Natural rubber as a green commodity – Part II

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Introduction

IN THE LAST ISSUE of *Rubber Developments* Dr Wan Abdul Rahaman clearly demonstrated the 'green credentials' for natural rubber over its synthetic rivals (the key data are repeated below). Some may be tempted to question whether there are hidden energy costs in the transport, use and disposal of natural rubber which offset the low energy budget of the natural material which is largely due to its solar, rather than fossil fuel origins.

Natural rubber versus synthetic rubber

Material	Energy consumption, GJ/tonne
Natural rubber	16
Polychloroprene	120
SBR	130
Polybutadiene	108
EPDM	142
Polyurethane	174
Butyl rubber	174
Polypropylene	110

The data show the amount of energy which is required to manufacture raw natural and synthetic rubbers. It is obvious that natural rubber enjoys a very considerable competitive edge in energy terms as compared with synthetics. The energy required to harvest, process and transport natural rubber is approximately one quarter of that required for the feedstocks for the synthetics.

Natural rubber's hidden energy costs

There are some modest energy penalties involved in the processing of natural rubber, as compared with its competitors. These are the need to thaw bales under certain circumstances and a possible increase in the number of mixing cycles. The typical power requirements for rubber processing (natural or synthetic), including overheads like office lighting, are probably in the region of 20–30GJ/tonne. The US Big Five (Goodyear, Firestone, *etc*) consumed 31GJ/tonne in 1976: some of the individual process requirements for energy at that time are:

Banbury	4.1 GJ/tonne
Calender	6.6
Extruder	3.8
Curing	6.3

The first figure is in general agreement with measurements made at MRPRA at about the same time, which estimated 1.2GJ/tonne for mastication and 2.9GJ/tonne for mixing. Both the overall figure of 30GJ/tonne and the individual energy breakdowns are probably well in excess of the current best industrial practice. One efficient Scandinavian company claims to be able to mix for an energy cost of 0.4–1GJ/tonne within an overall energy requirement of 20GJ/tonne, or lower. British energy data for mixing reveal considerable differences between plants.

It is often, but not invariably, necessary to thaw bales of natural rubber before processing as heavily-crystallized natural rubber can damage mixing machinery. Thawing is a common, but not standard practice, in northern Europe and northern North America for two to seven months per year. Thawing is conducted in hot rooms which are maintained at 40–45°C. The dwell time ranges from two days to over a week. It has been calculated that the energy required to thaw natural rubber is $42 + 15t$ MJ per tonne, where t is the number of days taken to thaw. If a period of four days is involved, then the energy involved would be 100MJ. There has been a trend for the US rubber industry to move south: this will have lessened the need for hot rooms in that country. In any event the energy cost of thawing is relatively trivial. At the worst it is likely that mixing natural rubber may involve an energy penalty of between 10% and 15% as compared with SBR: this is trivial in overall energy terms.

Packaging

Many countries, and notably Germany, take a keen interest in packaging and argue that it is part of the supplier's task to arrange for its disposal, preferably by re-use or through a recycling operation. The construction of pallets and bale wrapping may need to be considered within the new context of environmental quality control.

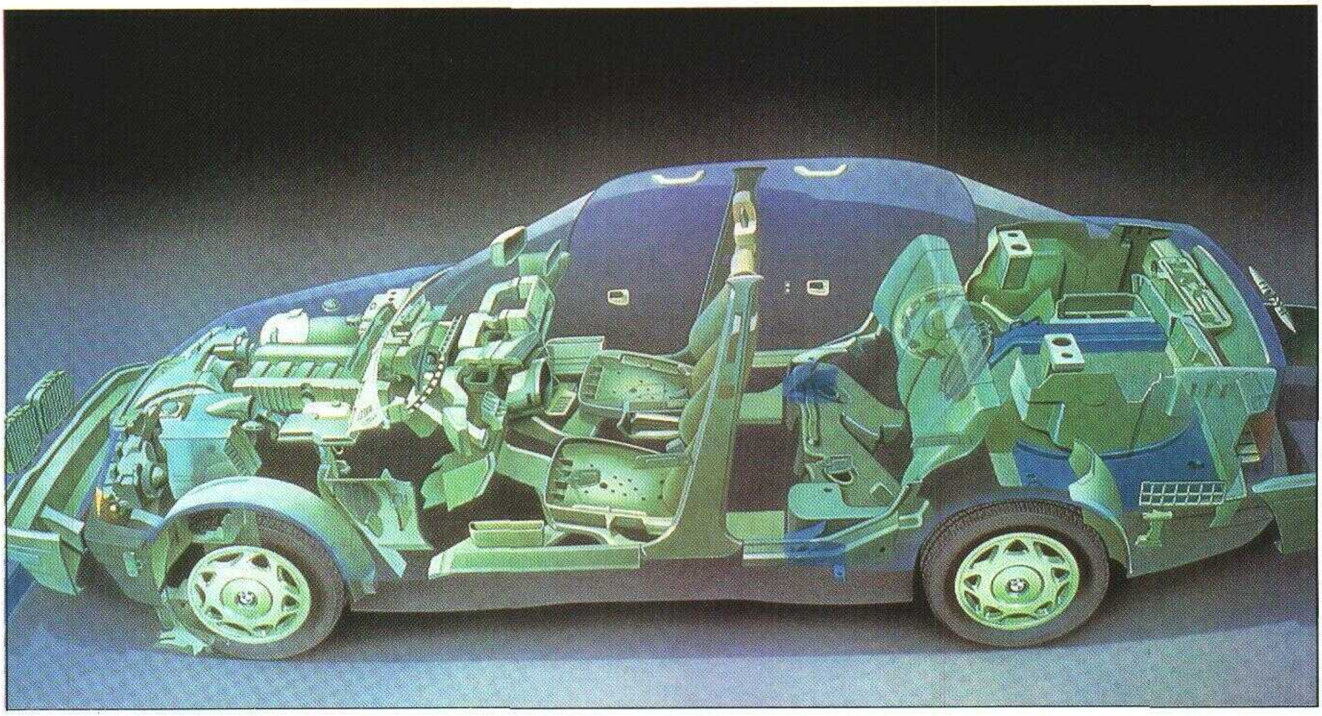
Environmental processing hazards

The rubber processing industry is subject to specific environmental control in some countries. In the United Kingdom there are specific health and safety/environmental protection regulations to limit the emission of dust and fumes from rubber processing operations. There is an implied assertion that such dust and fumes may be carcinogenic and that particular precautions must be taken. Access to areas where such activities take place has to be limited. It is not the rubber as such which is hazardous, but the accelerators and antioxidants which may be added to it. In this respect the rubber processing industry has never recovered from the industrial cancers which were caused by the long banned *alpha* naphthylamines.

Natural rubber processing sometimes involves an additional environmental hazard, namely odour. Although such odours may be characterized as being typical agricultural, most such odours are emitted in urban environments, where there is likely to be little sympathy. The odours originate from the ageing of proteinaceous material, and is a particular attribute of low grade rubbers. In some cases the unpleasant odours may be carried over into rubber products. When this happens it is probable that the processor will complain. Nevertheless, malodorous products may still reach the market place. If such products are identified as being natural rubber this may lead to a consumer backlash. A recent issue of *Rubber Developments* (Volume 46, page 35) showed how such odours could be greatly diminished by using SMR CV.

Recyclability

The automotive industry is being politically driven to introduce programmes for recycling the material from their products once they have



Major operators such as BMW are advertising their efforts to exploit an environmentally-friendly image. The increase in the use of thermoplastics is assisting this process. The picture shows a computer image of the new BMW 3 series; the recyclable components are coloured green, and the recycled components blue.

become life expired. Considerable progress is being made in Europe and the major operators, such as BMW, are advertising their efforts to exploit an environmentally-friendly image. The increase in the use of thermoplastics is assisting this process and many of the manufacturers are coding thermoplastic components to assist with the recycling process. An important side effect of this policy is that vehicle manufacturers are seeking to reduce the variety of thermoplastic materials to ease the recycling operations.

With the exception of tyres, the British automotive industry does not appear to be interested in recycling the elastomeric components even if thermoplastic elastomers (which are inherently recyclable) are substituted. The industry considers that all the engine compartment components will have been polluted by oils and exhaust gases, and that the external rubber components, like weatherstripping, will have been polluted by cleaning agents or by environmental pollution. If pressed to introduce recycling it is probable that the automotive industry will attempt to restrict the range of elastomers employed to reduce the problems of classification at disposal.

It is generally agreed that any form of elastomeric product recycling is difficult. This even applies to thermoplastic elastomers, where in service degradation and pollution damages the potential for recycling. Nevertheless, a producer of TPEs claims that it is possible to recycle automotive boots provided that they are subjected to a washing process. Furthermore, TPEs do save raw materials as the waste from scrap is greatly reduced: in the case of TPNR, however, the raw material does involve the use of a material (polypropylene) with a high energy content (110GJ/tonne).

Natural degradation

Very thin rubber products, such as balloons and condoms, will degrade naturally especially if they are subjected to natural sunlight. As is evident from the problems which are associated with sealing rings natural rubber is capable of being biodegraded. It should be possible to compost thin rubber articles: unfortunately the most important outlet for thin rubber articles is the medical industry, and the hazards of medical applications are liable to preclude the adoption of composting.

The presence of sulphur in medical gloves may create problems for their disposal by burning as the sulphur dioxide produced is liable to damage the incinerators. Radiation curing of the gloves can eliminate this problem. Radiation curing also reduces the zinc effluent problem which is associated with traditional curing methods for latex products.

Tyre recycling

Between 60% and 70% of natural rubber is consumed in tyres. In some countries, notably the USA, Japan, France, Germany, the UK and Brazil, over 75% of the natural rubber consumed is in the form of tyres. In many countries, especially those with high population densities, there is a growing awareness of a tyre disposal problem and this is accentuated when serious fires occur at tyre dumps. These fires can cause serious air pollution as well as damage to water courses. Consequently, some countries ban tyre dumping.

If the life of the product is extended then the disposal problem is reduced. There is considerable evidence that tyre life has increased. This has created problems both for the tyre manufacturers and for suppliers to the industry, but it has coincidentally reduced the scale of the disposal problem. Automotive manufacturers are seeking products which last for the whole vehicle life: any progress in this direction will be regarded as steps towards easing the environmental burden.

Retreading truck and aircraft tyres is normal practice. Aircraft tyres are designed for multiple retreading and airliner tyres may be retreaded up to eight times. Truck tyres may also be retreaded more than once. In some countries truck tyre life is also prolonged by regrooving. Relatively few passenger tyres are retreaded and this is mainly due to the lightweight carcasses which are employed. It is arguable that this may be better in environmental terms than retreading as the lighter weight will assist to reduce vehicle fuel consumption.

There are a limited number of non-destructive markets for old tyres. These include their use as reefs for fish farming, as fenders for boats and jetties, as footwear in poor countries, and as swing seats for children. The outlets extremely are restricted in relation to the scale of the problem.

Rubber crumb from tyres

If the old tyres are crumbed then the potential markets are increased to include play areas for children (which can greatly enhance safety) and rubberized bitumen for roads. The use of rubber in roads has had a long, long history and there is little doubt that the use of a wide variety of elastomers, including natural rubber in several forms, enhances the life and skid resistance of roads. Unfortunately, this is achieved by increasing the cost of a very cheap material and by marginally increasing overheads in a highly competitive industry. Thus a major market has never emerged despite pressure from both natural and synthetic rubber producers.

With few exceptions road funding is provided *via* central or local governments which attempt to minimize the cost of road repair. Most such bodies appear to be keenly interested in short term cost savings. This has inhibited the development of a market for rubber in roads. The same bodies, or more correctly different arms of the same bodies, are also aware of the problem of tyre disposal. It is possible that this second group might persuade those responsible for road repairs to incorporate tyre crumb as a component. There is no evidence to suggest that the addition of tyre crumb in any way detracts from the life of road surface dressings.

Although the use of recyclable crumb from tyres is using only a very small proportion of the millions of scrap tyres discarded every year, it is an idea worth pursuing. Progress is being made: two schemes which make use of crumbed tyres are featured on page 43 of this issue. Although tyre recycling involves natural and synthetic rubbers, any attempts seen being made to reduce the worldwide scrap tyre problem, can only improve natural rubber's image as a green material.

Reclaim

Chemical reclamation is capable of producing a material that can extend the overall life of the elastomer involved. The practice has virtually ceased in the west, but has continued in Eastern Europe and in India. Energy is involved in the process, and some methods also employ solvents. It could be argued whether it is justifiable to recycle products made from natural rubber in energy accounting terms. Some speciality elastomers are still reclaimed in the west: this may also be indicative of their high original energy inputs. Nevertheless, a new reclaiming plant is being built in the Netherlands – mainly to accommodate waste tyres.

Pyrolysis is frequently proposed as a means of extracting a useful range of raw materials from discarded rubber products. Such raw materials include oils and carbon blacks. There is little evidence that commercial success has been achieved with such processes, although new processes continue to be advocated.

An exciting novel method of recycling is currently undergoing tests at present. 'De-Link' is a material that breaks the crosslinks in vulcanized rubber, the recycled product can be revulcanized without the addition of extra materials and is likely to be a suitable material for a wide range of products (see the announcement on page 46).

Combustion remains the most promising technique for the bulk disposal of discarded tyres. It is a technique which is employed in some tyre plants to get rid of waste and faulty products: the heat generated is used to mitigate the loss. Some cement works add tyres to lessen the considerable call for fossil fuels in cement manufacture. The process appears to be limited by the amount of non-elastomer present in the tyre and by anti-pollution legislation.

The West Midlands Whole-Tyres-to-Electricity Facility at Wolverhampton, owned and operated by Elm Energy and Recycling (UK) Ltd, was the first power station of its kind in the UK. It generates over 175 000MW of electricity per year for the Grid by burning used whole tyres, and also produces useful by-products for the steel and zinc industries. Elm Energy's initial proposal for a tyre combustion facility was made in 1989, in response to the Department of Trade and Industry's requirement for a long-term solution to the nationwide problem of scrap tyre disposal.

Gates' wellington boots (LEFT) *and Dunlopillo mattresses* (ABOVE), *were both advertised as 'green' products to try and promote sales.*

A number of tyre disposal plants are proposed or are under construction. These are intended to produce heat to generate electricity. Problems include the elimination of sulphur dioxide from flue gases, gaining environmental approval to build such plants, obtaining contracts for electricity sales, and gathering sufficient fuel and storing it prior to use. Rubber has a high calorific value, but the geometry of tyres precludes efficient storage. Unfortunately, crumbing which eases storage adds to the energy and economic overheads.

It must be emphasized that the natural rubber element within the tyre will not add to the global CO_2 budget when the tyre is burned. As the natural rubber is produced from trees – the same trees are highly capable of re-absorbing the CO_2 to produce further rubber. Moreover, as fuel has to be burned in high latitude locations to provide heat and energy, old tyres form a useful fuel source, and a far less environmentally damaging one than the displaced coal or oil.

Exploitation of green image

Gates exploited the greenness of natural rubber to promote sales of its wellington boots. Consumer market research had shown that the general public was unaware of the difference between rubber and plastic boots. This research also showed that the public appreciated the excellent environmental image of natural rubber. On the other hand the company is also cautious about a potential backlash from the inclusion of environmentally unfriendly materials, like carbon black, in its black boots.

Dunlopillo foam also ran an advertising campaign which exploited the connection between environmentally-friendly rubber trees and its product. The campaign was considered to be a success, but the company is cautious in case of backlashes from such issues as energy consumption in production, effluent disposal and the inclusion of SBR latex in its products.

Most of the major tyre companies are introducing green tyres, which claim to be green through reducing rolling resistance (without loss of wear properties), hence reduced fuel consumption and reduced CO_2 emissions. Michelin, Goodyear and Continental have announced such products. Winter tyres based on OENR could also claim to be more environmentally friendly than their studded counterparts.

Suitable products for promotion as green products

Latex products are especially suitable. Household gloves have been marketed in this way. They are consumer products and they are a visible product. Balloons have been the subject of backlash in the form of danger to wildlife: in this case a more degradable product might have a sales edge, although this implies better packaging and the risk of consumer disappointment if the product is stored.

Latex thread and garment tapes could be marketed as being environmentally preferable to the energy-based polyurethane materials. This may be difficult to achieve, however, as the actual quantities of material employed greatly favours polyurethane: the threads are far finer.

Latex foam is less environmentally damaging than its cheaper polyurethane competitors. Polyurethane not only requires very high energy inputs, but is also associated with the use of CFCs and with dangerous household fires. Unfortunately many, but not all, of the the latex foam manufacturers also have more important interests in urethane foams. Low cost is very important in the furniture and car seating markets. Rubberized fibres (hair or coir) are environmentally friendly materials and are competitive with foams for upholstery.

Other consumer products which might exploit the natural rubber green image include hot water bottles, swim fins, bathing caps, bladders for sports balls and sports and leisure footwear. There is a draft European Union directive which may require footwear manufacturers to place a symbol on products which contain natural rubber.

Tyres form a far more complex market to exploit. Clearly all natural rubber used in place of synthetic is an environmental gain. Furthermore, an increase in the use of natural rubber would reduce rolling resistance, hence lower fuel consumption. Nevertheless, if this displacement leads to higher tyre wear, or poorer wet grip, or greater noise then there may be no environmental gain as environmentalism is a holistic concept.

General environmental debits

If an extreme stance is taken, then no industrial material can be environmentally friendly, as the processes and in many cases the end-uses exploit the use of fossil fuels. This is especially the case for tyres which are intimately associated with the automotive industry: to use tyres one has to burn fuel – even electrically powered vehicles are likely to use power generated from fossil fuels. Thus natural rubber, which has been shown to be a 'green material' is exploited within an energy consuming context. Globally, 14% of the carbon dioxide derived from fossil fuels can be attributed to road vehicles. In the USA this contribution reaches 24% of carbon dioxide production.

Private motoring is an extremely popular activity, and it would be an extremely difficult political manoeuvre to limit it. Nevertheless, the public has mixed perceptions depending upon use *versus* environmental damage. In the United Kingdom the presence of a small plot of environmentally sensitive woodland has been sufficient to interfere with a major stretch of traffic-relieving road near London. The Swiss have recently decided to ban trucks from using their Alpine roads for transit traffic as it endangers their mountain forests and increases the risk of avalanches.

Within this context natural rubber in tyres is only liable to be perceived as green if it can diminish tyre noise, reduce the fuel consumption of cars and other vehicles, or it can be shown that tyres last longer because of it. Furthermore, there are considerable energy accounting problems within the concept of a green tyre, but such products are being marketed. Lighter tyres reduce vehicle fuel consumption, but the lighter construction lessens the potential for retreading.

For every 100 parts of rubber in a typical tyre, there are 55–60 parts of carbon black and 20–30 parts of oils. The former is produced by combustion of fossil fuels: therefore the energy content is high (104GJ/tonne). The latter is much lower: 7GJ/tonne.

Although the quantity of sulphur in rubber products may not appear to be high it does create considerable problems for waste disposal by combustion as this leads to the production of sulphur dioxide which is a major cause of environmental damage to forests, buildings and health.

The German environmental ministry has published a report which claims that vehicles, especially their tyres, may be polluting the environment with heavy metals as they wear. The quantities involved per annum are 44 tonnes of lead, 32 tonnes of zinc, and 8 tonnes each of chrome and nickel (not all of which can be attributed to tyres). There are fears that such metals may find their way into water courses and thus lead to the pollution of drinking water supplies.

Conclusion

Natural rubber is an inherently environmentally-friendly material as its demands for energy during its production are trivial. In comparison synthetic rubbers are a contributor to the increase in global CO_2 levels. Furthermore, although natural rubber may require some extra energy to process this is still insignificant in relation to the total energy inputs for synthetics.

The only limitations to exploiting this 'green' image are the dangers of backlashes in various forms from a lobby which is not noted for its balanced opinions. It is hoped that this paper has indicated the care necessary to ensure that such sources of environmental dispute are known within the rubber industry and, if possible, minimized.

SCRAP RUBBER – REFUSE OR RESOURCE?

You will be very aware of the problem of waste rubber, especially used tyres, in the national waste stream. The problem is topical and many of your potential clients are trying to devise strategies to deal with it. It is highly likely that you will be asked to advise them with information and recommendations for solutions.

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It reviews the various types of rubber, the additives with which they are compounded, their principal properties, the products in which they are used and the volumes produced.

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The Study is available for £180, in hard copy format, from Rubber Consultants.

For further information please use the RD fax back sheet

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