CAMELBACK

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CAMEL BACK

PART I

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Manufacture of Camelback or Retread compound is one of the major rubber industries in India and accounts for roughly 6% of the total rubber consumption. With the rapid growth of automobile vehicle population in the country this sector of Industry is bound to show a rapid expansion. It is estimated that in 1968 about 13,000 tons of camelback will be produced.

In the early stages of pneumatic tyres, when cotton carcass was being used, the life of the tyre carcass was of the same order as that of the tread and retreading of tyres was not generally resorted to. With the advent of synthetic yarns like Rayon, Nylon, Polyester etc. in the tyre construction, the life of the carcass increased manifold compared to that of the tread rubber and thenceforward the retreading industry developed. Since the casing forms the major components of the tyre costwise, retreading of the tyre becomes an attractive economic proposition. The present-day tyre carcasses are so strong that they last 3-5 retreads without difficulty, even eight retreads in exceptional cases.

The retreading of a tyre is not too difficult a process and quite a number of retreading establishments have come up in our country both as medium scale units as well as small scale units. Barring a few units these retreaders generally purchase their requirements of the camelback from the manufacturers of camelback—the tyre industry or medium scale rubber factories.

The retread compound is available in many forms—the familiar camel-back is but one of these. The name camelback is derived from the appearance of the

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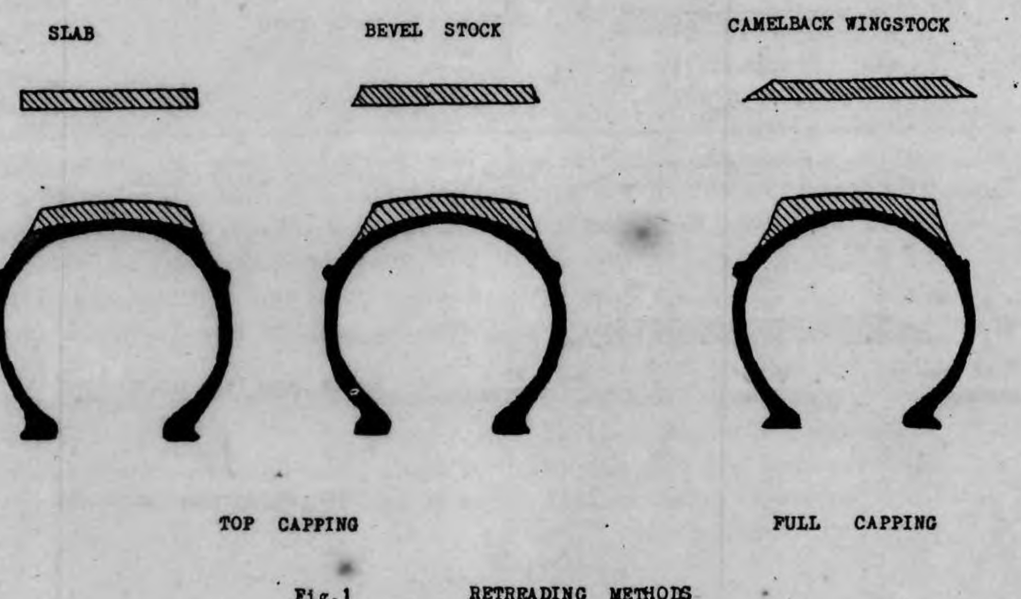

Fig.1 RETREADING METHODS

green compound extruded with a hump like that of a camel, in the centre. Presently these materials are available in the following forms.

1) Slab: Straight edge or bevelled edge.

2) Camelback: Wingstock (single hump) or valley type (Double hump).

Slab: Straight edge slab can be directly calendered out from the mixing mill using cutting knieves adjusted to the required width. This type can be manufactured by small scale rubber industries also, as the only machinery required is a mixing mill. Bevel stock is generally extruded.

Slab is used for "resoling" or "top-capping" only the worn out tread part on the tyre.

CAMELBACK: Manufacture of camelback requires special extruders and hence it is manufactured by the medium scale manufacturing units or the tyre companies.

The single hump or double hump camelback is used for "retreading" or "full capping" and is used when it is desired to re-rubberise a worn tyre from over the shoulder i.e. from beginning of one sidewall over to the other sidewall. The use of single hump or double hump camelback will depend on the design of the retreading mould.

Both these types are available in various dimensions to suit the retreading of various sizes of tyres. The dimensions of these are expressed generally in a specific manner. The widths of base and crown are given as numerals recorded in inches and eights of an inch and gauge is expressed in thirty seconds (1/32") of an inch. Thus first the widths (crown-followed by base) and then the gauges

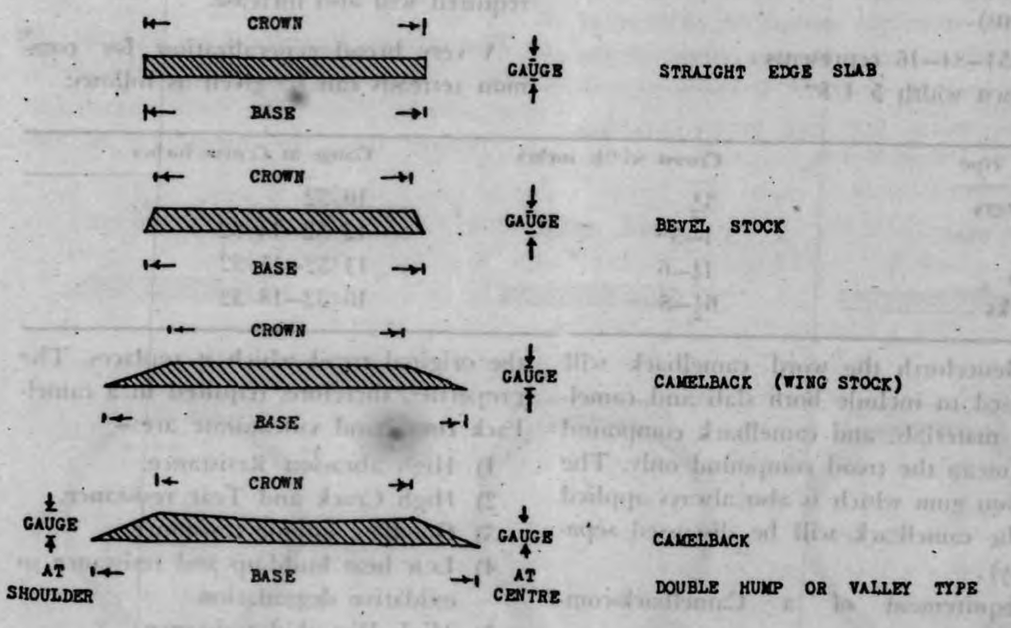

Fig. 2
TYPES OF RETREAD MATERIALS.

(gauge at center followed by gauge at shoulder) are given in 2 to 4 sets of numerals depending on the type of slab or camelback. In case of widths upto 9 inches *the first numeral of the set for* width represents inches and the second figure represents eights of an inch. For widths of 10 inches and above (both crown and base) the first two figures in each set will be thirty seconds of an inch. The set for gauges expresses thickness in thirty seconds of an inch. The method will be understood from the examples given below.

Straight edge slab (Two dimensions only)

Size 64 – 16 represents crown and base width 6 4/8" and gauge 16/32".

Bevel edge slab (Three dimensions)

Size 60 – 64 – 16 represents crown width 6" – Base
width 6 4/8" and gauge 16/32".

Wingstock camelback (Three dimensions)

Size 54–84–16 represents
crown width 5 4/8"
Base width 8 4/8"
Gauge at centre 16/32"

Double hump (four dimensions)
60–90–18–20 represents
Crown width 6"
Base width 9"
Gauge at centre 18/32"
and
Gauge at shoulder 20/32".

The bevel slab is generally wider at base than at crown by ½" forming a ¼" bevel at the shoulder.

In camelback the base width is generally more than the crown width by 4", 5", 6" and so on in integral inches.

Recently the *sizes are expressed in* metric system also. In this system the dimensions are given in the same order in millimetres directly.

Generally as the tyre size increases the crown widths and gauges of the retreads required will also *increase*.

A very broad generalization for common retreads can be given as follows:

Tyres type	Crown width inches	Gauge at Centre inches
Scooters	3½	10/32
Cars	4–5	12/32–14/32
Jeeps	4½–6	14/32–15/32
Trucks	6½–8	16/32–18/32

(Henceforth the word camelback will be used to include both slab and camelback materials, and camelback compound will mean the tread compound only. The cushion gum which is also always applied to the camelback will be discussed separately).

Requirement of a Camelback-compound :–

A camelback compound when cured is expected to give the same performance as the original tread which it replaces. The properties, therefore, required in a camelback compound vulcanizate are:–

1) High abrasion Resistance.
2) High Crack and Tear resistance.
3) Goodflex fatigue resistance.
4) Low heat build-up and resistance to oxidative degradation.
5) High Wet skid resistance.
6) Soft ride and low *noise-level*.
7) Low rolling resistance.

The importance of abrasion resistance in the camelback is obvious. The service-life of the retread will depend on this property. No laboratory evaluation test can give a correct picture about this property and actual service trials are still the preferred way of gauging the performance.

However one fact has been clearly established that as regards abrasion resistance, the performance of compounds from different polymers can never be correlated with the tensile-strengths measured in the normal manner in the laboratory. Recent work by R. Ecker has shown that the factor important is the ratio of tensile-strength at high temperature and at high rates of elongation to the tensile strength at Room temperature measured at normal speeds and not their absolute values. Tensile strength is a good criterion for quality control of camelback production as per a particular recipe but it can never be used as a yardstick for comparing camelbacks made from different polymers.

The abrasion resistance also depends on the resistance of the compound to oxidative degradation at high temperatures.

Tear resistance is an important property required in the retreads to be used on "Off The Road" (OTR) tyres. These tyres suffer more damage from cuts induced by the rough hard roads over which they travel rather than by abrasion. Tear resistance is correlated with high tensile strength, high elongation and low modulus, and when designing camelbacks for use on OTR tyres designing for these properties can be expected to give a good performance camelback.

The rubber in the tread region flexes when it passes through the foot-print region. Due to continuous flexing during service life, flex-fatigue failure cracks appear in the shoulder region (radial cracks in tyres treads) and in the tread grooves (groove cracking in tyre-treads and retreads). These cracks are dangerous because these develop depthwise faster than lengthwise and quickly extend upto the casing, afterwards leading to separation from casing.

Low heat build up is a property necessary in thick retreads only e.g. on earth-mover tyres. For passanger and truck tyre retreads heat build up is not a problem. The heat build up is low if the resilience of the vulcanizate is high and the dynamic modulus is also high.

The tyres run at higher temperature. The temperature of the tyres running on highways can reach as high level as 140°C because of the continuous non-stop runs. The retread exposed to high temperatures continuously undergoes fast deterioration not only on the surface (and abrades away fast) but also in the mass of the retread. Retread made from more heat resistant rubber obviously scores over the retread from less heat resistant rubber in service life under these conditions.

The properties wet skid resistance, soft ride, low noise level and low rolling resistance are also properties connected with the resilience of the retread.

Wet skid resistance or the ability of the tyre to hold down to the wet road is important from safety point of view. The wet skid resistance is inversely proportional to the resilience, higher the resilience of the compound, greater the tendency of the tyre to skid on wet road.

Soft ride and low noise-level depend upon the design on the retread and as to the compound. Compounds with low resilience give a softer ride and a low noise level.

Low rolling resistance depends on the coefficient of friction between the road and the retread and also on the resilience of the compound. Lower the coefficient of friction and higher the resilience lower is the rolling resistance and higher is the mileage per unit volume of the fuel.

These factors play more or less important role in designing of the camelback compounds depending upon the type of service the retread is expected to undergo, and hence it is not uncommon to have separate compounds for camelbacks to be used on tyres for differring services.

From processing point of view the desirable characteristics in the camelback compound are:—

1) Storage life.
2) Tack
3) Nonblooming tendency.
4) Low nerve.

The period between the time when the camelback is prepared and the time when it is cured may be very long even upto 6-8 months. This is because retreader purchases the camelback from the manufacturer and since he has to store a large number of sizes of camelback suiting different tyres, the storage of the camelback is prolonged. The camelback must not set up during the storage or it will become useless for the retreading. Even with a slight set up in the camelback it will have a high nerve making the splicing difficult and the retread will mould poorly. The other processing properties are of comparatively less importance. Generally all camelbacks have an undertread or cushion gum layer of natural rubber compound. So long as this layer remains free from sulfur bloom and does not set up, problem of adhering of the camelback to the buffed casing due to non-tackiness of camelback compound is not present. Tackiness is required at the splice. But even here the problem is overcome by placing a thin strip of cushion-gum at the splice or by use of homogeniser tool. Tack in the camelback compounds is an important property only when the camelback is not to be applied with the cushion gum on the base of the camelback.

Non-blooming tendency is essential in the cushion gum layer on the camelback because any bloom, especially the sulfur bloom, kills the tackiness of the cushion gum. The nonblooming tendency in camelback compounds is desired mainly from the point of view of customer appeal only.

Low nerve is desirable in the camelback. The retreaders have a tendency to stretch the camelback while applying it to the casing. If the camelback has high nerve, splicing is difficult because the camelback shrinks, opening the splice either during the building stage or during the storage of the retreaded casing prior to cure.

Lastly is the most important point of economics. The cost performance characteristics i.e. the mileage obtained per unit retread cost must justify the use of the camelback. In camelback compounds the primary cost is that of the polymer and, hence if greater extension of the polymer can be carried out i.e. if the polymer content of the camelback compound can be reduced by use of other cheaper ingredients without lowering the service performance of the retread, cheaper will be the compound in the longer run.

Keeping in view the above requirements of camelback compounds the designing of compounds for camelback and cushion gum is discussed below:—

Designing of Camelback compounds.

Choice of the Polymer

From viewpoint of abrasion-resistance only the polyurethane rubbers are best but cost of these polymers is prohibitive. The traditional rubbers used for camelback compounds are natural rubber and emulsion SBR. During the last decade several new general purpose rubbers which have found a place in the tyre industry for use in tread and retread compounds are solution polymerised poly butadiene (stereo polybutadiene) emulsion polymerised poly butadiene and recently solution polymerised SBR (Stereo SBR). The rubbers considered for this application but which have not found any substantial acceptance in the camelback field are butyl and EPDM (Solution polymerised ethylene propylene terpolymer rubbers).

Natural rubber:— Natural rubber was the workhorse of the tyre and camelback industry prior to the World War II. Natural rubber retreads have good abrasion resistance, high tear strength and low heat build up. Tack of natural rubber is excellent. However the drawbacks of natural rubber retreads are:—

i) Lower abrasion resistance than SBR retreads, ii) susceptibility to oxygen and hence the degradation that occurs during service-life especially at higher temperatures iii) low flex fatigue resistance (groove cracking) iv) lower wet skid resistance than SBR retreads. (It is reported that in England where rainy season is year around, truck drivers refuse to drive trucks with tyre having natural rubber treads or retreads.) v) low shelf life especially for camelback with the fine particle size furnace blacks.

From cost point of view it is difficult to extend the polymer by use of high black-high oil technique. Recently oil extension of natural rubber has been studied and it has been found that suitably oil-extended natural rubber can be used for camelback compounds. But the difficulty is that only special types of oils can be used for extension and that such extension can be carried out only at latex stage or in high speed banburies capable of using upside-down mixing techniques. Oil extension is not possible on normal mixing machinery. With oil-extension the wet skid resistance is improved but the drawbacks of heat degradation and flex fatigue do remain, are even enhanced.

Natural rubber is still preferred for camelbacks where very high tear-resistance is essential in the vulcanizate e.g. retreads on OTR tyres and tyres on earth moving machinery tractors etc. The tyres are thick and heat-build up has to be kept low. Since these are slow speed vehicles heat degradation is not so severe problem if heat-build up is kept low.

SBR: At present the rubber used in largest proportion for camelback compounds the world over is SBR. The primary reason is the high abrasion resistance of the retreads especially at high speeds. Under severe abrasion conditions e.g. city driving (start-stop driving) the wear-life of SBR retreads is about 30% greater than that of natural rubber retreads. Under highway driving conditions also wear life is about 20% greater than that of natural rubber retreads.

The better wear life is also due to the better resistance to oxidative degradation of the SBR retreads. SBR has also better resistance to flex fatigue. Under wet road conditions, the coefficient of friction of SBR retreads is better than that of natural rubber retreads under same conditions (SBR retread 1.0 vs. 0.88 for natural rubber retread). The other factor influencing the wet skid resistance viz. the resilience of SBR retread compounds is lower than that of natural rubber treads *with the result that the wet skid resistance* of SBR retreads is far superior to that of natural rubber retreads. SBR 'loves' oil and hence greater extension of the polymers is possible by use of high black-high oil loading techniques. Comparatively the retention of the abrasion resistance flex fatigue resistance and resistance to oxidative degration even after extension is excellent. The wet skid resistance is enhanced by the extension. Processibility of the polymers in banbury mixers or on two roll mixing mills is excellent. Though the coefficient of friction under wet conditions is higher than that of natural rubber compounds under wet conditions, under dry conditions the Friction coefficient of SBR compounds is lower than that of natural rubber compounds. (SBR retreads 1.1. vs. 1.2 for Natural rubber retreads). Hence in spite of the fact that the resilience of SBR compounds is fractionally lower than that of natural rubber compounds, rolling resistance of compounds of both rubbers are similar, hence fuel economy is the same.

The SBR compounds, especially made from the oil-extended SBR like Synaprene 1712, have lower nerve and hence are easier to handle during the building up process. SBR compounds have longer storage safety even when they are compounded for equal cure-rate as that for natural rubber compounds. Higher temperatures of moulding can be used without any reservations about reversion occurring. The thermal conductivity of SBR is higher than that of natural rubber, hence the incubation time i.e. the time required to bring the compound to the curing time is less. In retreading moulds the heat flow is only from the outside and hence the incubation time *forms a considerable part of the curing* time.

SBR are man-made rubbers and hence the properties of the polymer can be changed by changing the compositions of the polymers. Synaprene 1500 is a resilient rubber only slightly less than the natural rubber. By oil extension or by increasing the styrene content of the polymer or by both, SBR polymers can be obtained which have resilience characteristics similar to those of butyl rubber. Camelbacks from such rubbers are as soft riding, with low noise level and with high wet skid resistance, as that from butyl rubber. High mu tyres have treads made from high styrene content-oil extended SBR. Retreads for such tyres can be made only from same type of SBR if the comfort level is to be maintained.

One more reason of popularity of SBR for treads in the developed countries has been the availability of carbon-black masterbatches. In camelback compounds the performance of the vulcanizate depends upon the proper dispersion of carbon black. In masterbatches the manufacturer already gets the black uniformly dispersed in the polymer. The mixing time for camelback compounds is also drastically reduced since in camelback compound the main part of the mixing cycle is utilised for mixing the carbon-black. With carbon black masterbatches all that the camelback manufacturers have to do is to mix the vulcanizing ingredients and activators. Because of the simplicity of manufacturing the camelback from the masterbatches, many retreaders in the developed countries have started manufacturing themselves their requirements of camelback. In USA and Europe the latex base carbon-black masterbatches are popular but in Japan the hot mixed masterbatches made from the dry SBR polymer are popular for this use.

Natural rubber cushion-gum has to be used with SBR camelback. With the cushion gum layer of natural rubber compound, and if as stated before, a thin strip of the cushion gum is placed at the splice, SBR camelback presents absolutely no problem at building up stage. In cases where the cushion gum is not applied blending of SBR with natural rubber will give adequate green tack.

With the recent methods of retreading, e.g. arbitread process use of cushion gum is eliminated, but these new methods cannot be adopted in India because the necessary equipment is not available. However in India very few manufacturers give camelback without the cushion gum.

Higher heat build up is not as acute a problem in retreads as in the original tyre. At retread stage, the casing is fully grown and the contribution to heat development by casing is low. The retreading material replaces only part of the original tread and considerable part of natural rubber tread is left in conjunction with carcass. Therefore except for very thick threads as used on tractor or earthmoving equipment tyres, SBR content of retread can be increased considerably than that used in the original tread.

SBR retreads have lower tear strength than natural rubber retreads and hence where very high tear resistance is essential e.g. on tyres for earthmoving machinery, SBR retreads are likely to give lower performance. However for all automobile and truck applications, SBR camelback compounds will give adequate tear strength.

Generally for retreads for tyres for passenger car, motorcycles light trucks, Synaprene 1712 is suitable. The Synaprene 1712 retreads have excellent abrasion resistance, flex fatigue resistance, heat resistance and wet skid resistance. The polymer can be further extended by use of high black-high oil technique for better economics. Synaprene 1514 is useful for retreads of high mu tyres. For medium truck tyre (upto 900-20 size) retreads Synaprene 1500 should be preferred because of the greater resilience and higher tear strength of its vulcanizates than that of those from Synaprene 1712. Blends of Synaprene 1712 with natural rubber can also be used for camelback compounds for this application.

Stereo-Polybutadiene

This polymer made its debut on the tyre applications field in 1960. Very high hopes were raised about this polymer as a complete replacement of natural rubber. However experience over the years has limited the scope of the polymer in Tyre Industry.

Stereo polybutadiene vulcanizates have exceptional resilience (higher than that of natural rubber) and low coefficient of friction on dry roads (0.72); better abrasion resistance than even SBR compounds, good fatigue resistance good heat resistance and excellent low temperature properties. All these properties would have made it an exceptionally good polymer for tyre applications. Treads made from this polymer give longer wear life than SBR treads and mileage obtained per gallon is greater because of low rolling resistance. But its limitations have considerably restricted its use in this field.

The polymers are very difficult to process and hence have to be used in blends with either SBR or natural rubber. The polymers have no green tack. Because of these troubles the polymers be handled only in banburies.

The tear resistance of the vulcanizates is very low and on rough roads cracking, *chipping and chunking are severe problems.*

The high resilience and low coefficient of friction on wet surface (0.52 vs. 1.0 for SBR) give a very low wet skid resistance and make the tyres or retreads very unsafe on wet roads. In UK one tyre company advertises that their tyres do not contain stereo polybutadiene and hence are safe tyres.

Though resilience of these polymers is high, the internal friction is also high. The polymers have to be compounded with low sulfur levels to get some tear resistance in the vulcanizate. But at low sulfur levels, resilience is reduced. Thus in practical compounds it has been found that the heat build up characteristics of the vulcanizate are similar or even inferior to those of vulcanizate from natural rubber.

Abroad the enthusiasm about these polymers has waned out and their share of the rubber consumption has remained almost static in last two years.

In India few tyre companies have evaluated these polymers for car tyres and in camelback compounds. Unless some breakthrough occurs in their manufacturing techniques and their limitations are overcome, these polymers are unlikely to have wide-spread usage in our country in tyre and camelback Industry.

Another recent newcomer in this field is emulsion Polybutadiene. The polymer was originally made in World War II period as arctic rubber but was found to be very difficult to process. Recent advances in emulsion polymerisation techniques made it possible to get a rubber with better processing characteristics. This rubber has better abrasion resistance and flex fatigue resistance than SBR, good ageing characteristics and excellent low temperature properties equal to those of stereo polybutadiene. Its resilience and wet skin resistance characteristics are similar to those of SBR. Its blends with natural rubber have excellent properties. Even with addition of this polymer upto 40% of the total polymer in natural rubber compound, the is retained. Natural rubber retreads have green tack of natural rubber compound low heat build up characteristics but during service life as the ageing proceeds the heat buildup characteristics deteriorate fast and the heat generation becomes even higher than that in a SBR retread aged for the same period. Part replacement of natural rubber by the emulsion polymerised polybutadiene has been claimed to eliminate this heat build up reversion of natural rubber. The wet skid resistance of the retreads is far better than those of retreads from stereo polybutadiene.

Stereo SBR has been developed and is under active evaluation stages in USA. This polymer has given very promising results. The vulcanizates from this polymer have better abrasion resistance, flex fatigue resistance than SBR; the heat build up is low and wet skid resistance is as good as that of SBR. This polymer however is still in developmental stage and may yet take quite some years before it becomes a contender in this field. Butyl has long been considered for the retread use. The excellent low temperature characteristics, low hysterisis, abrasion characteristics similar to those of natural rubber, excellent flex fatigue resistance and resistance to heat and age of the butyl compounds would have made it possible to use it for tyres where extreme comfort levels are desired. The chief difficulty has been the complete noncompatibility of the polymer with the other normal unsaturated polymers. Therefore special precautions are necessary in processing the polymer in the factory and special cementing solutions are necessary for its application to the casing. Its use was limited at one time to tyres of high mu type and tyres for icy roads. The development of high styrene SBR rubber have eliminated butyl from the high mu tyre field and the polybutadienes have replaced it from tyres for low temperature use.

EPDM rubber was supposed to become the cheapest polymer available because of the cheapness of the raw materials ethylene and propylene. The rubbers have good abrasion resistance, excellent flex fatigue and age resistance. The polymers can be extended to a far greater extent than any other polymer. Therefore the polymer raised great expectations. However manufacturing costs of the polymer have been found to be high and the non-compatibility with other polymers has restricted its use. The polymer has not made any headway in tread and retread compounds as yet.

To be continued

CAMELBACK*

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Part II

RETREADS must have a very high resistance to wear and tear The primary filler must therefore be a very highly reinforcing filler. Fifty years ago zinc oxide was used as the reinforcing filler for tyre tread compounds but once the better reinforcing characteristics of the carbon-blacks became known, carbon-blacks have become almost the sole fillers to be used in tyre tread and retread compounds.

CARBON BLACKS

The reinforcing characteristics of the blacks depend on the particle size of the black, finer the black higher the reinforcing effect. Therefore the fine particle size blacks like EPC, MPC, HAF, ISAF and SAF are the ones considered suitable for use in tyre tread and retread compounds.

The channel blacks EPC and MPC were favourite blacks in this trade when the blacks were cheap and the natural rubber was the only polymer available to the Industry. Because of the increased cost of their raw material—the natural gas—and the low yield of the black, the cost of these blacks has been steadily going up and now the cheaper fine particle size furnace blacks have taken up the place of the channel blacks.

In spite of the higher cost these blacks do find applications in this industry in certain few applications. The channel blacks give low hardness low modulus natural rubber vulcanizates with excellent tear strengths. Therefore in cases such as retread compounds for earthmover tyres in which tear strength of the vulcanizate is more important than the abrasion resistance, these blacks are used along with natural rubber.

One additional reason of their popularity in the days previous to the discovery of the sulfenamide class of accelerators was their retarding nature giving very safe processing with natural rubber compounds. Recently fine particle size oxidised furnace blacks (ASTM class S) known as channel replacement Furnace blacks (e.g. Philblack 55) have come on the market. These blacks are cheaper in cost than the channel blacks, but give equivalent performance.

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From view-point of abrasion resistance however, the channel or the oxygenated furnace blacks rank lower to the equivalent particle size normal furnace blacks.

With the advent of Styrene-butadiene rubbers in the tyre field, the furnace blacks have become more popular. These blacks give better processing and physical properties in SBR than the channel blacks. With the recent advances in carbon black technology it is now possible to control at will all the four characteristics of the carbon black--*the particle size, surface area, chemical characteristics of the surface and structure.* The surface area (independent of particle size) and the chemical characteristics of the surface are changed by oxygenation. The vital characteristics from view-point of abrasion resistance are the particle size and the structure.

The wear life of tread or retread increases with decreasing particle size of the black while increasing black structure contributes to increased tread life under severe service conditions. The particle size of modern furnace carbon-blacks ranges from 20 mmu (10^{-6} mm) to 150 mmu. Structure as measured by Dibutylphthalate absorption varies from 0.6 cc/gm to 1.4 cc/gm. It is also possible to get carbon-blacks with the same particle size range but with different structures and a wide range of spectrum is now available. The blacks used in retread industry are:

	HAF-HS		ISAF-HS	SAF-HS
FEF	HAF	N285	ISAF	SAF
	HAF-LS		ISAF-LS	SAF-LS

Among these the 'SAF's give the ultimate in abrasion resistance, however because of the extreme fine particle size the dispersion of these blacks is a problem and the flex characteristics of the vulcanizate are adversely affected. Some success has been achieved with SBR masterbatches of the black and retread compounds based on such masterbatches are used for retreading of tyres demanding supreme abrasion resistance.

The blacks commonly used in the industry are the 'HAF's and the 'ISAF's. ISAF gives almost as good wear performance as the SAF black. In original tread compounds, ISAF black is still not preferred as there is a greater tendency to groove-cracking with the black. But in retreads groove-cracking is less troublesome and hence ISAF blacks can be used.

For premium retreads ISAF blacks are used in SBR or SBR/NR blends. This combination of better abrasion resistant polymer and better abrasion resistant carbon blacks gives retreads with superior resistance to abrasion. The main difficulties with the black compared with HAF are the greater difficulty of dispersion of the black especially on mixing mills and the higher heat build up in the retreads in service.

Work Horse of Industry

The work horse of the industry is still HAF black. This is the major black used in the original tread as well as in retread compounds. In USA there was a trend towards increased replacement of HAF by ISAF but with the passage of the safety bill, there is shift back to HAF the black proved over the years.

The recent variant introduced in these blacks is structure variation. HAF, ISAF and SAF blacks are available in normal, low structure and high structure. High structure blacks are easier to disperse and improve processing. In vulcanizates with equal loading of blacks, these blacks will give higher hardness. At equal loading of the blacks or when compounded for equal hardness, these blacks give higher modulus, better abrasion resistance especially under severe wear conditions, but with higher running temperature and lower flex resistance, in SBR.

The low structure blacks give lower modulus vulcanizates with higher tear strength. The lower structure blacks are more difficult to disperse in the rubber than the normal blacks. The high structure blacks and the normal structure blacks should therefore be preferred for highway tyre retreads with SBR and the low structure blacks for "off the road" tyre retreads and especially those from natural rubber.

Furnace Black N 285

The latest carbon-black coming as a contender for the tread rubber application is the furnace black N 285. It has particle size range intermediate between that of HAF and ISAF and it is a high structure black. Thus N 285 can be used to impart better wear resistance than HAF without the attendant flex-cracking and higher running temperatures of ISAF carbon-black.

The fine particle size (20-30 mmu) carbon-blacks are the major blacks used for retread compounds but the coarser blacks are used sometimes for part replacement of the fine particle size blacks either for processing advantages or for special properties e.g. low running temperatures in thick tractor tyre retreads. Carbon-black FEF is used in minor quantities for this purpose.

At one time the coarse thermal blacks FT and MT were being used as part replacement of the then costlier fine particle size blacks in cheaper grades of camelbacks. With the advent of high black—high oil techniques, these blacks are rarely used in camelback compounds.

MINERAL FILLERS

Mineral fillers have been rarely used in tread or retread compounds. However with recent advances, silica fillers have been developed with reinforcing qualities equivalent to those of carbon-blacks, and coloured tyres are now within realms of possibility. Retreads for these coloured tyres will of course have to be based on these same reinforcing mineral fillers. The volume cost of these fillers is still high and coloured tyres are still a rarity.

Recently it has been observed that inclusion of reinforcing silica fillers in normal black tread compounds changes the nature of tear of the vulcanizate from a plain tear to a knotty tear. The tear strength is not enhanced much but the tearing energy is enhanced considerably. This has a bearing on chipping and chunking problems connected with tread. Minor quantities of silica fillers (3-5 phr) are being used in synthetic rubber tread compounds to this end and can also be used in retread compounds.

Hard clay has been recommended in synthetic rubber retreads for improvement in cut growth resistance of the retreads at levels of 10-15 phr. Very fine particle size clay is essential otherwise coarser particles of clay are more likely to cause more flex cracks.

Zinc oxide is used for its accelerator-activation capacity. Zinc oxide is one of the most difficult filler to disperse efficiently in rubber compounds. A badly dispersed zinc oxide will lead to early flex cracking. The particle size of the oxide is important and the oxide must be free from grit and zinc metal traces.

PLASTICISERS AND SOFTENERS

The primary function of the plasticiser in a camelback compound is to aid the processing. Addition of the plasticiser softens the rubber, thereby increases the rate of absorption of the filler and reduces the rate of heat generation on the mixing mill and the extruder. It also enhances the extrusion rate. However the plasticiser must be such that it will not adversely affect the dispersion of the ingredients or the quality of the retread.

Not all the plasticisers used in rubber industry are suitable for use in camelbacks. The plasticiser has to be carefully chosen especially when the camelback compounds are to be based on high carbon-black high oil loading techniques. The plasticiser must have a good compatibility with the polymer, very low volatility and should have the least effect on the cure-activity of the compound or the ageing characteristics of the vulcanizate.

The plasticisers and softeners used in camelback industry can be classified as follows:

A) Petroleum Oils

B) Pine tar, pitch or resin

C) Special plasticisers

Petroleum Oils

These are the refined residues from the refineries nearer to lubricating oil base stocks. The requirements of a good processing oil for camelback compounds can be given as:

i) Free from asphaltenes

ii) Nitrogen bases below 10 per cent: The nitrogen bases have good plasticising effect and tack but these affect the cure rate.

iii) First acidaffins low (below 20 per cent): The first acidaffins are unsaturated compounds, hence may form gummy resinous products during storage and may also rob the polymer of the sulphur during vulcanization to some extent.

iv) Paraffins below 20 per cent: These fractions have lower compatibility with natural rubber or SBR and may bloom out of rubber when added above certain level.

The petroleum rubber process oils are classified into three groups.

A) Paraffinic

B) Naphthenic and

C) Aromatic processing oils depending on the percentage of carbon-atoms on the hydrocarbon chains.

A rough guide to the classification can also be found from the aniline point (i.e. the temperature at which the oil becomes soluble in aniline).

It is the aromatic class of oils that are suitable for use in camelback compounds. Generally the higher the aromaticity i.e. higher the percentage of aromatic carbon atoms in the oil hydrocarbon (or as a rough guide lower the aniline point) and higher the molecular weight (or viscosity) of the oil, better the compatibility of the oil in rubber and also the processibility of the compound. These oils help the dispersion of carbon-black in the rubber to some extent, impart some green tack and have less influence on the tensile strength, tear strength and cut growth resistance of the vulcanizate, flex resistance is many a time enhanced because of the better dispersion.

Addition of any plasticiser to the camelback generally reduces the abrasion resistance but in SBR if the hardness of the retread is maintained by simultaneous additions of carbon-black along with plasticisers, surprisingly large quantities of oil and carbon-black can be incorporated before the abrasion resistance of the retread drops, and higher the initial molecular weight of the SBR polymer greater is the quantity of oil that can be added.

This observation is at the basis of the use of high black high oil loading compounding technique of SBR—camelbacks and the preference for SBR-1712 in such compounds. This compounding technique is not possible in natural rubber because during the addition of the larger quantities of oils and black the molecular weight of natural rubber degrades and hence the physical properties and the abrasion resistance of the vulcanizate degrades. Another drawback is that the aromatic oils have a solvating action on the natural rubber molecule and higher additions of the oil make the stock sticky, devoid of strength and body thus making the processing difficult. In SBR such problems do not arise, because of better affinity of the polymer to these oils.

A slight disadvantage of the aromatic oils as compared to the other two types is the slight lower resilience but this is outweighed by the other advantages.

Typical specifications of suitable aromatic oils are:—

1) Aniline point 30°—50°C.

2) Hydrocarbon analysis C-aromatic 36-48%, C-naphthenic 11-29% C-paraffinic 25-41% (—Cp not to be confused with the paraffins in Rostller analysis mentioned before. Cp is the number of paraffinic carbon atoms on the hydrocarbon chain and paraffins in the Rostller analysis is the fraction of the oil which have no reactivity even with fuming sulphuric acid).

Nitrogen bases	2.5 per cent
First acidaffins	below 20 per cent
Second acidaffins	60 per cent or above
Paraffins	below 20 per cent

High Black — High Oil Loading Technique

The camelback compounds are compounded to a certain hardness (around 60 Shore A). In natural rubber compounds therefore a definite loading of carbon-black is used with only a minor quantity (3-6 phr) of processing aid, which will give the required vulcanizate hardness. Higher loadings of carbon-blacks give lower flex life and lower quantity of black gives lower abrasion resistance. Higher amounts of processing oils cannot be used because of the deterioration in abrasion resistance of the retread.

However in SBR compounds high loadings of oil are compatible and there is no appreciable loss in abrasion resistance provided the drop in hardness caused by the addition of oil is compensated by increased loading of carbon black. Thus the polymer can be extended to a great degree by simultaneous addition of the black and the oil, and thus economic camelback compounds can be obtained without any loss in performance of the retread.

The following can be used as a guideline — for Synaprene camelback compounds.

(1) For every phr HAF above 50 phr loading in Synaprene 1500, 0.8 phr extra oil is added e.g.

Synaprene 1500	100	100
Carbon black HAF	50	62.5
Aromatic Oil	8	18

ii) For every phr HAF above 50 phr loading in Synaprene 1712 1 phr extra oil is added e.g.

Synaprene 1712	100	100
Carbon-black HAF	50	62.5
Aromatiç Oil	3	15

This will maintain the hardness, modulus and the stiffness of the compounds to the level of that of the conventional compounds. The compounds so made are not only economically advantageous, but also more safe as the wet-skid resistance of the retread increases (High mu).

Pine Tar Products

These are residues from pine-wood

(*Contd. from page 16*)
face. Typical levels would be:

Santoflex IP	0.5 phr
Santoflex AW	1.0 phr
Paraffin Wax	1.0 phr

Synaprene rubbers contain sufficient antioxidant to protect against normal oxidation but in case of camelbacks based on blends of natural rubber and Synaprene rubbers or natural rubber alone, protection against normal oxidation has also to be provided for. Hence for such camelbacks the level of Santoflex IP has to be raised. The typical levels for these camelbacks would be:

Santoflex IP	1.0 phr
Santoflex AW	0.5 phr
Paraffin wax	1.0 phr

Santoflex IP and Santoflex AW are both powerful antiozonants and each functions by a separate mechanism to act as antiozonant. Santoflex IP increases the critical stress at which the ozone cracking would be maximum while Santoflex AW reduces the rate of crack growth. The combination delays the onset of ozone cracking and reduces the crack growth also. The paraffin wax should have a melting point between 65-70°C.

CHOICE OF CURATIVE SYSTEM

When channelblacks were being used, because of their retarding nature, the benzothiazyl disulfide (MBTS) accelerator provided a sufficient safety during processing and storage of the camelback. However with the advent of furnace blacks which do not have the retarding nature and on the other hand because of their structure are slightly hot processing during mixing, warming and extrusion, the safety given by the accelerator is quite inadequate and sulfenamide class of accelerators have become a must.

Another important part of the curative system is the sulphur in camelback compounds, traditionally the insoluble variety of sulphur is used for two reasons viz.

I) to reduce the blooming of sulphur and

ii) to increase the storage life of the product.

Retread compounds contain sulphur at 2-3 phr level. Soluble sulphur at this level is soluble in rubber at the mixing mill temperatures. But at room temperatures the solubility of sulphur in rubber falls to only 0.7 phr. Hence the excess blooms out slowly and kills the surface tack of the camelback. The bloom cannot be removed by solvent swab. This leads to the difficulty in building up and proper fusion of the retread to the casing. Insoluble sulphur a polymeric allotrope of normal sulphur is completely insoluble in rubber and therefore does not bloom. Thus the green tack of camelback is preserved.

Blooming of Sulphur

Insoluble sulphur is inactive and does not cross link with rubber till 90°C. at which temperature it gets converted to ordinary active form. So if during the processing stages or during storage, the temperature of the rubber stock does not reach upto 90°C, the compounds containing insoluble sulphur can be stored for long periods.

Blooming of sulphur must be avoided on the cushion gum side of the camelback. Hence use of insoluble sulphur is a must in the cushion gum compound. The low carbon-black loaded compound undergoes only warming and calendering operation and it is possible to maintain the calendering conditions such that the rubber temperature does not go above 90°C the transition temperature of insoluble sulphur. However in case of the tread part of the camelback the conditions are different. Actually blooming of sulphur on this part of the camelback is not a serious drawback, excepting that of customer appeal.

The main advantage of use of insoluble sulphur is for the enhancement of the storage life. However the tread part camelback is a comparatively stiff compound and it is very difficult to maintain the rubber temperature below 90°C during processing especially during extrusion. *In case of slab material directly* calendered from a comparatively cool mixing mill there may not be much reversion of insoluble sulphur to the soluble stage and storage stability of the slab *may remain good but in case of the* extruded camelback where the temperature of the extrudate goes as high as 90°-100°C, at least for a short duration of time.

Insoluble Sulphur

The insoluble sulphur may get partly converted to the soluble variety thus losing partly the advantage of insoluble sulphur in prolonging the storage life of the camelback. Therefore at present use of insoluble sulphur is limited to the cushion gum compounds only and normal soluble sulphur is used in the tread part of the camelback especially when it is based on SBR rubbers. Synaprene rubber compounds have inherently better scorch safety and hence the storage *life of synaprene camelback is more than* that of the corresponding natural rubber compound. Even at normal temperatures, normal sulphur has less blooming tendency in SBR especially the oil-*extended varieties than in natural rub*ber. Therefore the customer appeal is also better.

Experiments were carried out in our Technical Service Laboratory on the effect of use of normal soluble sulphur in Synaprene rubber camelback compounds.

Following two compounds were prepared and stored at room temperature for 8 months in Bombay. (February to October) packed in polythene liners. They were checked for blooming and the Mooney Scorch time.

Synaprene 1500	100	—
Synaprene 1712	—	100
ISAF	—	12.5
HAF	50	37.5
Aromatic Oil	10	8.5
Zinc Oxide	3.5	3.5
Stearic acid	2	1.5
PBN	0.5	0.5
Santocure	1.2	1.0
Normal Sulphur	2	1.5
Mooney scorch time Minutes to 5 point rise @ 126°C		
Original	39	25
After 32 weeks' storage	32	23
Blooming tendency	slight at edges not covered with polythene.	NIL.

Thus in Synaprene 1712 camelback compounds use of the costly imported *insoluble sulphur can be avoided.* The storage stability of the Synaprene camelback compounds is high in spite of the fact that normal soluble sulphur is used in the compounds.

The storage-life of Synaprene camelbacks with treads containing normal sulphur can be further enhanced by replacement of the Santocure accelerator by Santocure NS or still preferably by *Santocure MOR along with small quan*tities of the retarder *'Curetard'*.

Typical regular curative systems would be:—

Synaprene 1500	100	—
Synaprene 1712	—	100
Santocure MOR	1.1	1.1
Curetard	0.5	0.5
Sulphur normal	1.8—2.0	1.5—1.7

This cure system will require about 5 minutes per 1/32nd inch of gauge of camelback for passenger tyre retread cure and 6-7 minutes per 1/32nd inch gauge for truck tyre retread cure.

In advanced countries now generally 'Fast' or 'Quick cure' camelbacks are manufactured. The 'fast cure' stock develops optimum physical properties in 20-25 minutes versus 35 minutes @ 143°C. for normal camelback stock. Addition of C 2 phr of DPG to the normal or regular stock will convert it into a fast cure cam 'back. The fast cure camelback will require about 3 1/3 and 5 minutes per 1/32nd gauge for passenger and truck tyres respectively.

However in the tropical climate as in our country, the storage life of fast cure camelback is very limited if normal sulphur is used in the compound. Hence fast cure camelbacks are made only by those manufacturers who do the retreading themselves and can consume the stock quickly.

COMPOUNDING OF CAMELBACK

The properties desired in a camelback compound are:—

Mooney Viscosity ML4 @ 100°C.	30-45
Mooney Scorch Time minutes to 5 point rise @ 126°C.	20-30 min.
Cure-time @ 152°C. (on 1/8" thick test slab)	about 30 min.
Shore Hardness A	58-65
Modulus @ 300% Elongation	90-120 kg/cm²
Angle-tear strength kg/cm.	35-60

The already stated tensile-strength and elongation at break are no criteria for *performance of a camelback. Synaprene* camelback with a tensile strength 225 kg/cm² *will have a far better wear life* than a natural rubber MPC camelback with tensile strength of above 300 kg/cm². Tensile strength is a good quality control criterion for checking the dispersion *in a number of batches of the same* compound.

Heat Build-up Problem

For better abrasion-resistance in the retread, Synaprene rubbers are the ideal rubbers. Since heat-build up is not so *severe a problem in camelbacks,* Synaprene rubbers can be used even in cases where these rubbers cannot be used in original treads because of the heat build up problem. The advantages are the *better wear-life and the better flex resist*ance of the retreads.

For passenger tyre camelbacks Synaprene 1712 is preferred because of its better road holding ability, relative freedom from noise and lastly for better economics. The economics can be further improved by use of high carbon-black, high oil techniques. In passenger tyres, the wear action is mainly of 'rubbing' nature because of the frequency of 'stop and go' type motion and the abrasion resistance is of primary importance and the extended compounds have almost as good abrasion resistance as the normally loaded ones. In addition the safety on roads especially on wet roads is further enhanced.

In truck tyre camelbacks because of the heavy loads, in addition to the wear by the normal rubbing action, wear also *occurs by cutting action and some in*creased resistance to cutting or tearing is necessary. For this reason the camelback compounds are based on blends of Synaprene 1712 and Synaprene 1500 for *Light-truck tyre retreads, on Synaprene* 1500 alone for larger truck tyres and on lends of Synaprene rubber and natural ubber for thick camelbacks (16/32" or 18/32" gauges). Typical formulations would be as shown in table A below:

TABLE A

Typical Formulations

ASSENGER TYRES

		Treads	Cushiongum
ynaprene 1712	100	100	10
RMA	—	—	90
Carbon black HAF	50	60	—
Carbon Black FEF	—	—	40
Aromatic Oil	3.5	12.5	—
Pine tar	—	—	8
Zinc Oxide	3.5	3.5	4
Stearic acid	2.5	2.5	2.5
Santoflex AW	1.0	1.0	1.0
Santoflex IP	0.5	0.5	—
Paraffin wax	1.0	1.0	—
Santocure MOR	1.1	1.1	0.6
Curetard	0.5	0.5	—
Normal sulphur	1.7	1.7	—
Insoluble sulphur	—	—	2.5

TRUCK TYRES CAMELBACK

	Premium		*Economy*
Synaprene 1500	100	80	—
Synaprene 1712	—	—	60
RMA	—	20	40
HAF	62.5	50	65
Aromatic Oil	15	8	18
Zinc Oxide	3.5	3.5	4
Stearic acid	3	3	2.5
Santoflex AW	1	0.75	0.75
Santoflex IP	0.5	0.75	0.75
Paraffin wax	1.0	1.0	1.0
Santocure MOR	1.1	1.1	0.9
Curetard	0.5	0.5	0.5
Normal sulphur	1.85	2.0	1.0
Insoluble sulphur	—	—	1.2

(To Be Continued)

CAMELBACK

By K. J. JANAKAR, Technical Officer, Synthetics and Chemicals Ltd., Madras.

PART II

(Continued from August issue page 33)

FOR better processing characteristics especially for mill-mixing, the passenger tyre camelbacks can be based advantageously on HAF-HS.

If Banbury mixing facilities are available HAF can be partly or wholly replaced by ISAF for better wear life.

Manufacture of Camelback

The mixing can be carried out in Banburies or on mixing mills.

Banbury Mixing

Generally two stage mixing technique is used. When natural rubber is used alone or in blend with SBR, it is prepeptised and then used. Synaprene rubbers do not need any premastication and can be used directly for making the compounds.

In the two stage mixing a masterbatch of the polymers, fillers, activators, plasticisers and antioxidant is made. Generally this operation is carried out under high speed mixing. The addition sequence is 1) polymers + zinc oxide + antioxidants 2) carbon-blacks + stearic acid and 3) when the temperature reaches around 120°C, the oil is injected.

The batch is dumped at temperatures between 150°-160°C. Temperature at dump should not be allowed to reach higher figures because of excessive carbon gel formation. Though the formation of carbon-gel increases the abrasion-resistance, the flex resistance is adversely affected.

After a rest period of about 24 hours the masterbatch is fed to the banbury again with rotors at low speed and the curatives are added. The batch is dumped at temperature of around 120°C.

This remastication of the master gives good dispersion of carbon-black in the polymer and the processing characteristics of the compound (e.g. die swell, extrusion rate etc.) are improved. Because of the low working temperature the scorch safety of the compound is better.

The safety is more enhanced if the accelerator is added on the slab off mill rather than in the banbury.

Mill-Mixing

On mixing mill because of the low temperature of rubber attained on the mill, the mixing can be carried out in one step. Two stage mixing on mill can also be carried out and will improve processing and properties of the retread. However one alteration of the order of addition of ingredients from that in natural rubber—MPC camelbacks has to be done.

In old days it was customary to add the accelerator MBTS along with the polymers before addition of the carbon-black fillers. Sulfenamide accelerators should not be added to the polymers at the beginning of the mixing cycle. Sulfenamide accelerators should be added towards the end of the mixing cycle just before the addition of sulphur and preferably too after cooling the batch for some time. Subjection of sulfenamide accelerators to high temperatures reduces the scorch safety imparted by the accelerators.

Addition of Zinc Oxide

With Synaprene rubbers, mixing the compounds is easy and can be completed in short time. The rubber should be passed 2/3 times through tight nip without banding. The addition of zinc oxide and antioxidants and the first addition of carbon-black should be done on a tight nip to avoid bagging and breaking of the band. The nip should be slowly opened as the filler is absorbed in. Stearic acid should be added along with the first additions of carbon black but never with zinc oxide. Simultaneous addition of zinc oxide and stearic acid leads to poor dispersion of the zinc oxide. Oil addition should be started when at least 2/3 rds. of the carbonblack is absorbed by the polymer.

When mixing camelback compounds based on Synaprene rubber natural rubber blends, the natural rubber should be first masticated and then the Synaprene rubber should be added to the natural rubber band slowly. With simultaneous addition of the two rubbers, the nerve of the high mooney natural rubber will not be killed leading to high die-swell and rough extrudate surface in extrusion. After blending the normal mixing procedure can be used.

After mill mixing the stock should be cooled by immersion in water and kept overnight for maturation.

Slab

The slab material can be produced directly from the mixing mill or by extruder. With Synaprene compounds, it is difficult to take out a thick sheet like 14/32" from the mill, because of bagging difficulty and consequent air entrapment. In such cases, it is preferable to roll out bundles, feed to the nip vertically and the sheet taken out without allowing the band to form.

CAMELBACK

For the manufacture of camelbacks generally the same machinery is used as for extruding new tyre treads. The compounds, usually taken from a storage room, must be replasticized so that the extruder is fed with a pre-warmed compound. The warm-up mill should not be too small in order to enable a continuous feed of the extruder. As soon as the compound on the mixing mill becomes extrudable (at about 80°C) it is fed to the extruder.

This is preferably done by means of a conveyor-belt. A pair of knives, properly fixed, cuts a strip from the mill. The width of the strip is dependent on the dimensions of the tread to be extruded. The travelling speed of the conveyor belt should be adjusted to the circumferential speed of the mill, since an even feed of the extruder is necessary to maintain the proper dimensions, of the extruder tread. The diameter of the *work-screw ranges from 150-200 mms.,* sometimes even up to 250 mms.

Moulding Ledges

Normally a double-thread screw is used. A feed roller fixed to the extruder aids in an even feed. The extruder head is built flat. The construction of the head is of great importance. (*See Fig. 3 below*). The passage from the round section to the flat orifice should be designed to ensure an even flow of the material. Bevelled edges assist a smooth extruding of the material. The inner part of the flat head should be polished. Sharp edges and "dead" angles must be avoided.

The extruder head consists of two parts for easier polishing and cleaning. Near the die a groove is made for the fixing of the so-called extruding or moulding ledges. A moulding ledge, is normally of a flat bar steel, approximately 38 x 16 mms. The dimensions of the moulding ledges are very different, since it is often necessary to switch from one size to other.

That is the reason why modern machines are equipped with hydraulic rams which permit a quick replacement of the extruding ledges. The shape and dimensions of the moulding ledges must be adjusted to the various swelling effect of the mixes. Th extrusions leave the extruder head at a high extruding speed and the relatively thin side-wall edges do not travel as fast and tend to crack. In order to prevent this, it is advisable that the centre part of the tread is *machined parallel to the counter ledge.* In this way, a retardation of the flow of the material is effected.

Contrary to this the flow of the material on both sides of the mould ledge must be improved. This is achieved by

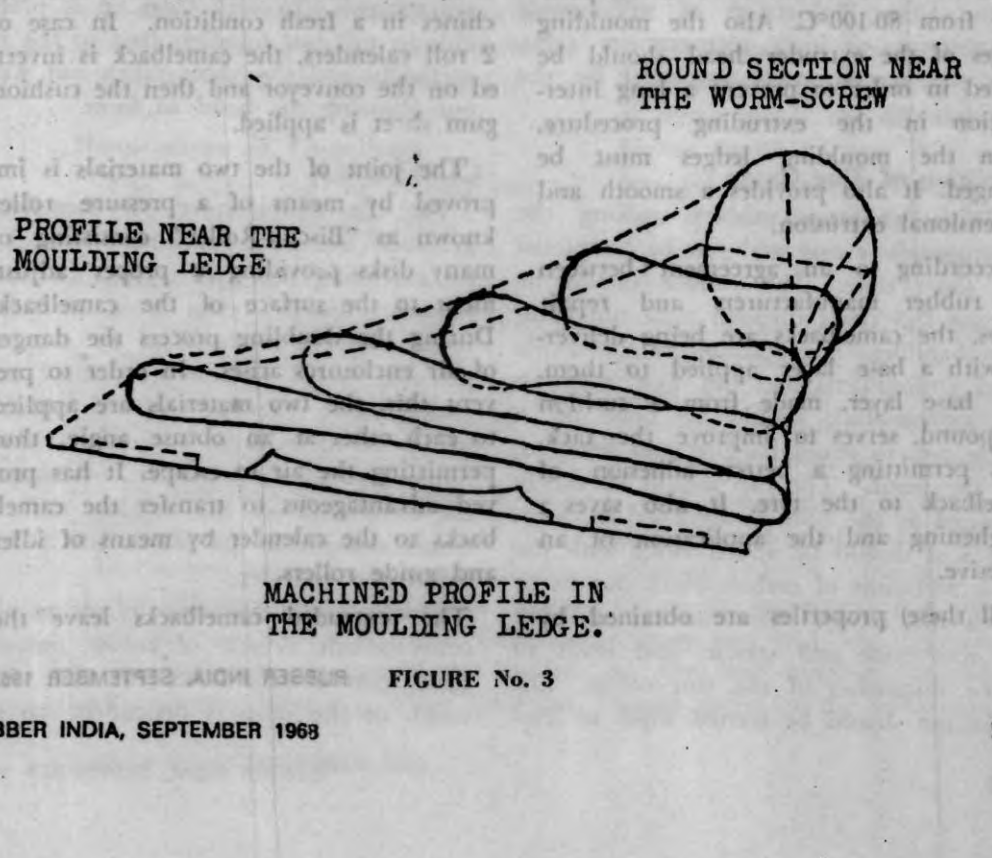

FIGURE No. 3

bevelled edges, and by means of additional outlets on both sides of the moulding ledge in order to decrease the pressure exerted by the compound in this area of the tread section. The last item is especially important for the manufacture of small treads, where the rubber develops a high pressure in the extruder head.

It must be stressed that the inner pressure of the extruding machine also has an influence on the dimensions of the extruded material. A faster feed and a higher speed of the worm-screw result in a greater swelling of the extruded material. Sometimes use is made of these influences in order to correct small deviations in the final dimensions of the extruded tread. Heating and cooling possibilities of the extruder are necessary for a perfect extrusion of camelbacks.

Smooth & Dimensional Extrusion

Practically the worm-screw is always cooled. The barrel temperature ranges from 40-60°C. The front of the extruder head, however, should have a temperature from 80-100°C. Also the moulding ledges of the extruder head should be heated in order to prevent a long interruption in the extruding procedure, when the moulding ledges must be changed. It also provides a smooth and dimensional extrusion.

According to an agreement between the rubber manufacturers and repair shops, the camelbacks are being delivered with a base layer applied to them. The base layer, made from a cushion compound, serves to improve the tack, thus permitting a better adhesion of camelback to the tyre. It also saves a roughening and the application of an adhesive.

All these properties are obtained by the application of a base layer having a thickness of 0.5-1.0 mm. The base layer, however, is not meant to replace the cushion located between the tread and the carcass. For full effectiveness, the base layer must be applied to the camelback in a hot condition, i.e. the extruded sheet must be put into the extruded camelback with both materials in a fresh condition.

Adhesion Effect

For this reason the installation of a small 2 roll or preferably a 3-roll calender near to the extruder is necessary. With the 3 roll calender the extruded camelback is lead over the top roll of the calender. The pre-warmed compound is fed into the nip between the centre and bottom roll. Exact dimensions of the material are obtained by re-passing the sheeted material through the nip between the centre and top roll. On top of the top roll the sheeted material is combined with the camelback.

A perfect adhesion-effect is obtained in this way without any solvent or adhesive, since both materials leave the machines in a fresh condition. In case of 2 roll calenders, the camelback is inverted on the conveyor and then the cushion gum sheet is applied.

The joint of the two materials is improved by means of a pressure roller known as "Biscuit-Roller" consisting of many disks providing a proper adjustment to the surface of the camelback. During the doubling process the danger of air enclosures arises. In order to prevent this, the two materials are applied to each other at an obtuse angle, thus permitting the air to escape. It has proved advantageous to transfer the camelbacks to the calender by means of idler and guide rollers.

The extruded camelbacks leave the

extruder at a temperature of 90-100°C. They are cooled slightly while being transferred to the calender. For this reason the sheet is preferably calendered at the same temperatures in order to obtain equal working conditions, thus preventing varying shrinking effects. The adhesion obtained in this temperature range is good. The temperature required for a smooth calendering should range from 60-70°C. Naturally the compound used for the base layer must be pre-warmed prior to calendering.

The circumferential speed of the calender rolls must be adjusted to the output of the extruder. For this reason a variable speed calender drive or better still coupled DC drive for extruder and calender is required. The proper adjustment only of the speeds of the machines employed guarantees a perfect joint of the two materials.

Take-off System

A new equipment for producing camelbacks, and applying them to prepare casing is offered by Barwell Engineering Ltd., Cambridge. This equipment permits making very short runs with quick attainment of the dimensional specification. The compound is preheated in a warming chamber and plasticised, the warmed sheets are rolled up in the roll former, the roll of the warmed compound is placed into the extruder and extruded by two hydraulic rams. As the hydraulic pressure is infinitely variable it is possible to attain any desired thickness of the camelback. The extruder can produce extrusions from 0.04 sq. in. to 15 sq. ins. cross-sectional area.

The take-off system is very important in the manufacture of camelback. It could be as crude as passing through long-length water bath (even upto 50 mtrs. depending on speed of extrusion. About 5-6 minutes cooling in the trough is necessary, thicker the camelback longer the residence time necessary) to the most elaborate double deck perforated metal conveyor coupled with cold air jets at the end of the run for removing the moisture. The idea is to cool the material fast and complete as much as possible to avoid any set-ups.

Quality Control of Camelback

However too rapid chilling of the tread causes bloom problem. Therefore generally the camelback is first cooled in water at normal temperat .re and then by chilled water. The camelback from the cooling trough goes over a slanting conveyor where adhering water is drained off or removed by impinging air jets. Polythene sheet is then applied over the cushion gum layer and the camelback cut to size is canned. The temperature of the camelback at this stage should not be above 36°C. Application of the polythene preserves tack of the cushion gum layer by prevention of any contamination and more important lessens the chances of bloom formation.

The camelback is used even by a small retreader who has no facilities to check the camelback he buys. He relies on the curing instructions given to him by the camelback manufacturer. Therefore the camelback manufacturer has to ensure himself that the product he supplies has consistent qualities. The checks generally used are:

Specific Gravity

This ensures that i) there are no gross inaccuracies in making the compound and that the camelback is not porous (a difficulty sometimes come across in extruded camelbacks either because of too low back pressure in extrusion or because of decomposition of the nitrosoamine type retarder because of high temperatures during extrusion or warming up.)

Cure Characteristics

These are checked by means of step cures. The camelback is vulcanized in press for different time and the rate of modulus development in the vulcanizate is checked. The test need not be elaborate. Instead of the stress measurement at definite elongations, for sake of simplicity the strain at a definite stress (e.g. hanging a known weight) is measured.

Tensile Strength of the Vulcanizate

This test gives a measure of thoroughness of dispersion of the ingredients and it is advisable to check certain batches at random especially when new supplies of raw materials are to be used.

Storage Life

There is no short and quick method for determination of this quality. Mooney scorch time can give a qualitative indication. In certain big factories accelerated results are obtained by storing the camelback at higher temperatures (around 70°) for 3 or 4 weeks and the drop in the mooney scorch time is checked.

Performance Test

These are long exhaustive tests and very few manufacturers undertake these. However even though large fleet scale evaluations are not carried out most manufacturers do try the retreaded tyre from their camelback on a known vehicle, a bus or a taxi and check the performance of their camelback.

Application of the Camelback — Retreading Process

The retreading process is done as follows:

Inspection

The tyre is first inspected to mark for all nailholes and other foreign substances. It is carefully sounded particularly at the shoulders for ply-separation. The tyres with defects such as separated plies, breaks in the bead reinforcement area, exposed bead wire or loose and broken cords are rejected. Tyres which are worn through bead or more plies for a distance of 4" or more are also rejected.

Buffing

The tyres found to be suitable for retreading process are then buffed to level clean and roughen the tread. Generally the buffing is done in stages. If the old tread part is thick, the old tread is skived out by means of a sharp knife and then by a rotating drum with a number of sharp projections and finally by an emery wheel grinder if required. In advanced countries because of the high cost of labour the handwork is omitted and the tyre is directly subjected to an emery grinder operating automatically. Care is taken to see that only the tread rubber is removed so that the cords are untouched and the original strength of the casing is preserved. Care is also taken that no exposed loose cord ends or deep furrows are left on the buffed surface.

Inspection and Repairs

After buffing, all exposed fabric holes, cuts etc. are checked and spot repaired after filling with cushion gum and removing all air pockets.

Cementing

The tread surface is then given a coating with cement and thoroughly dried before the attachment of the camelback.

Building up

The polythene liner is removed from the cushion gum side of the camelback, the camelback cut to length and then applied over the dry tacky cemented layer of the casing. It is preferable that the camelback is applied without any tension to prevent any tendency to spring back and create open splice. It is practice to make bevel splice but even butt splicing has been found satisfactory.

In such cases, a homogeniser tool having two prongs is inserted in either side of the splice joint and given a twist to force the edges of the butt splice more tightly. Sometimes a thin strip of cushion gum is put at the splice for better adhesion.

Orbitread Process

Recently a new process for application of the retread rubber other than in form of a camelback has been developed. It is the *'Orbitread'* process. In this process a thin ribbon of the tread compound 2.5 mm thick and 25-35 mm wide is extruded directly onto the buffed cemented casing and wound helically on the casing. The total thickness of the applied rubber is controlled electronically. No cushion gum is necessary and there is no tread splice.

Curing

The curing is done in two ways. In the tyre-sole process, the tyre after application of the camelback is then opened up the cover on a special spreader. A light flexible curing ring is fitted around the green rubber. The curing ring is carefully selected in such a way that it will not touch shoulders or sidewalls. This curing ring contains the tread pattern on the inside while around the outside passes a coiled steam tube. After removal from the spreader, the tyre is next fitted with an ordinary inner tube, placed on the ring and inflated.

In this position it is clamped down at centre right and steam of correct pressure is passed through the coiled tube. The curing rings are made of copper. In this process a controlled and localised heat is applied to the new green rubber and the old tyre carcass is not damaged by further heating.

Vulcanizing conditions are:

Truck Tyre Retreading

Air pressure in inner tube at 125 psi. Steam pressure 80-85 psi curing time 130 minutes. Passenger tyre retreading: Air pressure in inner tube 120 psi. Steam pressure 80 psi curing time 70 minutes.

The vulcanized tyre is then placed on the special spreader and bead extended. thus releasing the tyre from the rings. Depending upon the patterns, there are different types of curing rings fitted:— 1) Zenith curing rings 2) Ultra curing rings 3) Wembley curing rings. These rings are made of cast iron with copper spirals over it for circulation of steam. The ring is selected as per dimensions of the buffed tyre.

In the second process the tyres are vulcanised using Lodi moulds. The tyre is placed inside the mould together with the curing bag. The moulding pressure is given by air pressure of 125-150° psi for passenger tyres and 150-200 psi for truck tyres. The heat is supplied by steam of 60 psi in the jacket. The curing time depends upon the thickness of the new tread and is about 6 minutes per 1/32nd gauge thickness of the new tread. In case of recapping split moulds are used. The air pressure is lower in this case —50 psi. The cure time is about 150 minutes using 75 psi pressure of steam in jacket.

Small remoulders sometimes use sectional moulds with sectional air-bags. The air pressure is in the range of 100 psi and steam pressure about 50 psi. This method is generally used for tyre repair rather than tyre retreading. Cures are many times as long as 3 hours.

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extruder at a temperature of 90-100°C. They are cooled slightly while being transferred to the calender. For this reason the sheet is preferably calendered at the same temperatures in order to obtain equal working conditions, thus preventing varying shrinking effects. The adhesion obtained in this temperature range is good. The temperature required for a smooth calendering should range from 60-70°C. Naturally the compound used for the base layer must be pre-warmed prior to calendering.

The circumferential speed of the calender rolls must be adjusted to the output of the extruder. For this reason a variable speed calender drive or better still coupled DC drive for extruder and calender is required. The proper adjustment *only of the speeds of the machines* employed guarantees a perfect joint of the two materials.

Take-off System

A new equipment for producing camelbacks, and applying them to prepare casing is offered by Barwell Engineering Ltd., Cambridge. This equipment permits making very short runs with quick attainment of the dimensional specification. The compound is preheated in a warming chamber and plasticised, the warmed sheets are rolled up in the roll former, the roll of the warmed compound is placed into the extruder and extruded by two hydraulic rams. As the hydraulic pressure is infinitely variable it is possible to attain any desired thickness of the camelback. The extruder can produce extrusions from 0.04 sq. in. to 15 sq. ins. cross-sectional area.

The take-off system is very important in the manufacture of camelback. It could be as crude as passing through long-length water bath (even upto 50 mtrs. depending on speed of extrusion. About 5-6 minutes cooling in the trough is necessary, thicker the camelback longer the residence time necessary) to the most elaborate double deck perforated metal conveyor coupled with cold air jets at the end of the run for removing the moisture. The idea is to cool the material fast and complete as much as possible to avoid any set-ups.

Quality Control of Camelback

However too rapid chilling of the tread causes bloom problem. Therefore generally the camelback is first cooled in water at normal temperature and then by chilled water. The camelback from the cooling trough goes over a slanting conveyor where adhering water is drained off or removed by impinging air jets. *Polythene sheet is then applied over the* cushion gum layer and the camelback cut to size is canned. The temperature of the camelback at this stage should not be above 36°C. Application of the polythene preserves tack of the cushion gum layer by prevention of any contamination and more important lessens the chances of bloom formation.

The camelback is used even by a small retreader who has no facilities to check the camelback he buys. He relies on the curing instructions given to him by the camelback manufacturer. Therefore the camelback manufacturer has to ensure himself that the product he supplies has consistent qualities. The checks generally used are:

Specific Gravity

This ensures that i) there are no gross inaccuracies in making the compound and that the camelback is not porous (a difficulty sometimes come across in extruded camelbacks either because of too low back pressure in extrusion or because of decomposition of the nitrosoamine type retarder because of high temperatures during extrusion or warming up.)

Cure Characteristics

These are checked by means of step cures. The camelback is vulcanized in press for different time and the rate of modulus development in the vulcanizate is checked. The test need not be elaborate. Instead of the stress measurement at definite elongations, for sake of simplicity the strain at a definite stress (e.g. hanging a known weight) is measured.

Tensile Strength of the Vulcanizate

This test gives a measure of thoroughness of dispersion of the ingredients and it is advisable to check certain batches at random especially when new supplies of raw materials are to be used.

Storage Life

There is no short and quick method for determination of this quality. Mooney scorch time can give a qualitative indication. In certain big factories accelerated results are obtained by storing the camelback at higher temperatures (around 70°) for 3 or 4 weeks and the drop in the mooney scorch time is checked.

Performance Test

These are long exhaustive tests and very few manufacturers undertake these. However even though large fleet scale evaluations are not carried out most manufacturers do try the retreaded tyre from their camelback on a known vehicle, a bus or a taxi and check the performance of their camelback.

Application of the Camelback — Retreading Process

The retreading process is done as follows:

Inspection

The tyre is first inspected to mark for all nailholes and other foreign substances. It is carefully sounded particularly at the shoulders for ply-separation. The tyres with defects such as separated plies, breaks in the bead reinforcement area, exposed bead wire or loose and broken cords are rejected. Tyres which are worn through bead or more plies for a distance of 4" or more are also rejected.

Buffing

The tyres found to be suitable for retreading process are then buffed to level clean and roughen the tread. Generally the buffing is done in stages. If the old tread part is thick, the old tread is skived out by means of a sharp knife and then by a rotating drum with a number of sharp projections and finally by an emery wheel grinder if required. In advanced countries because of the high cost of labour the handwork is omitted and the tyre is directly subjected to an emery grinder operating automatically. Care is taken to see that only the tread rubber is removed so that the cords are untouched and the original strength of the casing is preserved. Care is also taken that no exposed loose cord ends or deep furrows are left on the buffed surface.

Inspection and Repairs

After buffing, all exposed fabric holes, cuts etc. are checked and spot repaired after filling with cushion gum and removing all air pockets.

Cementing

The tread surface is then given a coating with cement and thoroughly dried before the attachment of the camelback.

Building up

The polythene liner is removed from the cushion gum side of the camelback, the camelback cut to length and then applied over the dry tacky cemented layer of the casing. It is preferable that the camelback is applied without any tension to prevent any tendency to spring back and create open splice. It is practice to make bevel splice but even butt splicing has been found satisfactory.

In such cases, a homogeniser tool having two prongs is inserted in either side of the splice joint and given a twist to force the edges of the butt splice more tightly. Sometimes a thin strip of cushion gum is put at the splice for better adhesion.

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CAMELBACK . . . *(Continued from page 29)*

In case of tyres having prominent tread patterns e.g. farm tractor earth-mover tyres etc. a different method is used (Vaculug process). After removal of relics of the old tread pattern by buffing, the tread pattern is restored by re-forming each bar of the pattern by applying the cemented sections piece-meal by hand. The bars are made from lug-stock—an extruded stock of approximately rectangular section subsequently cut to length. Curing is done by open steam in a horizontal vulcaniser, the tyres being rotated during the process to prevent loss of shape. Tyres upto 100 in. x 30 in. may be retreaded by this method. For average sized tyres cure is 40 minutes at 140°C., air at 20 psi being applied before steam pressure is admitted.

The camelback industry ranks third after tyres and footwear industry in consumption of rubber in India. As the industrialization of our country progresses, the transport industry will progress very rapidly and the tyre retreading industry will have to keep up with the progress. Attempts are being made to start the manufacture of retreading machinery indigenously and shortly small scale retreading industry may become commonplace.

Errata

In part I (April 1968 issue) please read *"low resilience"* in place of *"low hysterisis"* on page 24 LH column line 10 from top. ■ ■