OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

06208

Distr.
LIMITED

ID/WG.1[illegible]/10
28 February 1975

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Expert Group Meeting on the Study of
Synthetic versus Natural Products

Vienna, Austria, 16 - 20 September 1974

STUDY ON SYNTHETIC VERSUS NATURAL PRODUCTS
PILOT PROJECT ON THE RUBBER INDUSTRY
AND ITS IMPACT ON THE ENVIRONMENT 1/

by

B. Whittaker*

---

* UNIDO Consultant.

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.75-3011

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards even though the best possible copy was used for preparing the master fiche

CONTENTS

SECTION 2

SECTION 3

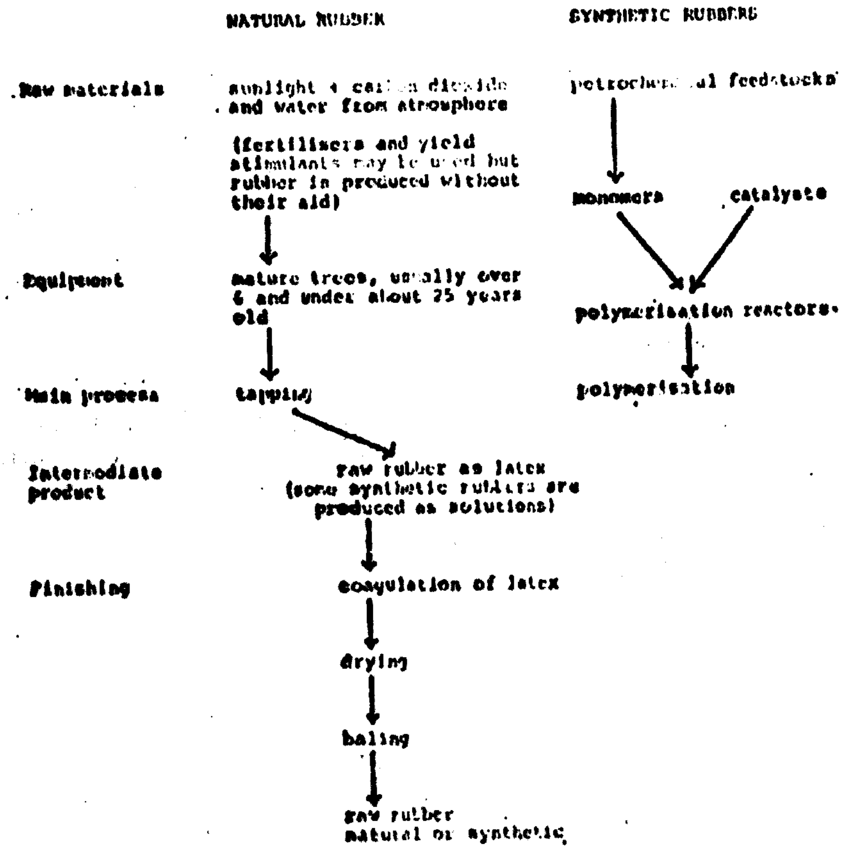
2 (f)

RELATIVE SOCIAL COSTS, BENEFITS AND THE EFFECTS ON THE ENVIRONMENT OF NR AND SR PRODUCTION

INTRODUCTION

There are major and obvious differences between the technologies of the production of natural and synthetic rubbers. Natural rubber is produced by nature in the tree and is essentially a free and reproducing process discounting the cost of land, tree planting and cultivation for about 6 years before the tree is ready to produce rubber.

On the other hand synthetic rubber production requires first the synthesis of monomers, almost invariably from petrochemicals, followed by their polymerisation. From this point onwards the technologies converge, for many synthetic rubbers, like natural rubber, make their first appearance in the form of aqueous suspensions of rubber particles: the latex. Processing of the latex into a marketable dry rubber follow a similar pattern. The following diagram shows the comparison of the two production processes:-



Discussion

Comparing costs of production of the two types of rubber (natural and synthetic) is difficult since, for example, NR production is very labour intensive and SR production is low labour intensive. The capital costs per ton of both types is about the same at approximately £250 per tonne at 1971 prices.

On average 1 worker on a NR estate produces about 1 tonne per year which sells at about £280 per tonne (July 1974 London price). The means that the labour is very lowly paid and any increase in the standard of living in the NR producing countries will inevitably have a marked effect on the selling price of NR.

On the other hand a SR plant producing say 20,000 tonnes per year employing about 100 people and selling their product at £350 per tonne (SBR price July 1974 UK) means a production sales value of £70,000 per man employed. Hence any changes in raw material costs (e.g. petrochemicals) have a marked effect on the selling price of SR.

20 refs.

2(g)

EFFECTS OF POLLUTION CONTROL ON NR AND SR PRODUCTION AND EFFECTS OF NEW TECHNOLOGY AND COSTS OF POLLUTION CONTROL

Very little information appears to have been published on this topic in relation to the rubber industry. Some of the references given under Section 3(a) of this survey may well, in their detail, contain some information with respect to this section. It is possible that some information on this subject may be held by the Central Environmental Pollution Unit or the U.K. Department of the Environment Library which are situated at:-

Department of the Environment,
2 Marsham Street,
LONDON S.W.1.

32 sources of general information on pollution control and the social effects of Industry.

3(a)

THE ENVIRONMENTAL AND SOCIAL EFFECTS OF THE RUBBER PRODUCTS MANUFACTURING INDUSTRY AND OF THE CHEMICALS USED THEREIN

INTRODUCTION

The Rubber Products Manufacturing Industry can be generally itemised, in terms of rubber consumption, as follows:-

Tyres and Inner Tubes	60%
Industrial Rubber Products	23%
Footwear	5%
Latex Products	6%
Other Consumer Products	6%

In terms of sales value the products can be generally itemised as follows:-

Tyres and Inner Tubes	50%
Industrial Rubber Products	37%
Footwear	2%
Latex Products	5%
Other Consumer Products	6%

The composition of these rubber products into the important groups of compounding ingredients and chemicals gives an average, on an estimated basis, compared with a typical car tyre composition, as follows:-

table overleaf

Component group	Average: all rubber products — Per 100 parts rubber polymer		Typical car tyre — Per 100 parts rubber polymer	
Rubber polymers	100	41.1	100	45.4
Carbon black	47	19.3	60	27.2
Whiting	15	6.2	-	-
Clay	13	5.3	-	-
White pigments, titanium dioxide etc.	2	0.8	-	-
Other inorganic fillers	8	3.3	-	-
Softening agents, consisting on average of more than 70% hydrocarbon oils, in tyres more than 90%	25	10.3	25	11.3
Zinc oxide	4	1.6	3	1.4
Stearic acid	1.5	0.6	1.5	0.7
Sulphur	2.5	1.0	2.2	1.0
Accelerators, on average 65% thiazoles and thiazole derivatives (more in tyres), 15% dithiocarbamates, 8% thiuram sulphides, 12% guanidines	1.5	0.6	1.2	0.5
Anti-oxidants, on average 80% amines, (more in tyres) and 20% phenols	2	0.8	2	0.9
Other additives	3	1.2	0.5	0.2
Textiles	14	5.8	18	8.2
Steel, e.g. bead wire in tyres	5	2.1	7	3.2
Total	243.5	100	220.4	100

The effects of polymer production are dealt with under Section 2(f) and 2(g). The production of other materials and chemicals are dealt with in this section together with the effects of actual rubber product manufacture.

DISCUSSION

(A) Chemicals used in Rubber Product Manufacture

It is well known that this industry is a huge consumer of chemicals and these range from highly hazardous to the worker to the innocuous. Proper environmental controls must be applied in order to handle them safely. In general, industrial hygenists use a basic guiding principle for all environmental health hazard control and that is: all materials are toxic to some degree. The problems are to determine the level or quantity at which a specific material is harmful or produces an adverse effect. It would be impossible for most industrial operations to occur if the requirement was for zero exposure of the workers to the materials. The definition of the hazardous amount of a material is frequently very difficult since it involves skills of several disciplines, including toxicology and medicine, and often requires controlled studies on animals and the observation of humans during their working lifetime.

The methods used for the control of environmental health hazards in the Rubber Industry are those that are generally used elsewhere. These are:

Modification of the Process.
Enclosure.
Isolation.
Substitution of a Material which is less Hazardous.
Personal Protective Equipment.
Ventilation.
The use of Shields or Barriers.

It is well recognised that the science of industrial hygiene is a highly specialised one and those personnel engaged in it in the rubber industry must be well equipped by training and experience to evaluate properly manufacturing processes with respect to environmental hazards and to devise proper means of control. They must constantly be knowledgable in the ever-changing spectrum of manufacturing operations and materials used. They must be well versed in proper techniques of air sampling that are applicable to the specific materials that present potential health hazards. Sufficient atmospheric evaluations must be made so that proper conclusions can be drawn as to whether or not a health hazard exists. If it does, then means of controlling it to safe levels must be devised.

The most effective control of environmental health hazards is accomplished by a combined use of appropriate environmental controls and proper examinations of personnel. The latter serve to pinpoint those individuals who are hypersensitive, as well as to provide proper documentary records for any future need by either the employee or the company. However, in order to be effective the examinations must be of a type whereby some biochemical change can be readily observed prior to the onset of symptoms of organic damage. The procedure must also be simple so that it can be readily done with little or no discomfort to the employee. It should be an index of over-exposure, not a diagnostic sign of existing disease. There are many acceptable procedures now being used for this purpose. Among them are: complete blood counts, chest x-rays, quantitative examinations of blood and/or urine for specific materials, such as lead and mercury; and liver function tests. However, there are still many materials that are used for which it is desirable to have some better index of over-exposure.

The actual and potential health hazards of the Rubber Industry fall into three general categories: inhalation of airborne dusts, vapours, mists etc.; skin contact whereby either dermatitis is produced, or systematic absorption may occur: physical agents, such as noise, and heat. Hazards from oral ingestion of toxic materials may be present, but in general, they are not the dominant factor. Oral ingestion can, however, be quite significant in the overall hazard of materials, such as lead, mercury, selenium and others, because this factor may increase the total body burden.

There are 15 literature references dealing with the toxicity of chemicals used in the Rubber Industry and also the possible toxic and health hazards of rubber products.

(B) Rubber Processing

The main processes used in the Industry are:-

(i) Preparation of the raw polymer for mixing:- usually involving bale cutting, mastication and polymer blending.

(ii) Mixing of the many other chemicals into the polymer either in an internal mixer or on an open two-roll mill.

(iii) Shaping of the mixed rubber compound either by forming (extrusion of hose etc., calendering of sheet, for conveyor belting etc.) or building either by hand or automated (e.g. tyres) or moulding.

(iv) Vulcanisation of the shaped product either in a heated press, a steam autoclave, or by a continuous vulcanisation system (e.g. hose, cable, extruded profiles etc.).

(v) Finishing of the product (e.g. trimming) and inspection.

There are 19 references to the above in terms of improved processing, handling, mechanisation and the pollution and water effluent from the processes.

C) Rubber Products and their Relationship with the Environment

Without rubber products there would be no Industry as we know it today. The effect on civilised life is wider and more far-reaching than most people realise. Just considering the major industries; chemical, engineering and transport, these could not exist, without a rubber industry supplying the products which they need in order to function.

The chemical industry requires plant, pipes, tanks, valves etc., lined with suitably compounded and specialised rubbers to prevent corrosion by the many environmentally hazardous chemicals produced.

The engineering industry uses rubber O-rings, seals, anti-vibration mountings etc., in order to produce its own products and supply the needs of the community

The transport industry could hardly exist without rubber. The car and commercial vehicle depend entirely on rubber for tyres, for the smooth vibration-free, engine; for the safety aspects (e.g. braking) and for the passenger protection.

20 references.

3(b)

THE PROBLEMS AND EFFECTS ON THE ENVIRONMENT OF THE POLYMER CONTAINING WASTE PRODUCTS PRODUCED BY THE RUBBER INDUSTRY AND IT'S CUSTOMERS

INTRODUCTION

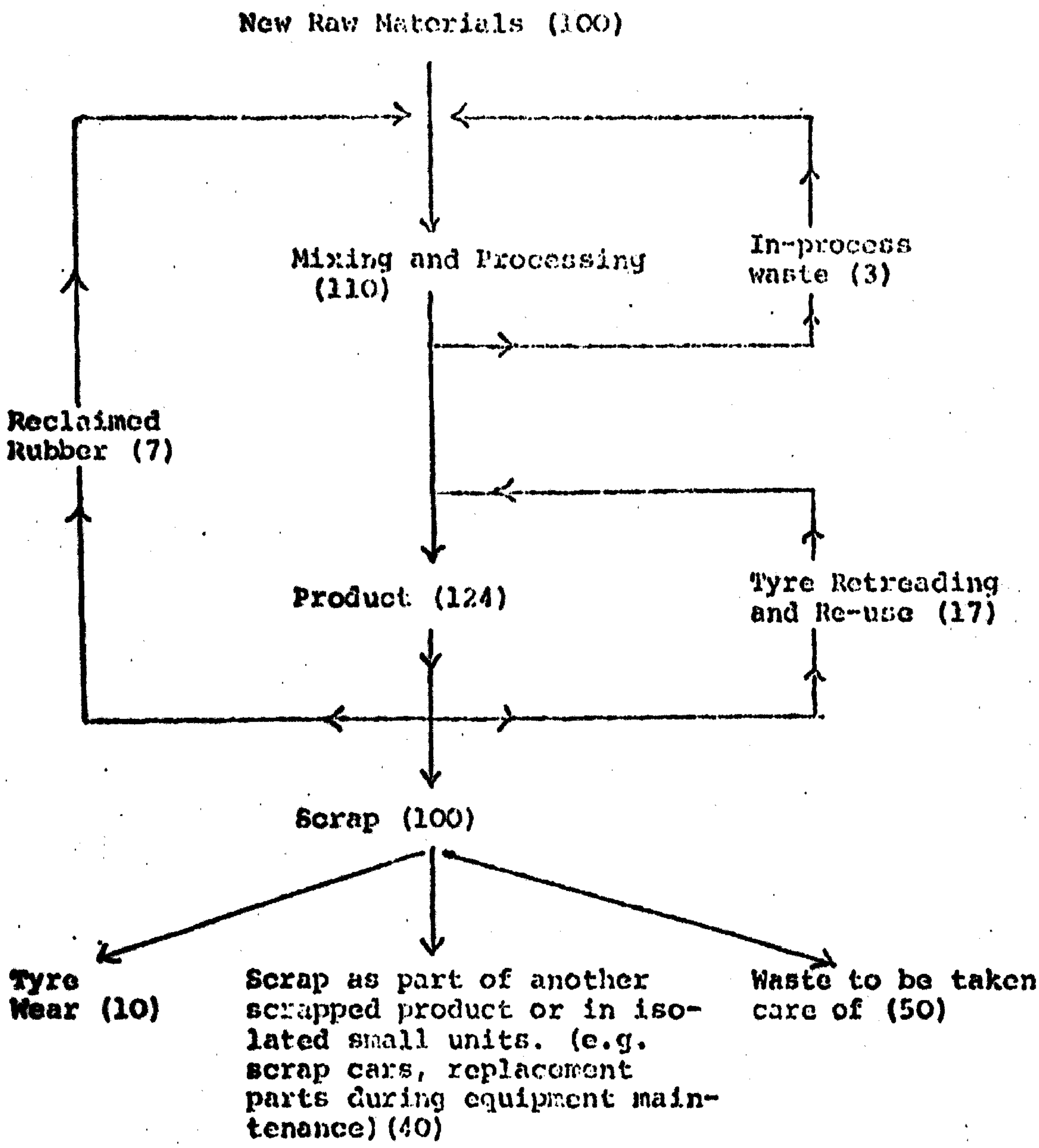
Since the largest volume of rubber is used in relatively short lived articles such as car tyres the average life of rubber products is as short as 5 to 10 years. If the car is taken as an example and not including the tyre about 30 Kg of rubber is scrapped in conjunction with the scrapping of the car.

If the tyre alone is considered then some of the scrap tyres go back to the rubber industry for retreading or reclamation. Tyre wear in use is an important factor in dispersion of waste rubber. In the USA about 350,000 tonnes per year of rubber is rubbed off the tyre and is normally in very small particle size. It has been estimated that for each kilogram of rubber worn off a tyre a car consumes about 500 Kg of petrol which probably pollutes the environment to a far greater extent.

Scrap rubber can be dealt with in a variety of ways, from re-using the product in a manner approaching as closely as possible the original function and employing the products original properties to simply disposal and tipping. The following table shows possible different ways of dealing with rubber waste taking the tyre as an example:-

Usefulness of scrap	Principle	Example	Degree of decomposition or conversion	Cost of collection, sorting, preparation, etc.
HIGH	1) Reuse with product identity unchanged.	Retreading, scrap tyres as dock fenders & artificial reefs.	NONE	HIGH
↑	2) Reuse as another rubber product.		↓	↑
	3) Reuse in rubber product after modification of material.	Reclaiming.		
MODERATE	4) Addition to other materials/product.	Addition to asphalt for road surfacing.	MODERATE	
↑	5) Use of products of decomposition.	Pyrolysis.	↓	
	6) Source of fuel.	Steam generation.		
NONE	7) Destruction/tipping.	Burning, tipping	TOTALLY CONVERTED	LOW

Waste is also generated during the rubber product manufacturing process. In many cases the material can be re-used in the factory either by re-processing in the same product process line, downgrading of the material to another, less demanding product or by returning the used product to the factory and by additional processing returning it to the consumer as the same product (e.g. retreading tyres). All material must end up as scrap or waste at some time and the following diagram illustrates an estimated cycle for the new raw materials through to waste based on a 100 weight units of input new raw material.


New Raw Materials (100)
Mixing and Processing (110)
In-process waste (3)
Reclaimed Rubber (7)
Product (124)
Tyre Retreading and Re-use (17)
Scrap (100)
Tyre Wear (10)
Scrap as part of another scrapped product or in isolated small units. (e.g. scrap cars, replacement parts during equipment maintenance) (40)
Waste to be taken care of (50)

DISCUSSION

(A) Re-use of Rubber Products

Listed below are a few examples of the re-use of rubber scrap, especially scrap tyres, for purposes other than the original. At present this area of disposal does not constitute a particularly large volume. The reasons are limited adaptation of the material to its function, and the fact that much manual labour is often required for preparation; this means that it is more efficient to manufacture a new product directly suited to operating requirements. On the other hand, in times of blockade and shortage of raw materials, the "tyre splitting industry"has been very extensive.

Examples of scrap rubber's uses, especially scrap car tyres, for purposes other than the original include:-

(a) fenders for boats, jetties, quays etc.;

(b) explosion screens (pieces held together by steel rope);

(c) entrance mats, floor coverings (pieces of tyres or conveyor belts held together by pins, etc.);

(d) soles for sandals in developing countries (cut from used car tyres);

(e) solid wheels (rounds stamped from tyre sides and assembled into packages);

(f) gaskets, distance pieces (stamped from tyres casings, first flattened in a heated press);

(g) padding of exposed points on motor-racing circuits;

(h) padding for crash protection on bridge columns, poles, trees, etc., along roads;

(i) stabilising canal and river banks;

(j) swing, sandpits and other play facilities;

(k) non-slip livestock bedding (chopped car tyres);

(l) porous, soft coating of pavements, play and sport areas, etc. (chopped scrap rubber mixed with a binder of an attractive colour);

(m) artificial reefs for better fishing.

Of particular interest, in view of the large volume expected to be required, is the use of scrap tyres as artificial reefs intended to increase the number of fish for recreational and commercial fishing.

At first sight this appears simply to be a poor excuse for dumping scrap tyres on the sea bed, but the proposals and experiments are backed by several serious scientific investigations carried out with the support of the United States Government, among others. It is said that 1 to 1.5 thousand million tyres could be used along the American East Coast, laid with an average density of one ot two tyres per m^2, of sea bed. Of course, the tyres would have to be assembled in a special way to prevent their moving around or being washed up on beaches. They would have to be punctured to prevent air pockets causing them to float.

It must be noted that re-using tyres as artificial reefs does not really constitute a final solution to the scrapping problem, except where the solution does not directly replace newly manufactured products. Instead it simply means an extended life - "a new lease of life" - for the tyres. At some future time the question of scrapping would be bound to recur.

There are 6 references to re-use possibilities.

(B) Reclaiming of Rubber

Reclaimed rubber is a useful compounding ingredient in new polymer compounds since it contains about 50% rubber and is already plasticised, and thus lowers the power consumption in mixing. Many methods of reclaiming rubber are shown. 9 references.

(C) Pyrolysis and Destructive Distillation of Scrap Rubber

Pyrolysis, is breaking down organic material by heating in the absence of oxygen, is one proposed method of destruction of domestic refuse. It has been developed fully in such countries as the USA and Denmark, and has been studied in Sweden at the Institution for Chemical Engineering of the Swedish Royal Institute of Technology.

Pyrolysis of rubber is a technique employed for many years to study rubber's chemical composition, and later with a view to converting scrap rubber into usable products.

A typical pyrolysis gas from scrap rubber contains about 50% hydrogen and about 35% methane and ethane; that is, roughly the same composition as ordinary town gas. The liquid fractions consist of parts of the polymer chain (oligomers) and low hydrocarbons of varying compositions. The proportion of gas increases and the liquid fraction decreases as the pyrolysis temperature rises.

The pyrolysis gas can be employed for heating the pyrolysis process or for other useful purposes, and as a process gas for the chemical industry. The liquid fractions can be used, for example, as solvents, softening agents, reclaiming oils, petrol additives, synthetic raw material or as fuel. There is also a proposal to remove the carbon black contained in the original material from the liquid pyrolysis products by centrifuging - thus reclaiming it. The solid residue, which consists of 85-90% carbon and 8-9% ash, can be used as fuel, a filter medium in cleaning processes or as a substitute for carbon black.

The production of town gas from carbon is an old, well-known pyrolysis process. At a gasworks in Tokyo the carbon is mixed with 10-15% of ground rubber.

One method of using scrap rubber, which falls between pyrolysis and burning, is to mix in ground scrap rubber in oil to manufacture carbon black. First, the bead wire is removed from the scrap tyres. The tyres are then ground into a fine powder, which is mixed in a proportion of 10% at 225°C, and with vigorous stirring, in oil in order to produce carbon black, so that the rubber is broken down and dissolved. Carbon black produced in this way has been shown to have properties comparable with conventionally produced carbon black. The ash contents in the scrap rubber is so high, however, that current strict demands on the ash content of carbon black preclude more than 10% of scrap rubber being added. In addition, the ground scrap rubber must compete in price with a raw material costing about 25 US $/ton, which is probably less than the cost of collecting, preparing and grinding scrap tyres. If 10% ground scrap rubber could be used for all carbon black production, 10-20% of all scrap tyres would be consumed.

7 references.

(D) Burning of Scrap Rubber to Recover the Energy

Burning rubber waste without taking special measures, for example in open fields or conventional furnaces, involves considerable disadvantages and difficulties. Among these are the substantial soot and smoke produced, while some of the rubber melts on heating and consequent decomposition; on a large scale the melted rubber can contaminate water and form large lumps that are difficult to burn or give rise to other difficulties; then there is the unpleasant smell of certain unsaturated compounds ("burning rubber").

Undiluted rubber waste (scrap tyres) should therefore be burned in specially designed furnaces, in which disadvantages are eliminated.

8 references.

(E) Other Means of Disposal of Waste Rubber

Waste rubber has several advantages for tipping; it does not smell; it gives off very few water-soluble foreign substances which could contaminate ground water; people and animals cannot be harmed if it is tipped directly in the countryside; it does not attract vermin, bacteria or bacteria carriers; but, on the other hand, it is not aesthetically attractive (not even to rubber engineers!); it takes up a large amount of space (complete tyres weigh about 200 kg/m^3 though the volume weight can be raised to about 800 kg/m^3 by crushing compared with about 1200 kg/m^3 for the solid material); because of its softness and elasticity it is unsuitable as a filling material where buildings are to be erected.

To reduce the volume of scrap tyres, commercially available crushers may be used to grind complete tyres into pieces as large as the palm of one's hand. There is discussion about the feasibility of mobile plants in England and the USA. Interest is particularly great in Japan, where a new law requires that, after 1973, waste must be reduced to a particle size of not more than 15 cm.

Refuse tipping is normally based on the principle that the material will gradually decompose and be assimilated into the natural cycle. Of course, rubber does not corrode but it does age; that is, it decomposes through oxidation. The speed of this process is doubled by a temperature increase of about 10^o. Rubber can also be broken down biologically by moulds and bacteria.

If there is no economic justification for using scrap rubber nowadays in other ways and if we wish to benefit by the predictions of a crude oil shortage in the future, the logical consequence ought to be to conserve rubber. It would be convenient to use a disused mine or similar shaft, at the edge of which a tyre crushing plant would be installed. Then, in 30 years, when the world's raw material resources run short, the mine will contain a supply of raw materials which can be utilised in, say, an adjacent reclaiming plant. If the speculation turned out to be wrong, the material could always act as fuel. Tyres should not be stored in heaps in the open, since the risk of their catching fire as a result of sabotage or lightning is great over a long period. Besides, such a fire is almost impossible to extinguish and creates considerable environmental pollution. Even though the amount of chemicals that will be washed out of rubber which has been in use for some time is very small, the rubber store should not be sited close by a lake or river.

"Saving" scrap rubber has been the obligatory solution internationally of the scrap tyre problem in the absence of other suitable methods. Large numbers of scrap tyres accumulate in yards and refuse tips or are thrown into gravel pits, disused coal mines etc.

There is no lack of discussion over suitable methods of dealing with scrap rubber. The final decision is a question of technical, economic and environmental factors, which are the subject of political decisions. Different methods require different degrees of sorting, handling, transport and preparation of the waste, and this must also be included in the costs. Before accurate comparative calculations have been made for the various processes, it is difficult to make any firm recommendations.

There are 22 general references on the disposal of waste rubber.

75.08.11