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The Market for Polyester, Nylon, and Rayon Yarns in Tire Applications

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Synopsis

The use of rayon, nylon, and polyester in various tire applications is described, and the relative merits of each are defined. Future development objectives and expectations are outlined. Volume projections for polyester, nylon, and rayon in tire reinforcement are given as a function of tire type. Product life cycles of tire reinforcement materials are analyzed in terms of market share. Polyester is expected to become dominant in 1973.

INTRODUCTION

The ever-increasing activity in the tire design field over the last several years gives the impression that the industry is evolving into a fractionated manufacturing operation producing a wide range of basically different tire design and utilizing numerous fiber-reinforcing materials. It is becoming increasingly evident, however, that considerable resolution, both of tire styles and of the preferred fabric materials, is taking place and that major emphasis in the immediate future will be on product optimization rather than further diversification.

PASSENGER TIRES

First of all, obvious trends are being established with regard to the bias, bias-belted, and radial tires in the automobile tire field. As can be seen from Table I, bias-belted tires offer meaningful performance improvements

TABLE I
Comparative Performance of Bias, Bias-Belted, and Radial Passenger Tires

	Bias	Bias/Belted	Radial
Traction, handling	100[a]	120	160
Ride, uniformity	100	100	70
Road hazard resistance	100	140	140
Durability	100	100	130
High-speed performance	100	100	110
Cost	100	80	50
Treadwear	100	130	170
Operating economy	100	100	110

[a] 100 is standard of bias tire performance; higher values better.

TABLE II
Tire Construction—OE Passenger

	Bias, %	Bias/Belt, %	Radial, %
1967	100	0	<1
1969	42	58	<1
1971	13	85	2
1973	6	85	9
1975	5	78	17

TABLE III
Tire Construction—Replacement Passenger

	Bias, %	Bias/Belt, %	Radial, %
1967	99	<1	<1
1969	80	19	1
1971	55	41	4
1973	35	56	9
1975	30	50	20

TABLE IV
Tire Construction—Truck and Bus Total

	Bias, %	Bias/Belt, %	Radial, %
1967	100		<1
1969	100		<1
1971	100		<1
1973	95	<1	4
1975	90	2	8

compared to bias tires in terms of traction, handling, road hazard resistance, and treadwear, all at a modest cost increase over bias tires. For this reason, we expect that the bias-belted design will gradually replace the bias design in the original equipment and replacement markets despite the good performance that has been achieved with the bias tire over the years. With regard to the radial tire, its obvious major advantages when compared even to the bias-belted tire, particularly in traction, handling, and high speed performance, are offset by its disadvantages in terms of cost, ride, and uniformity, so that it is expected only to share the market with the bias-belted tire rather than to supplant it. Based on this understanding, our forecast of market share for each of the three tire types is given in Tables II, III, and IV. In summary, we predict in original passenger equipment, bias tires will decline to 5% in 1975, finding application on subcompact cars only. The bias-belted tire will maintain the lion's share of the market—78% in 1975. Radials, shown at 17%, could be 5% or 25% depending upon Detroit's attitude and the tire industry's rate of conversion. In replacement passenger tires, the bias construction will still be significant in 1975, but its share will be reduced by the incursion of

TABLE V
Cord Material Ratings—Bias Passenger Tires

	Rayon	Nylon	Polyester
Strength, impact resistance	minus	good	plus
Cut resistance	minus	good	plus
Fatigue resistance	minus	good	plus
Durability	minus	good	plus
Separation resistance	minus	good	plus
High speed	minus	plus	good
Aesthetics	good	minus	plus

TABLE VI
Cord Material Ratings—Carcass of Bias-Belted Tires

	Rayon	Nylon	Polyester
Strength, impact resistance	minus	minus	plus
Fatigue resistance	minus	plus	plus
Durability	minus	good	plus
Separation resistance	minus	good	plus
High speed	good	good	plus
Aesthetics, handling	good	minus	plus

belted constructions into the lower tire lines. The bias-belted share will suffer from the growth of the radial market but should maintain a 50% share in 1975. Until 1975, the growth of radials in replacement tires will be faster than in original equipment, but the degree of success of competitive marketing programs comparing steel-belted radial with bias-belted tires will strongly influence the radial trend. The majority of truck tires will continue to be bias through 1975. The steel/steel and polyester/steel radial will become significant in the mid to late 70's.

Naturally, our interest in trends in tire styles is due to the specific fiber requirements in each of the tire types. There are now very obvious selections being made in the fibers used to reinforce each of the tire styles. In bias passenger tires, where rayon, nylon, and polyester are all used, it is becoming increasingly evident that polyester is the logical choice on a cost/performance basis. The reasons for this are illustrated in Table V, where polyester is at least equivalent and frequently clearly superior to both rayon and nylon in each important fiber requirement. For this reason, we are expecting a continuation of the strong trend to polyester for bias passenger tires, almost completely replacing rayon in the small share of the OE market that this tire type currently holds, and progressively supplanting nylon in the replacement market.

As in the bias tire, polyester, rayon and nylon have all been used successfully as the carcass reinforcement for bias-belted passenger tires, and each gives good performance in commercial lines of tires. However, polyester has established a strong position as the yarn of choice in this application because of a clear superiority over both rayon and nylon (Table VI). The

TABLE VII
Cord Requirements—Bias Tire Versus Radial Tire

	Bias	Radial		
	Carcass	Monoply carcass	2-Ply carcass	Belt
Strength, g/den	8–9	9–11	6–9	8
Energy to rupture, g cm/den cm	80	50	50	80
Fatigue rating, durability	100	60	60	75
Hot Air Shrinkage, %	6	4	4	2
Growth, %	3	3	3	1
Modulus, g/den	100	100	100	300
Adhesion rating	100	100	100	150
Compression modulus, g/den	100	200	100	500

interaction between the stiff, rigid belt with a moderately flexible carcass has been best achieved by the use of polyester because of its relatively low growth tendency compared to nylon and good flex fatigue performance compared to rayon. Fiberglass has been used mainly for the belt of bias-belted tires, primarily because a high degree of cord rigidity is needed in this structure to compensate for the high belt angle required in bias-belted tires during tire forming. There have been problems with compression impact failure of fiberglass, however, and steel is expected to become important as a belt material in this tire by 1974/75. In terms of fiber utilization in passenger tires, the strong movement from bias to bias-belted tires will further reduce nylon's share of the market because of the technical advantage of polyester in the bias-belted construction.

Moving to radial passenger tire constructions, we feel that, despite the relatively long history of this tire type in Europe, because of the different requirements between European and North American markets, particularly in terms of tire size and operating conditions, sufficient time has not elapsed to establish definitely the superiority of any one fiber. Nevertheless, cord material requirements are known and are given in Table VII. We feel that nylon, with its physical stability deficiencies, will not be widely used in radials for tire uniformity reasons, but that it will gain some acceptance in high speed radial applications. We are aware of the European manufacturers' opinion that the durability of rayon is adequate for carcass reinforcement of their cooler-running, less demanding radial tires and that the low shrinkage of rayon will be an advantage in tire uniformity. On this basis, we believe that radial tires produced in this country with rayon carcasses will be commercially successful to some extent. However, we consider that the performance advantages seen for polyester in the bias-belted tire will translate also to the radial tire area, and we understand that preliminary commercial experience with polyester-reinforced radial tires is beginning to confirm this view. Current polyester yarns are considered to be suitable for radial tire use, but a reduction in treated cord shrinkage will improve tire uniformity, and such a yarn is under develop-

TABLE VIII
Polyester Cord Development Targets—Passenger Radials

	Control	Minimum targets: Monoply carcass	Minimum targets: 2-Ply carcass	Minimum targets: Belt	Individual experimental optimi
Strength	100	130	100	115	110
Durability, Mallory	100	80	80	70	500
Shrinkage	100	140	140	175	135
Modulus	100	100	100	200	200
Adhesion	100	100	100	150	150
Chemical stability	100	100	100	100	175
Compression modulus	100	200	100	500	1000

TABLE IX
Replacement Passenger Units Per Cent of Units by Carcass Reinforcement Material

	1967	1969	1971	1973	1975
Polyester	15	34	42	58	74
Nylon	69	49	40	32	20
Rayon	16	17	18	10	6

TABLE X
Original Equipment and Export Passenger Units
Per Cent of Units by Carcass Reinforcement Material

	1967	1969	1971	1973	1975
Polyester	—	58	85	92	95
Nylon	9	3	3	2	1
Rayon	91	39	12	6	4

ment. One of the areas open to polyester is the monoply carcass construction for radial tires, which is expected to offer improvements in tire durability and economics; polyester development programs aimed at this tire construction are underway, principally to increase the strength of polyester cord and to increase cord stiffness to improve tire directional stability between the bead and tread (Table VIII).

You might be surprised to hear that we are optimistic that polyester is a strong contender for the belt reinforcement of radial tires. This view is supported by calculations which favor polyester over all other fibers on a price/performance basis. We have established what we consider to be reasonable targets to enhance this position and consider that we are making good progress in our development efforts to achieve these targets, sufficient progress to be confident that the volume of polyester used in radial tire belt applications will begin to grow steadily.

Based upon these observations, we have calculated the relative share of the original equipment and replacement tire markets that will be held by polyester, nylon, and rayon to 1975. These calculations are given in Tables IX and X.

TRUCK AND HEAVY DUTY TIRES

A main area of growth in the use of polyester for tire reinforcement is expected to be in the truck tire market. We are optimistic that the current generation of improved polyesters now being introduced to the trade will accelerate the introduction of polyester into the light and medium truck tire fields, and will give a new lease to the plans to establish polyester as a universal truck tire yarn. Nylon is the major truck tire reinforcement at this time, but while giving good service in this area, nylon does not have the low shrinkage-growth characteristics of polyester. This is reflected in tendencies to tread separation and tread and sidewall cracking, all major problems with nylon truck tires. We also understand that truck drivers are no more enamored with the nylon bounce on their cross-country trips than are the typical automobile drivers who have shown a very marked preference for the ride and handling characteristics of polyester tires (Table XI). We realize that the fiber producers must set ambitious technical goals to assist the tire companies in developing polyester as a universal truck tire reinforcement, and ours are shown in Table XII. These include improved chemical stability to resist the attack on polyester cords by rubber ingredients at the very high operating temperatures that are generated in large-size truck tires, also improved high-temperature adhesion and improved durability. While we consider these targets to be a stiff chal-

TABLE XI
Comparison of Polyester and Nylon—Truck Tire Carcass

	Nylon	Polyester
Strength	very good	good
Energy to rupture	good	very good
Fatigue	good	good
Shrinkage	fair	good
Growth	poor	good
Modulus	fair	good
Adhesion	very good	good
Chemical stability	good	fair

TABLE XII
Polyester Truck Tire Cord Development Targets Versus Polyester Control = 100

	Minimum targets	Individual experimental optimi
Strength	120	110
Impact resistance	100	100
Durability, Mallory	500	500
Shrinkage	100	130
Growth, modulus	100	200
Adhesion	160	150
Chemical stability	180	175

TABLE XIII
Truck and Bus Units Per Cent of Units by Carcass Reinforcement Material

	1967	1969	1971	1973	1975
Polyester	0	0	0	2	6
Nylon	90	98	99	96	88
Rayon	10	2	1	0	0
Steel	0	0	0	2	6

lenge to our technical ability, work in progress convinces us that we are making significant progress and that these targets will be achieved with variants of existing polyester types.

We have already indicated that we expect gradually increasing acceptance of radial tires in the truck and off-the-road area, increasing to 8% by 1975. It is very possible that with new tire construction of this type, developments could accelerate the demand for the radial tire in heavy duty applications, but it is unlikely that scale-up could be achieved at a sufficient rate to substantially modify this predicted value. In terms of fiber use, steel will be the dominant belt reinforcement material, with polyester sharing a portion of the carcass reinforcement market with nylon and perhaps monoply steel fabrics.

A summary of the fiber usage in truck and bus tires is given in Table XIII. It can be seen that we feel nylon will maintain a strong position in truck tires through 1975. Polyester will continue to make some penetration through 1975, becoming significant in the late 70's. The use of steel in truck tires will grow through the first half of the decade, cutting slightly into nylon's share of the market.

TIRE UNITS THROUGH 1975

The next factor required in the estimate of total fiber requirements in the tire market is the estimate of the numbers of tires that will be used in each market sector. Our forecast is shown in Table XIV. In summary,

TABLE XIV
Total Tire Requirements (Millions of Units)

	1969	1971	1972	1973	1975
Passenger replacement	129	135	142	146	162
Passenger OE and export	48	50	51	54	58
Total Passenger	177	185	193	200	220
Truck/bus replacement	17	18	21	22	25
Truck/bus OE and export	10	10	11	12	14
Total Truck/Bus	27	28	32	34	39
Total Passenger Equivalent[a]	336	348	378	396	444

[a] Multiply truck and bus by 5.0 to obtain passenger equivalent; 7% added to allow for farm, aircraft, etc.

we expect that the combined replacement and original equipment passenger tire shipments will grow to 220 MM units by 1975. The ratio of replacement to original equipment is not expected to change significantly. The improved wear characteristics of belted tires will be offset by higher speeds, increased annual vehicle mileage, and softer rubber compounds to meet potential Department of Transportation stopping distance regulations. Truck and bus tires will continue their steady growth in total units, rising to 39 MM in 1975.

SUMMARY

Putting all of these elements together, we have estimated total fiber usage for tire applications through 1975 (Table XV). In summary, we predict polyester will continue its rise in market share over the next four years reaching 330 MM pounds by 1975. The growth of this fiber will be at the expense of both nylon and rayon. Nylon, currently the dominant fiber, will continue as such through 1973, but will decline to 225 MM pounds in 1975. Rayon will continue to experience economic disadvantages and will reduce to less than half (50 MM lb) of its current sales. Glass, assuming no significant breakthroughs in physical properties, will decline

TABLE XV
Tire Cord Total[a]

	1967	1969	1971	1973	1975
Polyester	49	172	176	255	330
Nylon	282	294	275	290	225
Rayon	118	111	110	70	50
Glass	—	32	45	50	40
Steel	—	2	5	40	160
High-modulus organic fibers	—	—	—	5	15
Total	449	611	611	710	820

[a] In MM pounds.

to 40 MM pounds by 1975. Because of its glamour image, steel tire cord will grow rapidly to 160 MM pounds in 1975. The demand for steel cord will exceed supply through 1977. High physical property variants of polyester and nylon will begin to become significant by 1975.

It is interesting to use these volume forecasts in combination with historical data to predict in a more general way the trends of the main fibers used in tires. A plot of the per cent share of market versus date, given in Figure 1, clearly highlights that the life cycle of a fiber as a significant reinforcement material has historically been approximately 12 to 14 years. Rayon is well past its peak, and its use is declining steadily. Nylon is in a mature

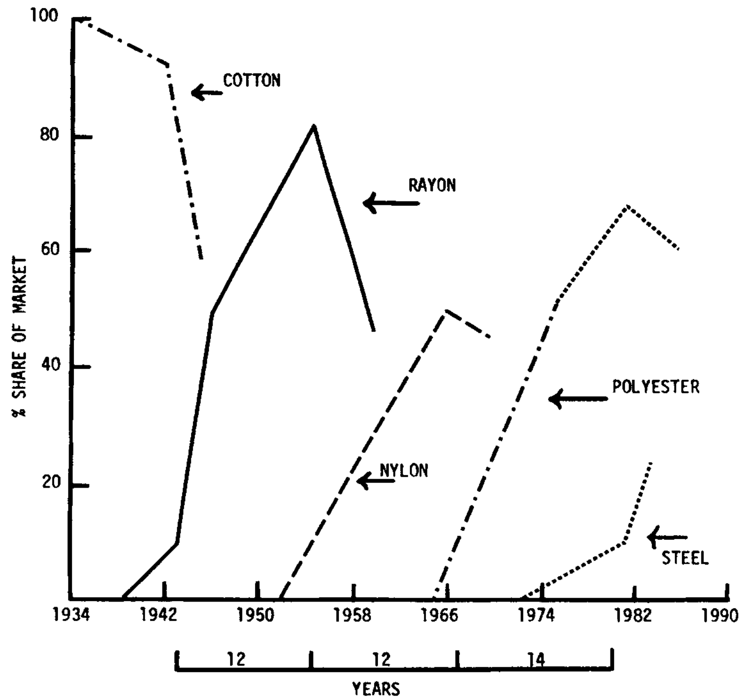

Fig. 1. Fibers used in tire carcass reinforcement.

state of its development, and the downturn we have predicted could have been anticipated from the historical pattern. Polyester is in a strong growth phase, but based on the life cycle trends, we must expect a peak by 1980–82, with the replacement fiber introduced commercially by 1975.