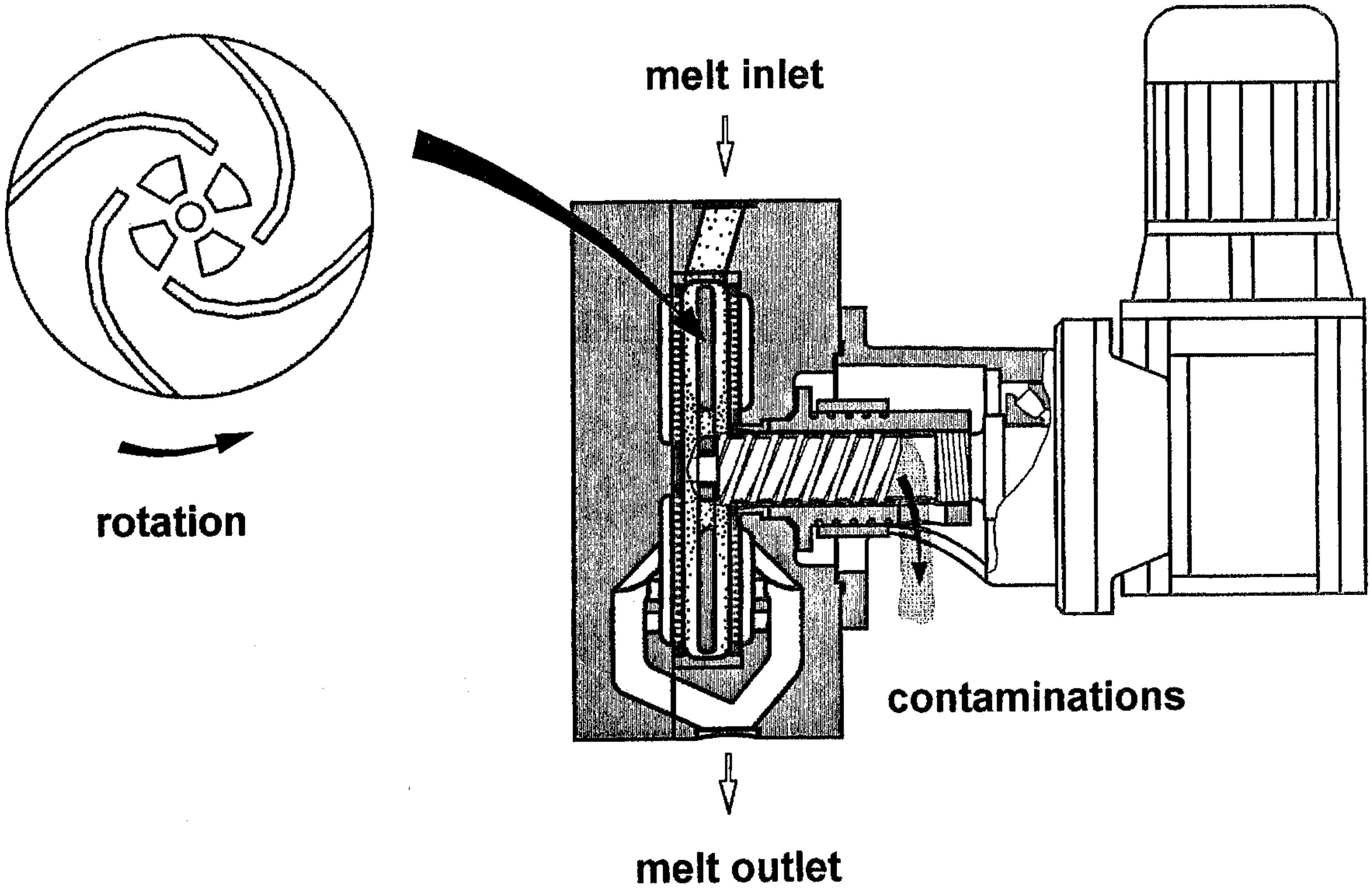

Figure 6: The melt laser filter

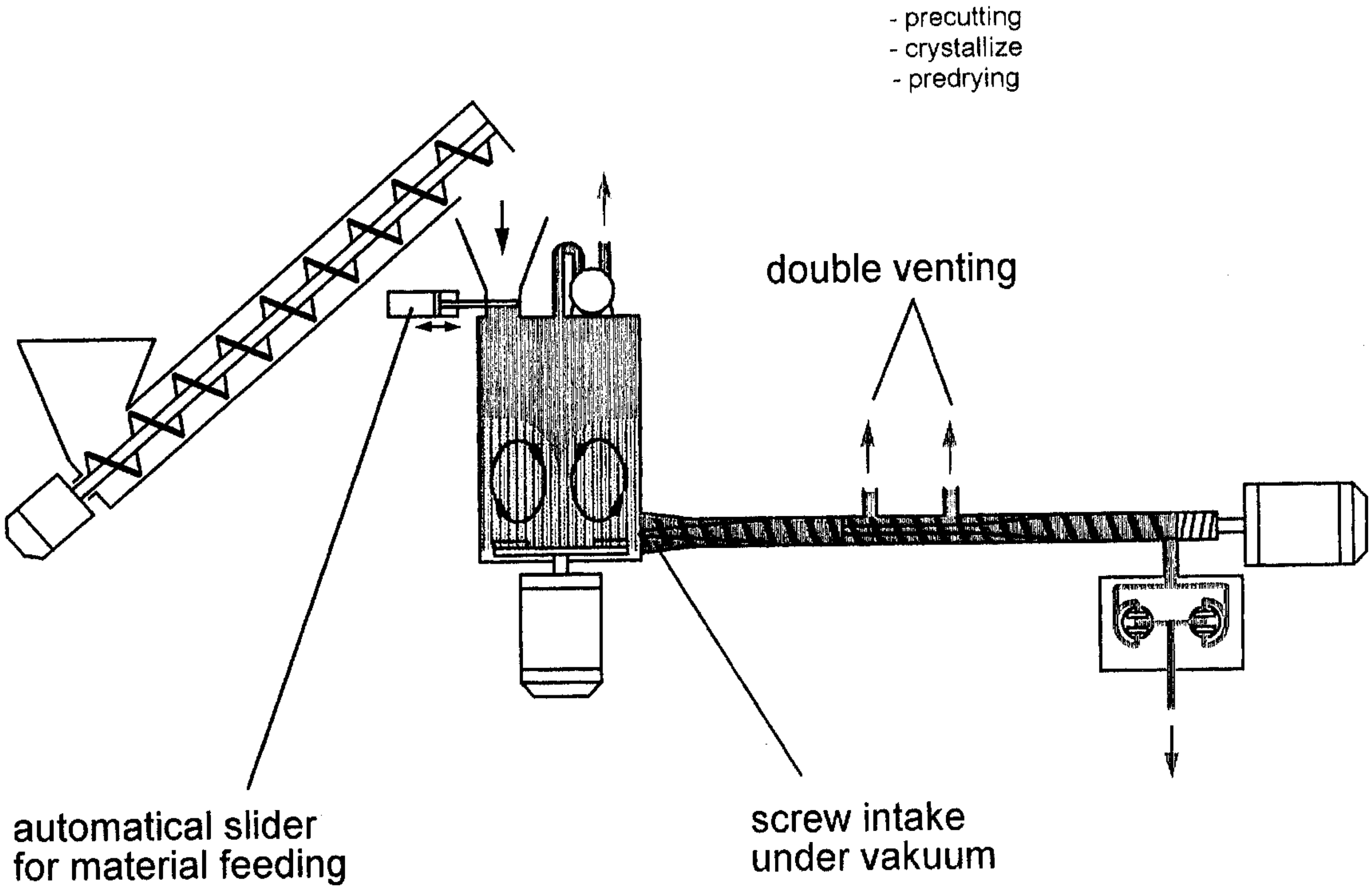

Figure 7: The vacuum shredder drum

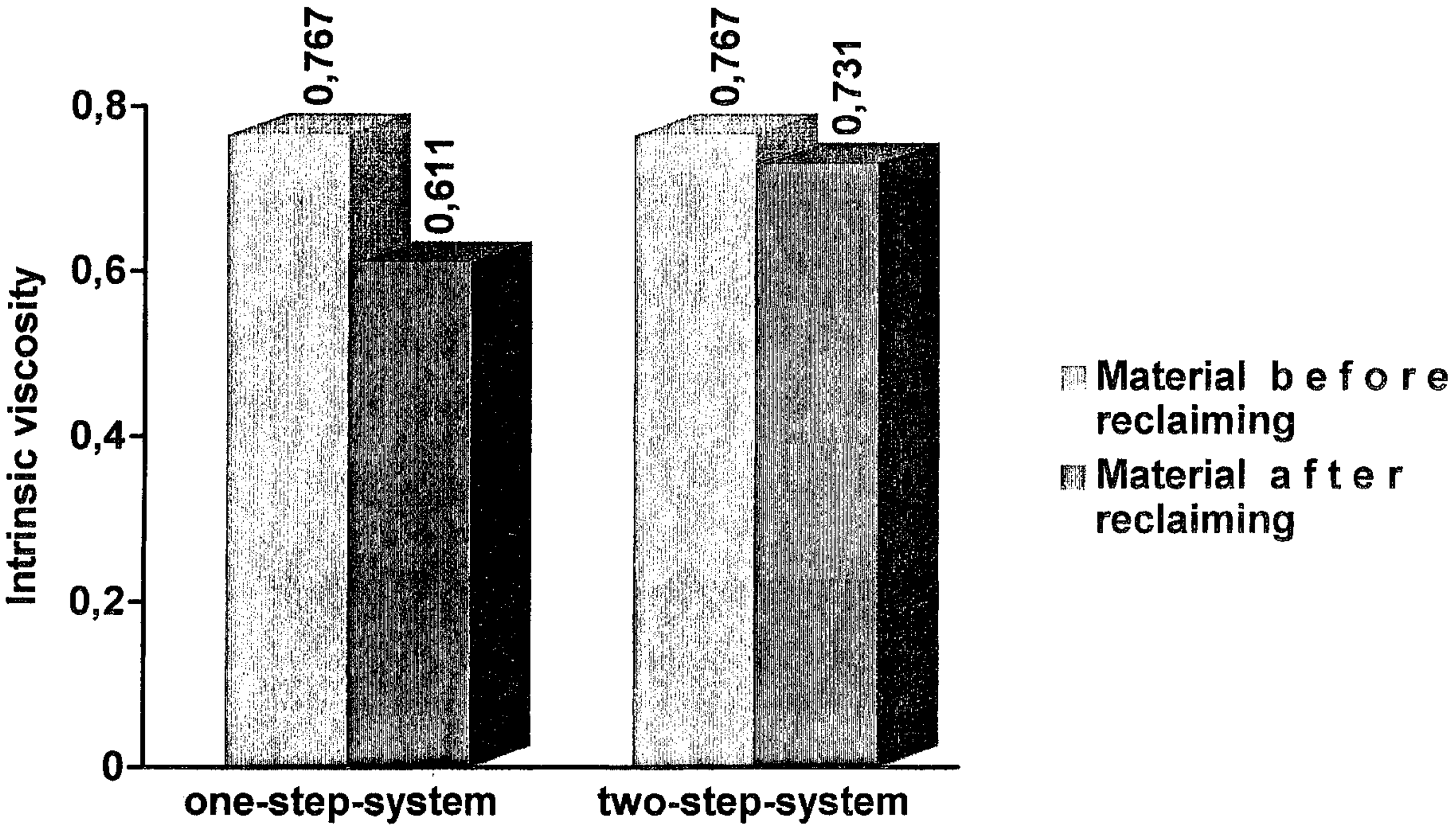

Figure 8: Intrinsic viscosity of PET bottle polymer before and after reclaiming

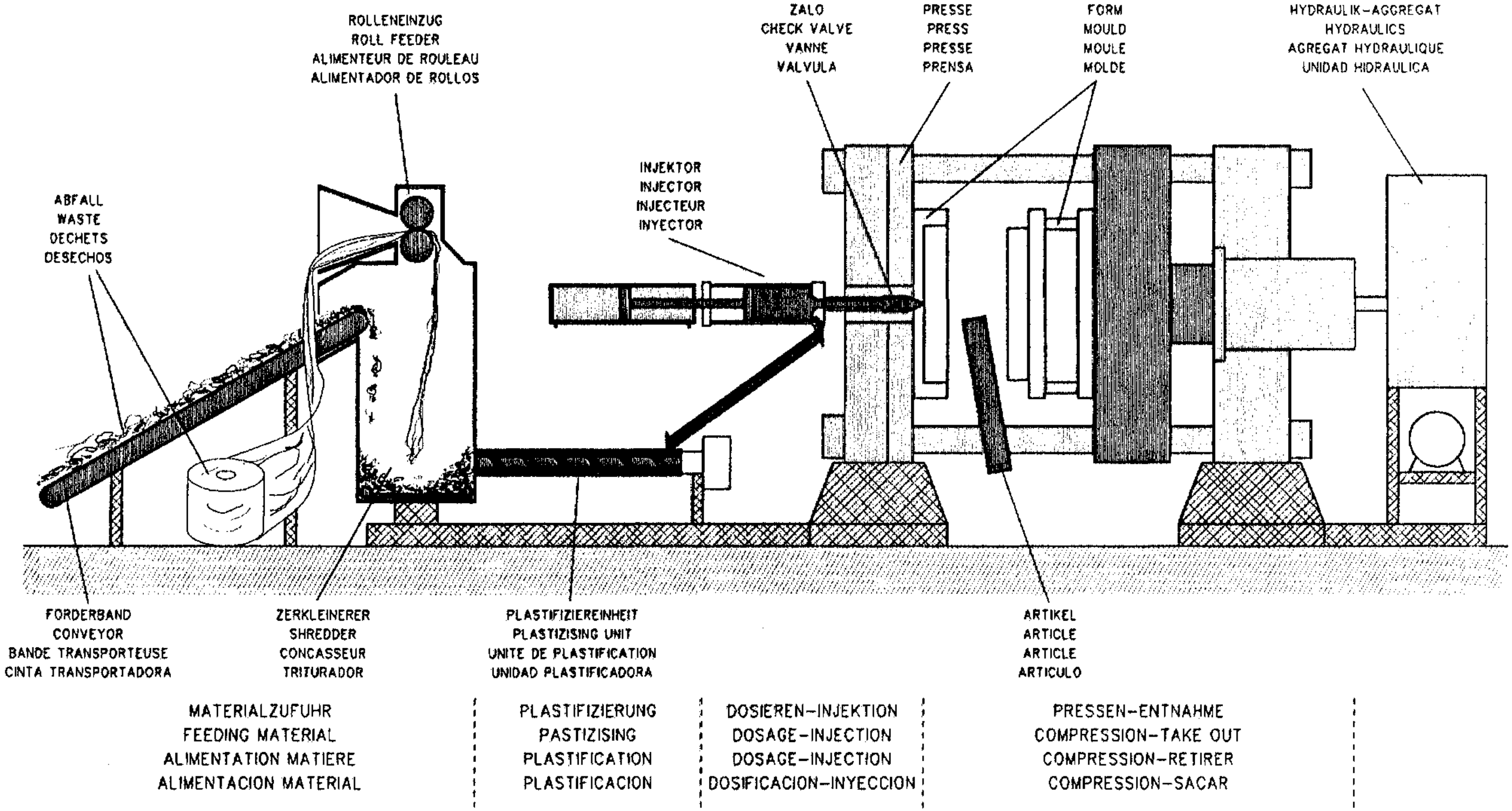

Figure 9: The Remaplan Process - Horizontal injection-compression installation for recycling

Comparison of PET-recycling
- all figures in DEM per ton -

Operation costs

Position as per December 1994

	conventional #	remaplan
	300	300
Refinishing work, washing, separating paper, drying	1.000	250*
Granulating	-----	-----
Pressing	-----	600
Overall costs	1.300	1.150
Turnover per ton	1.500	1.950
Value added	200	800

Coca-Cola-Daten
* only drying

Figure 10: Comparison of PET-recycling costs (in DM) for conventional versus Remaplan Processes.

KEY LESSONS FOR PLASTIC BOTTLE RECYCLING

Andrew Wood

Introduction

It is useful to break the recycling system into its key components. By taking a total systems view of the problem we can identify the key roles and the barriers to recycling and these are listed in Table 1.

Table 1: Roles and Issues for Bottle Recycling

STAGE	ROLE	KEY ISSUES
LEGISLATION	**GOVERNMENT**	**COMMON STRATEGY AND PLAN**
BOTTLE PRODUCTION	MANUFACTURER MARKETEER RETAILER	+ MARKET SHARE + RECYCLED CONTENT
DEPOSIT	CITIZEN	+PEOPLE WILLING +COMMUNICATION
COLLECTING } SORTING }	LOCAL AUTHORITY	+MRF'S-INTEGRATED +TECHNOLOGY +SUBSIDY
GRAN./CLEAN	REPROCESSOR	+BOTTLE DESIGN +SPECIFICATIONS +VIRGIN PRICE +VOLUME
MARKET	INDUSTRY	+PRICE +QUALITY +HIGHEST VALUE +FIT FOR PURPOSE

Legislation

The need for a common strategy and plan: The EEC packaging directive is an attempt to create a common strategy for recycling. The time it has taken to achieve consensus illustrates the variations of approach in each country. Nevertheless, it is a key step forward and will allow national governments to align their recycling strategies.

In the UK where each Local authority has been charged with recycling 25% of its domestic waste and each has its own plan and where industry has been charged with producing a plan to recycle between 50-75% of all packaging (domestic plus commercial), it is clear that there is, as yet, no common strategy and plan. Hopefully, impending UK legislation on the environment will provide the necessary legal framework to enable all parts of the recycling chain to develop a common objective. Without a shared view of the problem and an agreed objective we will struggle to make recycling work.

The challenge is to harness the goodwill of the public and align it with the responsibilities that Local Authorities have to recycle; and obtain the funding to enable it to happen from a levy on packaging organised by industry.

The Plastics Industry has a clear responsibility to make sure plastic bottles which are relatively easy to recycle into high value application are recycled.

Production of Bottles for Recycling

Plastic bottles offer design flexibility and low cost: The success of plastic bottles has been phenomenal. The relatively low costs of production combined with infinite design flexibility have enabled plastics to take a major share of the market.

The three main polymers are PVC, PET and HDPE. PVC (about 34 ktonnes per annum) offers gas impermeability, moulding flexibility and low cost, and is successful in carrying still mineral water, cordials, edible oils and cosmetics. PET (100 ktonnes plus per annum) offers mechanical strength and clarity, and has been particularly successful in taking a major share of the carbonated drinks market. HDPE (about 100 ktonnes per annum) which is widely used for household and dairy products offers good mechanical properties and design flexibility.

For plastics to continue to be favoured, we must continue to offer competitive materials but we must also meet the environmental challenge. The public has experienced the reduction in the use of plastics in detergent bottles as brand managers encourage its members to regard alternative packaging as more environmentally "friendly". Lever and Proctor and Gamble have both marketed concentrates in carton form. Another example is plastic pouches marketed together with refillable tins.

It is essential to design plastic bottles which are easy to identify and recycle, whilst not putting unnecessary constraints on bottle designers. To achieve this it must be clear what the design criteria are which significantly affect recycling viability. This factor must be consistent in the overall recycling message so that it is understood.

Plastic bottles offer recyclability: Significant progress has been made to demonstrate that plastic bottles are recyclable and the work of RECOUP in the UK has been significant. The cost of collection and reprocessing, which are high when volumes are low, has been a constraint to growth. The promise of a funding system in the future will help keep the momentum going. However, there is a need to increase recycling rates rapidly to ensure plastic bottles continue to be regarded as environmentally "friendly". This is the major challenge for the industry.

The recycled content of bottles is a key issue for some major companies who wish to offer environmentally "friendly" products. Either by using co-extrusion or by incorporating recycled polymer in non-food contact bottles recycling of bottles into bottles may be achieved. This provides an opportunity to demonstrate to the consumer that plastics are environmentally "friendly".

Plastics can be reformed into numerous useful applications. Plastic bottles can be easily identified and separated from the waste stream. Recyclability of plastic bottles is a major strength and it must be utilised to the full.

Deposit of Bottles for Recycling

People are willing to deposit plastic bottles for recycling: When REPRISE began its project in 1988, it had no idea what the public response would be. Two hundred homes were targeted in Stockport, and the response was emphatic, with everyone targeted (and some not) sending in their bottles. People wanted to recycle their plastic bottles. This may seem fairly obvious today but it is a key lesson and without this desire, recycling would not be possible. 70% of those targeted in Milton Keynes now consistently deposit their plastic bottles.

Post-consumer recycling is a new industry. It is an industry with a bright future. The key issue is who pays? The challenge is to make recycling as economic as possible and one day it will be on a sufficiently large scale to be self-financing.

Some would argue that plastic bottles should be incinerated with energy recovery in mind and of course it makes sense to recover energy from those bottles that cannot be recycled for whatever reason. However, this will not satisfy our need as consumers to be involved in a process - hands on - by which we can contribute to recycling. Most of us do care!

Communication of what we want is vital e.g. CAPS OFF!!: The first step in recycling is generally in the household. It is vital that we only collect materials which can be recycled. For example up to 10% of bottle weight is in the cap. The caps add considerably to the waste and incur extra costs to remove them.

People do not like change so there must be clear and precise instructions at the beginning. This should be reinforced by regular contact, newsheets etc. and also with posters at deposit sites. On kerbside schemes, we should be able to reject unrecyclable materials at the household level. People want to be helpful so let us make best use of this willingness and free labour and give clear instruction. The need to remove caps which is addressed below is an example of how clear communication to the householder can reduce recycling costs.

In this case, if all caps were removed before depositing, recycling efficiencies could be improved dramatically.

The same principle applies at the Material Reclamation Facility (MRF). The reprocessor should give clear specifications for recyclable materials and reject non-recyclable elements.

Collection and Sorting

Integrated Material Reclamation Facilities (MRF) are needed to make recycling work: Until December 1993 REPRISE reprocessed loose mixed bottles collected locally and delivered, with non-sorting, direct to the plant. Non-recyclable content was typically more than 25%, which means total process losses were high with the consequent effect on economics. The loose bottles could swamp the factory giving no room for manoeuvre if a breakdown or other unplanned event occurred. There were also hygiene problems.

In contrast, when dealing with pre-sorted bales as feedstock, quality can be monitored and communicated back up the chain. Furthermore, the Local Authority is used to providing a waste disposal system for its citizens, so it makes sense for the Local Authority to collect recyclable materials as part of a waste management strategy. The Local Authority can communicate directly with each household to enable best possible value to be derived from the waste.

This approach has one additional key advantage namely, the ability to handle mixed recyclable waste in an integrated facility. Thus cans, glass, paper and textiles as well as plastics can be collected together and separated before onward shipment to dedicated reprocessors. Information from the USA suggests that plastic bottle collection can make a contribution to income for the Local Authority when combined with other recyclable materials.

These Material Reclamation Facilities (MRF's) will need to be on a scale which is economic. They will also need to utilise reliable machines which can accurately separate recyclable elements. Business plans will need to be developed to optimise the potential of collectable raw materials in each major city and town in the UK. We do not know yet what can be achieved and whether value can be derived from the waste stream at no extra cost.

Facilities such as that at Milton Keynes (£6m MRF) will be studied closely and will help point the direction. Waste levels as low as 3% have been consistently achieved. The Milton Keynes Borough scheme yields 8 tonnes of plastic bottles per week from 53,000 out of 75,000 households targeted (70%). On average this is about 100 grammes (2 bottles) per household per week.

In another town in the UK the MFR installed recently is collecting 4.5 tonnes of plastic bottles from 115,000 households. This is about 40 grammes (1 bottle) per household per week. Significantly this scheme is compulsory rather than voluntary and is experiencing waste levels of 70%. In the USA schemes are achieving 300 grammes or 6 bottles per household per week and where overall 19% of all bottles are recovered. If we assume 250,000 tonnes of plastic each year is converted into bottles which find their way into the home, then about 5 bottles per household per week (average 50 grammes) will be available for recycling. Funds need to be found for detailed statistical work to verify the amount of bottles available and how this varies across the country.

When the UK achieves the USA recovery levels of 19%, we can expect to reprocess 48,000 tonnes of bottles. This is a totally different scale from the current level of 4000 tonnes or about 2%. However, this is still a considerable achievement because 2 bottles in every hundred on the shelf are being recycled.

It is clear that a total systems approach is required to achieve success. Simply building a MRF and leaving bags or green bins will not work without effective communication and co-ordination together with a programme of continual improvement.

It is clear also from the Milton Keynes experiment that integration of commercial and industrial waste streams is the way forward, at least until volumes of domestic collection grow. 70% of the 9000 tonnes per annum (of mixed recyclable) is commercial rather than domestic waste. By combining industrial and commercial waste, Milton Keynes is able to set the objective of covering its running costs by April 1995.

Ultimately there is a need for integrated material recycling facilities which are designed for multi-material wastes and with integrated domestic and commercial waste processing capabilities.

A subsidy is needed to increase collection: Until large-scale, integrated MRF's are fully utilised it will cost Local Authorities money to collect and separate plastic bottles even allowing for income from material sales. Typically the deficit is between £100 and £200 per tonne depending on local circumstances. This means a subsidy system is required to encourage collection.

The Local Authorities currently collecting plastic bottles are doing so because they want to preserve the environment and they have a vision of successful recycling where plastics have a key role. We must not allow these pioneering efforts to fail. The UK government has now accepted industry recommendations that legislation is required to ensure the whole packaging chain participates in a system of funding.

It is important that any funding system encourages the collection and separation of recyclable material and not just large volumes of waste packaging. It should be possible to credit Authorities for materials actually accepted by the reprocessor. This will prevent large quantities of unusable material being collected and thus avoid the adverse effects this would have on public opinion. We should also think about how we ensure that reprocessing capacity will be in place to cope with rapidly increasing volumes.

Automation of sorting will improve efficiencies: The REPRISE project has been based on the premise that full automation of bottle sorting and flake production was the key to success. This led to the development of the VinylCycle PVC separator and to encourage Milton Keynes to incorporate this device in their "state of the art" plant. REPRISE together with a partner has also developed a concept of a new type of optical sorting device for plastic flakes. However, it has not yet been able to raise sufficient funding to implement the system.

Whilst today at REPRISE hand sorting is still needed at the beginning of the process, automation enables bottles to be sorted accurately at high volume. The health risk to workers is also reduced as they have less direct contact with the waste. We will always need people in our sorting plants but their primary function should be quality assurance rather than sorting bottles.

Companies like REPRISE need to work with Local Authorities especially those in large centres of population to implement fully automatic plastic bottle sorting systems including PVC, PET and HDPE so that we can build on the achievements of REPRISE and Milton Keynes. Funding will need to be found for this important development work. Each country has a unique recycling position but the UK should review systems in use throughout the world to learn from the experience of others.

Reprocessing

Bottle design determines costs and therefore the viability of recycling: If all bottles were designed for ease of recycling, most of the problems faced would be removed. The technology required to reprocess then would be a fraction of the cost. This is clearly not going to happen overnight but many design decisions are made today, without regard to the costs of recycling. There are numerous examples, such as high temperature melt glues which cannot easily be washed away and inks printed directly on the bottles which cannot be washed out, or blue tinted PET bottles which are confused with PVC, or PET G which is used for cosmetics and contaminates PVC and PET streams.

Perhaps the best known problem is the use of PVC seals in caps on PET bottles. The PVC seal will degrade when the PET is processed and contamination levels need to be below 50 parts per million and below 10 parts per million in some cases to have adverse effects. The specific gravity of PET and PVC being very close means density separation is not possible. The options therefore are to remove the cap before washing or remove the fragments of seal by some type of optical sorter. Both of which are expensive. One or possibly both of these devices will be installed at REPRISE.

At REPRISE we compared the costs of recycling baled bottles with most (but not all) of the caps already removed with baled bottles with most of the caps still on. Labour costs were nearly 50% higher, waste losses rose by 30% which means profitability fell by about 50% and the recyclate was of much poorer quality. PVC seals on PET bottles need to be phased out.

Even without the PVC seals the caps are major contributor to costs. The cap material, at up to 10% of the bottle weight, significantly adds to the waste costs. They are usually a different colour and/or polymer which means that unless they are removed, they will reduce the value of the recyclate. An example of this is coloured caps on white HDPE milk bottles.

The problem of coloured PET bottles also requires mention. Much of the success of PET recycling has been built on clear PET bottles being recycled into white fibre. There are limited markets for green and tinted bottles but there seems to be general agreement that the choice of a coloured or tinted bottle by the designer will limit PET recycling. This is why we must communicate the message to the designers to stick to clear bottles. Any shape of bottle or label design may be used but choice of a coloured or tinted bottle should be determined by environmental reasons.

Thoughtful bottle design will enable Local Authorities and Reprocessors to derive full benefit from automatic sorting systems and enable quality specifications to be met.

Specifications are essential: It is apparent that without specifications enforced by the reprocessor and ultimately the end-user, the Local Authority and the public will not know what to collect. Without a target to hit, improvements cannot be made.

The discipline of specifications means that each part of the chain understands what is required and what is not. The difference, as seen with the caps problem, can be significant in terms of costs and, in the long run, viability! Collecting waste costs money; but collecting useful raw material can add value.

Where possible these specifications can be standardised across Europe but each reprocessor must contract with his/her supplier on the basis of an agreed specification.

The best way to encourage meeting a specification is to place as high a value as possible on material which meets it and a financial penalty for material which does not. Any finding system to support recycling should take into account the need to enforce specifications.

Virgin polymer supply and demand will directly affect the economics of recycling: The price obtained for recyclate is related to supply and demand. When prices are high, virgin together with sub-standard grades are in short supply and a higher price can be obtained for recyclate. There may be some effects from end-users preferring recycled materials but this has not been experienced yet in the PET or PVC markets.

From our experience, realistic targets for PET appear to be 40-50% of bottle grade polymer prices and similar targets can be set for PVC in relation to bottle compound prices.

For PVC this means we can expect to obtain 70-75% of virgin polymer prices. At current prices this means break-even is a possibility. However, the prevailing virgin price is critical. For example when considering a model of running PVC only and virgin PVC prices are £400 per tonne i.e. the recyclate price is £280 per tonne, REPRISE as it is set up now, could not break even at capacity.

This means in addition to providing funding for collection there will need to be a system of support which enables the reprocessor to take domestic bottles in times when virgin prices fall below economic levels. The same principle applies when volumes are below economic levels and capacity needs to be maintained to cope with future growth. This is the current position at REPRISE.

Rapidly increasing volumes are needed for viability; this means integration with commercial waste streams: Integration with commercial and industrial streams is the way forward. There is now sufficient demand for recyclate but it cannot be met from the bottles from the UK collection systems. This means more effort being put into bottle collection although this depends on others to provide systems of funding to stimulate growth. It is imperative that a funding system is put into place rapidly, otherwise there is a danger of plastic bottle recycling declining. If a part of the infrastructure disappears it will be much more expensive to re-create it in the future and much public goodwill will have been lost forever.

REPRISE has been successful in establishing a recycling route for PVC display trays used by retailers. About 12000 tonnes of PVC trays are used each year. For the past 3 years the company has been working with the Plastics Industry Films Association (PIFA) and Marks and Spencer to evaluate the feasibility of recycling PVC trays. Earlier this year we began recycling trays for 43 Marks and Spencer stores. The trays are delivered to REPRISE for washing and granulation on the PVC line (which is cleaned prior to operation) after which they are converted back into trays at Anson Packaging. This will produce about 50 tonnes per annum. Marks and Spencer plan to extend the scheme shortly to two other regions. We are also planning with Boots and other major UK retailers to recycle their PVC display trays.

REPRISE has in addition, been active in using the scrap PVC and PET bottles from the manufacturing process. The recyclate has been kept separate from the domestic stream to ensure that there is no interference with our approach to marketing recyclate from domestic waste. However, the integration of systems of recycling of domestic and commercial waste streams makes sense at least until volumes grow significantly.

Marketing

Price is the main reason people buy recycled plastics: The demands for REPRISE PVC and PET are determined primarily by price. REPRISE is a source of cheap raw materials. The construction and fibre industries respectively which use these polymers have no motivation other than as a source of cheap raw material to promote packaging recycling. This may change in the future but the key to creating a demand for recycled PET and PVC is to have material of the right quality at the right price. Furthermore, some users of PVC would not wish to draw attention to the recycled content in their products. In the future, this may change as recycling takes a higher profile and major companies wish to be seen to be involved.

In the early days of plastic bottle recycling, the price paid for recycled HDPE polymer was above virgin - this is known as "the green premium". The price was driven by a desire by the detergent manufacturers to beat the competition at a time when recycled bottle flake was in short supply, by having recycled bottles on the shelves. It was also hoped the consumer would continue to pay a premium for recycled packaging. This is no longer the situation. The evidence suggests that most of us do not wish to pay more for recycled products.

The current marketing approach of the packaging specifiers is to use the recycled material if it is cheaper or at least no more expensive. However, the challenge in the UK is to find markets for 60,000 tonnes of plastic bottles as agreed between industry and the government.

Highest value and highest volume markets should be targeted: This may seem an obvious point to make. However, a few years ago, about the time the author joined REPRISE, mixed plastic applications such as wood substitute were being identified as target markets for bottles. This would have valued the recyclate at less than £50 per tonne into established markets.

It is worth emphasising at this point, however, that 100% recycling is a false goal. For instance, an application such as extruded pipe may only tolerate 10% recycled content but the total volume potential may be several thousand tonnes per annum.

There is also the question of whether it is a good idea for bottles to be recycled back into bottles. They will only be back again next week! Two aspects of the opportunity need to be examined.

First, there is value in the public being able to buy recycled products and see for themselves that recycling is happening. For example, it is possible to recycle PVC bottles back into non-food contact bottles at 20-30%, and REPRISE intends to do this. There is also the well-established route for HDPE as the middle layer of co-extruded bottles, and in some parts of the world for recycled PET as the middle layer of 3 layer drinks bottles. Furthermore, it is possible to recycle plastic bottles into other packaging applications such as PET or PVC trays. These are all relatively high value applications with potential for significant volumes. The number of times a bottle can go through the recycling process will be determined by experience but it is believed that recycled content can be optimised to give viable recycling for a number of recycles. However each bottle has a relatively short life before it needs reprocessing.

Second, it is possible to recycle packaging into second-life applications with a much longer life. This may be for many years as in the case of PVC which is used in construction applications. Here it may be claimed that there is a direct saving of energy in the manufacture of the virgin plastic and also an easily quantifiable saving of the earth's finite resources.

Both of these opportunities must be explored and both will have a role to play.

In the early days of recycling, there was perhaps a tendency to regard recycled bottles as only being suitable for low price, non-critical application where the material would not be subjected to a high specification. This is not the best way to approach to problem.

There are barriers to entry in some applications for reasons such as: surface finish, colour, odour and mechanical properties. However, by targeting applications which match the properties of the recyclate, the highest value can be obtained.

The key to markets is understanding quality requirements: To achieve success we must understand the quality requirements of the target market and the specification of the recyclate. This requires looking for a match of characteristics. It is not always the lowest price markets where this match can be achieved.

A clear example of this is EVC targeting PVC bottle recyclate into foam core profiles having a virgin/polymer skin. The mechanical properties and colour are not affected and there may actually be some benefits for the customer from using the formulation based on recyclate such as faster throughout. The PET contamination of about 0.05% is not critical in this application. However, it may be in other lower value applications such as extruded ducting where surface finish is critical and impact properties are affected.

To be able to target particular markets there must be the ability to measure the key characteristics of the recyclate e.g. PET or PVC contamination levels. There must also be control of the quality of the output with variable quality inputs. Understanding quality and measuring quality are the ways to obtaining the highest value for recycled bottles.

Fit for purpose is the criterion for market acceptability: We can find high-value markets for recyclate providing that proliferation of standards does not create artificial barriers. By artificial, is meant the need to consider the implications of using recyclate. Many of the standards in the construction sector have a "standard" clause which precludes the use of recyclate other than from the manufacturing process itself. Another well known example is the general use of a "General Specification" for HDPE wheeled refuse bins which states no recycled content. A final example is the UN standard for plastic drums where again no recycled content is allowed.

These barriers are there to prevent poor quality products. However, if the standards are focused on achieving fitness for purpose then the emphasis must be on having appropriate test methods and which exclude waste polymer use only on sensible performance grounds.