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Foam Products Manufacturing Technology

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Latex foam rubber is defined as cellular rubber produced from rubber latex with open or interconnecting cells. Cellular rubber made from dry rubber with predominantly open cells is called sponge rubber. Earlier attempts to make cellular polymeric materials were all from dry rubber.*

29.1 PROCESSES FOR FOAM MANUFACTURE

Latex foam is manufactured by different processes. Most important among these are the Dunlop process and the Talalay process. The Dunlop process is done both in batch and continuous operations. Most small-scale foam rubber manufacturers use the batch process for foam production. Considering the importance of the batch process its details are given first.

29.1.1 Batch Process

Foam manufacture from natural rubber latex entails several steps, including preparation of latex and chemicals, compounding, foaming, gelling, and vulcanization. In the batch process the steps starting from foaming differ from those used for the continuous process. Batch operation starts at the mixer, where foaming takes place. Compounded latex is subjected to whipping action in the bowl of a frothing machine, a device that resembles a cake mixer in its operation.

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*Latex technology is covered in detail in Chapter 28. This chapter highlights the manufacturing technology, defects, and remedial measures, associated with foam products, as well as testing and quality control with reference to these goods.

As whipping proceeds, the volume of foam produced increases. This expansion is essentially due to the froth forming soap added to latex at the time of compounding. Also, however, the special design of the foaming machine is helpful in incorporating a large volume of air bubbles into the latex at every stage of its rotation. These bubbles become smaller during the ongoing rotation, and the process continues.

When the desired degree of expansion has been achieved, the whipping rate is reduced and the foam refined by rotating the mixer rotor at a lower speed. In most modern foaming machines there is provision for two or three mixer speeds. Refining of foam is not possible in single-speed mixers. During refining, all large bubbles will be eliminated, and the remaining bubbles/cells will be nearly uniform in size. After foam refining, gelling agents are added to latex in stages. Zinc oxide dispersion is added first, followed by a dispersion of sodium silicofluoride. The dispersion of silicofluoride may be added at 20% concentration and at a pH of 6–7.

After the gelling agent has been added, the latex will solidify within 2–3 minutes. It is transferred to molds while it can flow and fill the mold cavities. The mold lids should be placed in position immediately after filling. It is preferable to use molds preheated to 40–45°C. Gelation will be complete in 6–10 minutes. After gelation, the molds are placed in autoclaves for vulcanization. When the curing period is over, the molds are removed from the autoclaves, slightly cooled, and the foam stripped out. After each operation the molds are cleaned well and treated with such mold release agents as silicon emulsions or carboxymethylcellulose solutions. Low molecular weight polyethylene glycols are also used as mold release agents.

29.1.2 Continuous Foaming Process

In the continuous foaming process, a system seldom used in developing countries, special machinery is used to ensure continuous operation in all stages of foam manufacture. Compounded latex and air are admixed at the base of a long vertical chamber and whipped using a cage-type beater. The foam produced overflows into a second chamber, where gelling agents are added with further stirring. The foam is then transferred to molds loaded on circular conveyors [1].

The details of using various types of continuous mixing machinery in latex foam manufacture may be found in Blackley [2].

The following advantages are claimed for the Oakes continuous mixer:

1. There is uniformity in product quality, cell structure, and size.
2. The foam density can be easily varied and controlled within tolerance limit of ±2%.
3. Lower density foams can be prepared without unduly long whipping actions in the latex.
4. Process loss is reduced in bowls and vessels.
5. Labor costs are reduced.

29.1.3 Talalay Process

In the original Talalay process, expansion of latex was brought about by a chemical process involving liberation of gas in a latex matrix. Hydrogen peroxide and the enzyme catalase were added to compounded latex to induce expansion. Later, it was learned that addition of easily volatile solvents and application of vacuum bring about the same effect. In the process now used extensively, a combination of mechanical and vacuum application procedures is used to expand the compounded latex. Gelation is brought about by a combined action of freezing and circulation of carbon dioxide gas.

Usually in this case gelation occurs at pH range of 9–11. Details of this process are given by Madge [1]. The Talalay process is more suited for automatic production techniques. More than 40% of foam rubber production in the United State and Canada is through the Talalay process. This process also helps in making good quality foam products from blends of natural rubber (NR) and styrene butadiene rubber (SBR) latex [3].

29.2 COMPOUND DESIGN AND PRODUCTION OF FOAM THROUGH THE DUNLOP PROCESS

Natural rubber latex concentrate of 60% d.r.c. [high ammonia (HA) and low ammonia (LA) types] is the main raw material used in foam production. SBR latex is used along with NR latex, however. Shrinkage of NR latex foam is more than that from SBR latex; but the load-bearing capacity of SBR-based latex foam is inferior. Thus SBR is seldom used alone in foam production.

The HA type of natural rubber latex will have ammonia content in the range of 0.7 vol % of latex. In the LA type, ammonia content will be around 0.2 vol %, along with a secondary preservative. The most popular and widely used LA-type latex is NR latex concentrate preserved by tetramethylthiuramdisulfide (TMTD) and zinc oxide. Here the ammonia level is 0.2 vol % and the level of ZnO and TMTD is 0.025 vol %. In foam rubber production by the Dunlop process it is necessary to use low ammonia latex to avoid foam collapse and delayed gelation. When HA latex is the starting material, it must be deammoniated by agitation and air blowing.

Among the chemicals used in foam manufacture, foam promoters and stabilizers have a prime role. Most foam promoters used in industry are soaps of the higher fatty acids. Rubber technologists generally prefer a mixture of potassium oleate and castor oil soaps for this purpose. For natural rubber latex, the concentration of foam promoters varies from 0.5 to 2.0 parts per 100 parts of dry rubber. Synthetic latices generally require less foaming agent to achieve a given expansion. Foaming efficiency depends on pH. Best results are obtained at pH values around 8–10. As the length of the hydrocarbon chain of carboxylic acid increases, foaming efficiency also increases. But the solubility of the soap solution decreases with an increase in chain length.

Polyethylene oxide condensates also are used as foam promoters. The foam stabilizers usually used are amines, proteins, and quaternary ammonium salts. Most popular among these are amines. Diphenyl guanidine (DPG) is extensively used in the foam industry. It is thought that foam promoters impart a measure of stability to the serum–air interphase by some kind of absorption effect. It is also believed that these amines preferentially sensitize the serum–rubber interphase and accelerate gelation of the latex before foam collapse occurs. Proteins are also used as foam stabilizers.

29.2.1 Gelling Agents

In the Dunlop process, sparse quantities of soluble alkali metal silicofluoride and zinc oxide are used as gelling agents. In natural rubber latex, sodium silicofluoride is preferred, while in synthetic latices mixtures of sodium and potassium silicofluorides are used.

Table 1 Formulation for Foam Manufacture

Ingredients	Parts by weight	
	Wet	Dry
60% Centrifuged latex	167	100
20% Potassium oleate	2.5	0.5
50% Sulfur dispersion	4.0	2.0
50% Zinc diethyldithio carbamate dispersion	2.0	1.0
50% Zn MBT dispersion	2.0	1.0
50% Antioxidant sp emulsion	2.0	1.0
Stage II		
20% Potassium oleate solution	1.25	0.25
30% Potassium castrol soup	0.83	0.25
Ground whiting (67%) (filler)	30.0	20.0
50% Vulcafor (extended fatty acid)	1.6	0.8
50% Zinc oxide dispersion	8.0	4.0
20% Sodium silicofluoride dispersion	8.0	1.6

In the manufacture of natural rubber latex foam by the Dunlop process, 1.5 parts of sodium silicofluoride and 3.5 parts of zinc oxide per hundred parts of dry rubber are used. In SBR latices the dosage of silicofluoride is higher.

In addition to the foregoing ingredients specifically used in foam manufacture, vulcanizing agents, antioxidants, and fillers are necessary. Typical formulations used in foam manufacture are given in Table 1.

Compounding of latex is done in stages. In stage 1, chemicals other than gelling agents and foam promoters are added. This stage, also called the maturation period, is usually 1–3 days. It is believed that during maturation a proper colloidal equilibrium is attained between the chemicals and the latex and that a small degree of crosslinking occurs in the latex. Foam promoters and gelling agents are added in the second stage.

29.2.2 Formulations of Foam Rubber Based on Polychloroprene (Neoprene) Latices

Neoprene type 60 latex is the most commonly used Neoprene latex for foam production. Foam based on Neoprene latices is needed in some special applications requiring resistance to fire, oil, and oxidative degradation. Foam from some types of Neoprene latex have poor hot tear strength, and rejections and losses occur when such latices are used for producing thick foam slabs. Table 2 gives typical formulations for foam production from Neoprene latex. In these formulations, sulfur, *P,P'*-dibenzylquinone dioxime, and sodium dibutyl dithiocarbamate act as curatives.

Gelation is not directly dependent on concentration of sodium silicofluoride. It is influenced by such factors as initial pH of the latex, soap content, temperature of the latex compound, and duration of whipping.

Polychloroprene latex foam shows a high percentage of shrinkage. Fillers (e.g., mica, diatomaceous earth, ground silica) are found to reduce shrinkage.

Table 2 Neoprene-Based Formulation for Foam Production

Ingredients	Parts by weight	
	Dry	Wet
Polychloroprene (59% latex)	100	169.5
50% Zinc oxide	7.5	15.0
50% Sulfur	2.0	4.0
50% *P*,P′-dibenzylquinone dioxime	2.0	4.0
50% 2,2′-methylene bis(4-methyl,-6 *t*-butyl phenol)	2.0	4.0
40% Petrolatum	3.0	7.5
25% Sodium dibutyl dithiocarbamate	1.0	4.0
50% Catechol	1.0	2.0
15% Foam stabilizer	0.10	0.67
20% Sodium silicofluoride	2.0	10.0

Source: Ref. 2.

29.2.3 Principles of Gelation

Latex gelling may be defined as a homogeneous coagulation. Two types of gelling system are used in foam production, namely heat gelling and delayed-action gelling.

The most important type of heat gelling system is the zinc oxide–ammonia salt system. In such gelling systems both zinc oxide and the ammonia salt are used in solution. It is believed that zinc oxide dissolves in the aqueous ammonia solution present in the latex serum to form zinc amine complexes. At room temperature and at higher ammonia concentrations, tetramine complexes are formed, whereas at higher temperatures lower amine complexes are obtained. It is believed that the lower amines are responsible for inducing gelation. The gelling pH at room temperature in a zinc oxide–ammonium salt system is 9–10. Experimental evidence shows that gelation is induced by removal of fatty acid soaps as insoluble zinc salts by the lower zinc amine complexes. Formation of lower zinc amine complexes is favored by raising the temperature. This explains the rapid gelation noted in the zinc oxide–ammonia salt system.

Polyvinyl methyl ether (PVME) also is used in heat gelling. This nonionic stabilizer is soluble in water at room temperature but is precipitated as the temperature is raised. The property is also made use of in foam gelation by heat-sensitizing latices containing PVME. For satisfactory heat sensitization with PVME, pH should be around 8.0 in the absence of zinc oxide. When zinc oxide is also present, gelation occurs in the pH range of 9–9.5.

Polyglycols also give heat sensitization in NR latex. Poly glycols are preferred in foam production because they can be gelled at alkaline pH (9–10.8) in the presence of zinc oxide. PVME is preferred in the production of dipped goods by heat sensitization.

29.3 DELAYED-ACTION GELLING SYSTEMS

A good delayed-action gelling agent can be easily incorporated in latex and will bring about gelation only gradually and after a reasonable time interval. Most successful among delayed-action gelling agents are the fluoro complexes, including the fluorosilicates, fluorostannates, fluorotitanates, and fluorozirconates of sodium and potassium. These compounds are only sparingly soluble. Sodium fluorosilicate dissolves only to the extent of 1%. Potassium salts are less soluble than sodium salts. Fluoro compounds are added to latex as aqueous dispersions. The pH needed to achieve 20% aqueous dispersion of sodium silicofluoride is 3.3. The most satisfactory dispersing system for sodium silicofluoride is bentonite clay. A small amount of surfactant active at pH 3 can also be added if needed. Naphthaline formaldehyde sulfanates are suitable for this purpose. Despite its acidic pH, sodium silicofluoride dispersion is so little soluble that the dispersion can be added to ammoniated latex without risk of local coagulation.

For a standard ammonia-preserved natural rubber latex, thickening does not set in until the pH has fallen to about 9.2. The latex gels in at a pH value that is reproducible and characteristic. After gelling the pH falls, but seldom below 7.5. When sodium silicofluoride alone is used to obtain an uncompounded ammonia-preserved latex, the gelling pH is well on the alkaline side of neutrality. Comparison of sodium and potassium salts of fluoro compounds indicate that sodium salt is a more active gelling agent, presumably because of its faster hydrolysis. Potassium salts can be used to control gelling in unstable latices.

29.3.1 Mechanism of Delayed-Action Gelling by the Fluoro Complexes

As noted in the preceding section, when sodium silicofluoride alone is used to gel an uncompounded ammonia-preserved latex, the gelling always occurs on the alkaline side of neutrality. The hydrolysis of sodium silicofluoride is represented as follows:

$$2Na+SiF_6 \rightarrow 2Na+SiF_6^{2-}+4H_2O \rightarrow Si(OH)_4+4H+6F^-$$

Hydrofluoric acid is liberated in this hydrolysis. If the gelling were due solely to the acidity developed, the gelling pH would have been in the acidic range. Thus it is believed that part of the gelation process is due to the powerful absorptive effect of silicic acid, formed simultaneously on the stabilizers of the colloidal system of latex. When zinc oxide is present in the latex, it also plays a role. Thus ammonium fluoride formed from HF and NH_4OH reacts with zinc oxide, forming zinc amine complexes, which in turn attack soaps in latex to form an insoluble zinc soap.

A detailed study of the mechanism of gelation of latex-containing soaps indicated that a range of fatty acid soaps decompose at pH around 8 with formation of an acid soap complex. From this it is concluded that the production of a firm gel from an ammonia-preserved 60% latex, using sodium silicofluoride as gelling agent, depends on three factors: (a) the reduction of latex stability by formation of hydrofluoric acid, (b) the sensitizing action of the silicic acid formed simultaneously, and (c) the removal of soap, the protective layer of rubber particles in the latex, by the formation of an oil-soluble acid soap or an insoluble zinc soap.

29.3.2 Gelling Properties of Special Latices

When new preservative systems are used in NR latex preservation or when special stabilizers are used in latex to boost M.S.T., the gelling properties observed may differ from those enumerated above. In a latex stabilized with ammonium laurate or sodium laurate, zinc oxide will not react to replace soap because the laurates will not react with

with zinc oxide. Preservation systems such as zinc dithiocarbamate and boric acid also create problems. In the former case MST is low because zinc is stored in the latex. Here the zinc may be complexed with a sequestering agent to overcome the problem. Pentachlorophenate-preserved latices have high MST and chemical stability. They will not react with zinc oxide. Here secondary gelling agents must be used to obtain the desired gelling effects.

29.3.3 Physical Characteristics of Gelling

In natural latex, which is a variable raw material, differences in gelling path are common even if the same formulations are used in gelling and foaming. If the excess magnesium present in some latices is not controlled, a fluctuating viscosity is observed as the pH falls during gelling, presumably as a result of the early precipitation of magnesium soaps. Such a latex can form a pseudogel at high pH. With a certain type of high stability latex (e.g., sodium pentachlorophanate preserved latex), the gel formed with silicofluoride at room temperature can be pasty and ill defined.

29.4 DEFECTS OCCURRING IN FOAM PRODUCTION AND REMEDIAL MEASURES

Defective products may be produced by faulty operations at any stage of foam production. Commonly observed defects and the steps taken for preventing such flawed products are given in Table 3.

29.5 TESTING AND QUALITY CONTROL OF FOAM

Foam rubber is a consumer product. Therefore various national standards organizations have taken steps to ensure the production and marketing of good quality foam products by evolving suitable specifications. Important properties tested for quality control and their specification limits are given in the subsections that follow.

Table 3 Common Defects: Causes and Remedies

Defect	Possible cause	Remedy suggested
Coarse structure, rat holes, etc.	Gelation at a low pH	Increase secondary gelling agent
Loose skin	Insufficient gelling agent Cold mold	Increase gelling agent Use warmer mold
Thick skin	Mold too hot	Use cooler mold
Flow marks, splitting in center, etc.	Gellation too fast	Reduce gelling agent
Foam collapse before gelation	Poor foam stability	Increase foam stabilization and gelling agent
Shallow surface lake	Improper drying of the mold release agent	Dry the mold repease agent properly in the mold

29.5.1 Indentation Hardness Index

The indentation hardness index is the load in kilograms required to give an indentation in the sample equivalent to 40% of the original thickness of the sample under specified conditions. It is a measure of the load-bearing capacity of the foam. Foam products are graded by indentation hardness as follows:

Code	Indentation hardness
A	7–14
B	15–21
C	22–28
D	29–34
E	35–45
F	46–55
G	56–65
H	66–75 Ks

29.5.2 Compression Set

Compression set is a measure of state of cure of the foam. The test consists of compressing the test piece under specified conditions of time, temperature, and constant deflation and noting the effect on the height of the released test piece. There are two test methods using a $5 \times 5 \times 2.5$ cm^3 test piece and a whole sample test piece. The compression set of the sample when determined by the first method shall not exceed 15% and by the second method shall not exceed 5%

29.5.3 Color

The color of latex foam rubber products shall be as agreed between the purchaser and the supplier.

29.5.4 Odor

Latex foam products shall have no objectionable odor.

29.5.5 Flexing Test

The flexing test involves submitting the whole sample to a continuous flexing with an indenter for 2,500,000 cycles at 4 Hz and measuring the loss in hardness and thickness. The specifications are that the indentation hardness shall not be reduced by more than 20% and the thickness by not more than 5% of the original hardness and thickness, respectively.

29.5.6 Aging Test

The test sample is kept in an oven at 70 ±1°C for 168 hours. Upon removal from the oven after 10 hours, the hardness is measured. The hardness of the sample after aging shall not vary by more than ±20% of the value obtained with the unaged sample.

29.5.7 Metallic Impurities

The copper and manganese content in the sample shall not be more than 0.001 and 0.005%, respectively.

REFERENCES

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THERMOPLASTIC ELASTOMERS AND THEIR INFLUENCE IN FUTURE WORLD ELASTOMER CONSUMPTION

By
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INTRODUCTION

Thermoplastic elastomers (TPE) are called elastoplastics. These polymers combine the processability of plastomers (eg. polyethelene, PVC) and functional performance of vensional elastomers (natural / Synthetic Rubbers). Unlike conversional rubbers. thermoplastic Rubbers need no vulcanisation and yet they show elastomeric properties within a certain temperature range. They can be processed on conventional plastic equipment such as injection moulders, blow moulders, entruders and so on. The transition from a processible melt to a solid elastomeric material is rapid and reversible. The elastomeric perties are developed immediately on cooling. These rubbers are steadily replacing vulcanised rubbers from a large number of applications.

Depending on definition used, a TPE may be classified as either a rubber or as a plastic. In terms of properties most TPEs are rubbers, in terms of processing they are thermoplastic. Thus, TPEs are claimed by both rubber and plastic industries. TPEs have one foot in the rubber industry and the other in plastic industry.

The Continuing success and increasing acceptance of TPEs as a replacement for thermoset rubber, and to a lesser degree plastics and metals, is becoming a global phenomenon (IRSG. 1994).

ADVANTAGES

The practical advantages of thermoplastic elastomers in comparison to vulcanised rubbers are listed under :

1. Little or no compounding is required. Most TPEs are "ready to use" materials thus eliminating the batch to batch variations of convensional rubber compounds as well as the high energy consumption during mixing and vulcanisation.
2. Injection moulding cycles are very fast, leading to lower finished part costs.
3. The scrap can be easily re-cycled, whereas the scrap of vulcanised rubber is usually discarded, because it is difficult to re-cycle.
4. Most TPEs have lower density.
5. Product consistency is better than comparable vulcanised rubbers.

TPEs have certain disadvantages also like higher compression set, lower thermal stability, poor performance at high temperature applications (TPEs melt at high temperature) etc.

TPE GROWTH

Growth in consumption of TPEs for the period from 1970 to 1993 is given in Table-1 below :

Table 1: Growth in consumption of TPEs

Year	TPE Consumption Tonne
1970	1,50,000
1985	5,00,000
1990	6,00,000
1993	7,70,000

This reflects a compounded annual growth rate of 8 per cent in contrast to a 0 - 2.0 per cent for the non-tyre segment of the rubber industry and 1 - 3 per cent for the plastic industry.

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From considrations of predictions by various agencies on world-wide usage of TPEs it is concluded that this segment of polymer industry will have a growth rate between 5 to 8 per cent during the years 1994 to 2000. Projected consumption of TPEs is given in Table II. (European Rubber Journal 177, 5, p. 24 (1995).

A recent assessment by experts put the current global market for TPEs at 1.6 billion US $ which is nearly double the value of natural rubber produced in India. According to Jean Stemper TPE growth rate during 1994 to 2000 will be 8.5 to 11 per cent. He estimates a consumption of 1.7 million Tonnes of TPE by 2000 (IRSG - 1994). A study of the North American TPE market by the Freedonia Group Inc. (A group specialising in projections on industrial products). Styrene based TPEs will remain dominant till the year 1997 and after this very fast growth will be shown by Olefinic TPEs and Co-polyester type TPEs. Freedonia projection of TPEs by Tyres is given in Table III.

Table III : TPE Types

Type of TPE	1992 '000 Tonnes	1997 '000 Tonnes	Annual growth Per cent
Styrenics	134.2	159.2	3.5
Olefinics	74.9	112.0	8.4
Urethanes	34.0	44.5	5.5
Polysters	26.3	40.4	8.9
Other types	20.4	29.5	7.6
	289.8	385.6	5.9

Foot-wear, a major market for styrenic TPEs, will remain flat in North America as a result of competition from imports. Strong demand in olefinics is expected in products like automotive bumpers.

IMPORTANT CLASSES

TPEs are classified into six major classes. Styrene block co-polymers (SBCs) Thermo plastic olefins (TPOs), Elastometric alloys (EAs), Thermoplastic poly urethanes (TPUs), Co-polyster elastomers (CoPEs), Thermoplastic Co-poly amide elastomers (PEBAs). Thermoplastic natural rubber and blends of PVC with elastomers also are marketed as TPEs.

Table II : GLOBAL TPE USAGE (000 Tonnes)

Region	1993	1994	1995	1999
Western Europe	285	299	314	371
North America	320	358	387	496
Latin America	9.3	12	18	24
Asia/Pacific	138.0	148	154	179
CIS	9.0	10	30	110
Middle East/Africa	5	5.5	5.9	7.7
Total	766	833	909	1188

Styrene block Co-polymers (SBCs) : Three distinctly different types are included under this. The trade names of important varieties are Kraton D (USA) and Cariflex TR (Europe). Styrene butadiene Styrene (SBS) is generally classified as a low cost product. It has significantly displaced natural rubber and SBR in foot wear application. It is also used in bitumen and polymer modifications. Styrene isoprene styrene (SIS) is the material of choice for adhesive systems. In addition to hot melt adhesives, it has significantly displaced many rubber based adhesives.

Styrene ethylene butylene styrene (SEBs) is a more saturated TPE than SBS. So these materials are more resistant to Oxidative attack and more suitable for higher temperature applications in comparison to other TPEs. This styrenic is likely to show more growth in future.

TPOs

In general TPOs are simple blends of a thermoplastic such as polypropylene with an unvulcanised elastomer such as EPDM. During mixing of rubber with plastic the rubber is vulcanised using suitable additives. Since the rubber segment is vulcanised in-situ during mixing with poly propylene the cured rubber particles gets dispersed in the continuous matrix of polypropylene. They are also called elastometric alloys. They have good resistance to air oxidation and Ozone. Important commercial grades are Santoprene (blends of EPDM / Polypropylene) Geolast (blends of NBR/PP) and Alcryn (blends of Ethylene Vinyl acetate and vinyledene hloride). Thermoplastic natural rubber also can be included under this group (TPNR). Normally TPNRs are produced by blending natural rubber with certain grades of poly propylene. The properties of TPNR and its economics compares favourably with EPDM/PP based TPOs. TPNR can be used in the same way as these Thermoplastics for producing products like automobile bumpers. TPNRs of widely varying properties with various NR/PP ratio are also available for use in different elds of applications.

TPUs

Thermoplastic Urethanes are in market for the past 30 years. The thermoplastic poly urethane elastomers are block copolymers with amorphous and crystalline segments. Two types of TPUs are commercially available. One is Polyether Urethanes and the other polyster based Urethanes.

Polyamides (PEBAs)

Poly amides are the latest and best performing TPEs. They are block Co-polymers with hard and soft segments which are connected by amide linkages. This special structure gives them better Chemical resistance in comparison to other TPEs. For producing them a polyethene diol is allowed to react with a dicarboxylic poly amide. Unlike other TPEs they have good high temperature resistance and in some applications they can replace Silicone rubber and fluro elastomers.

APPLICATIONS OF TPEs

Automotive :

The automotive industry provided the most important market for TPEs. The lower-performing TPEs find use in exterior and passenger compartment applications, whereas the higher performing TPEs are used in under the hood applications. Automotive air intake hoses are manufactured using TPEs. Automotive bumpers is another important product. The global 1994 market for bumper materials is 1 million tonnes. TPEs are now the preferred materials in bumper manufacture. Poly Urethane based TPUs were popular in this area till recently. Use of thermoplastic rubbers in air bag covers, boots and cables of automobiles will grow in all developed countries. Window seals also will graudally be produced from TPEs. Axle boots is one item now produced from TPEs, because of the special properties and processing advantages of TPEs new designs are given to axle boots which in turn improves vehicle performance and service life.

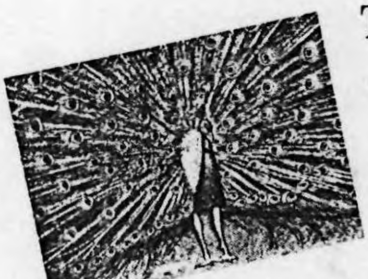
Construction uses :

TPEs are used in construction applications for the past ten years or so. The use is mostly in door and window seals. They are also used in producing attractive cupboard handles.

Home appliances :

TPEs are used in various house-hold articles, like dish washers, washing machines etc as gaskets. Their improved chemical resistance and weathering make them more attractive in these applications than convensional rubbers.

Electronic, electrical and medical applications of these polymers are also substantial. They are preferred in medical applications as they are cleaner than thermo-set rubbers and they contain fewer residual chemicals from processing. They are also bio-compatible and are generally inert to blood, tissue and other body fluids. The products of TPE in medical field include syringe stoppers, Catheters and hospital tubings.




KANAN DEVAN TEA

Future of TPEs and their competition with conventional rubbers :

Selection of polymer for product manufacture is based on its cost and ability to yield products that meet the service requirements. Thermoset rubbers were the polymer source for non-tyre rubber produce manufacturers till recently. The introduction of TPEs have changed this scenario. Many manufacturers are trying to replace Natural/ Synthetic rubbers using TPEs in non-tyre rubber products. Components of TPEs are preferred to rubber based components by many automobile manufacturers mainly on considerations of system cost factor.

TPE growth rate annually is projected at around 8 to 10 per cent till the year 2000. This would mean that by the year 2000 almost 1.2 million tonnes of TPEs will be used in industry. Almost all the TPE use is now in non-tyre rubber product sector. Annual growth rate in this sector is 0-2 per cent even during very favourable times. So TPEs will reduce the consumption of vulcanisable rubbers in non-tyre rubber products like automotive bumbers, axle boots, under the hood cables, Shoe soles, hoses, tubing insulation and jacketing of wires and cables. Solvent based and hot melt adhesives, toys etc. From the various growth projections it is estimated that TPE use will reach a level of 1.2 million tonnes by year 2000. At this level of consumption this new polymer will account for around 20 per cent of rubber use in non-tyre product manufacture. It is estimated that 65 per cent of TPEs used will be direct replacement of thermoset rubber compounds. Ten per cent of TPEs will be in areas where softer plastics were used. The remaining 25 per cent will be in new products requiring rubber like properties. This would have been growth areas for thermoset rubbers had this alternative polymer been not developed. Thus growth of thermoplastic rubbers will reduce consumption of thermoset rubbers in many non-tyre products manufacture. Introduction of thermoplastic rubbers thus will reduce growth in consumption of both natural and Synthetic rubbers.

Rubber based composites :

The mechanical properties of elastomers can be improved by adding reinforcing ingredients such as Carbon black and Silica. Recently it is reported that addition of a suitable short fibre can also improve mechanical properties of rubber. Fibre reinforcement of elastomers is already known in rubber industry. In products like tyres, belts, hoses and certain gaskets reinforcement by use of continuous fibres is well known. The extent to which discontinuous fibres can approach the performance of a continuous cord depends on its modulus relative to that of the matrix. Performance of a short fibre rubber composite depends on several factors, such as high aspect ratio of fibre (average length to diameter ratio), control of fibre orientation, generation of a strong fibre rubber interface, high state of dispersion of fibre in rubber and optimum quality of rubber compound.

In products such as conveyor belts and tyres elastomers reinforced with continuous cords are used. The cord rubber composite remains quite flexible both paralell to the direction of major reinforcement and more specially in the normal direction. Here the reinforcement does not alter rubber properties appreciably and the cords are free to slide past each other as the parts are flexed.

On the other hand reinforcement by short fibres offers several advantages like ease of fabrication, better economics at mixing and fabrication stages, high green strength, reduced and controlled shrinkage in moulded products, improved solvent resistance, better thermal ageing and improved cut and tear resistance. The manufacture of complex shaped engineering article is easily accomplished with short fibre composite which is not possible from elastomers reinforced with continuous fibres.

Short fibres can be incorporated directly to rubber compound along with other additives and the compounds are amenable to convensional rubber processing operations such as extrusion, Calendering and moulding. Well dispersed short fibres reinforce the rubber phase uniformly. The performance properties of short fibre-rubber composites depend on the bonding between fibre and rubber. For improved bonding fibre surfaces are modified by chemical treatment or bonding agents are added. RFL and hexa-methylene tetrammere based resins are used as bonding agents.

Some of the fibres used in rubber industry are cellulose, glass, asbestose, jute and nylon. The proportion of fibre to rubber in these cases is high and rubber acts only as a binder. Aramid fibres are also now available for incorporation with rubber matrix. This aramid Slurry is marketed by Akso-nobel company.

Various type of short fibres are used in thermoplastic elastomers also for reinforcement. Glass fibre, Carbon fibre and cellulose are used to reinforce TPEs. It is likely that TPE/fibre composite will slowly make an in road into Tyre industry. Main use of TPEs currently is in non-tyre rubber products. The availability of versatile TPE/Fibre composite can change this scenario. It may then be possible to produce even tyres by injection moulding. Such a development in Technology may not sound well for the rubber producing industries. So the rubber producing industries should carefully evaluate these technological developments and evolve strategies for improving the competitive position of the rubber produced by them.

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