BRIEF HISTORY & INTRODUCTION OF RUBBER

Rubber was known to the indigenous peoples of the Americas long before the arrival of European explorers. In 1525, Padre d'Anghieria reported that he had seen Mexican tribespeople playing with elastic balls. The first scientific study of rubber was undertaken by Charles de la Condamine, when he encountered it during his trip to Peru in 1735. A French engineer that Condamine met in Guiana, Fresnau studied rubber on its home ground, reaching the conclusion that this was nothing more than a "type of condensed resinous oil".

The first use for rubber was an eraser. It was Magellan, a descendent of the famous Portuguese navigator, who suggested this use. In England, Priestley popularized it to the extent that it became known as India Rubber. The word for rubber in Portuguese - borracha - originated from one of the first applications for this product, when it was used to make jars replacing the leather borrachas that the Portuguese used to ship wine.

Returning to the works of Condamine, Macquer suggested that rubber could be used to produce flexible tubes. Since then, countless craftsmen have become involved with rubber; goldsmith Bernard, herbalist Winch, Grossart, Landolles and others. In 1820, British industrialist Nadier produced rubber threads and attempted to use them in clothing accessories. This was the time when America was seized by rubber fever, and the waterproof footwear used by the indigenous peoples became a success. Waterproof fabrics and snow-boots were produced in New England.

In 1832, the Rosburg factory was set up. Unfortunately, cold weather affected goods made from non-vulcanized natural rubber, leaving them brittle and with a tendency to gum together if left in the sun, all discouraging consumers. After a long period attempting to develop a process to upgrade rubber qualities (such as including nitric acid) that almost ruined him, in 1840 Goodyear discovered vulcanization, quite by accident.

An interesting fact: in 1815, a humble sawyer - Hancock - became one of the leading manufacturers in the UK. He had invented a rubber mattress and through an association with MacIntosh he produced the famous waterproof coat known as the "macintosh". Furthermore, he discovered how to cut, roll and press rubber on an industrial scale. He also noted the importance of heat during the pressing process, and built a machine for this purpose.

MacIntosh discovered the use of benzene as a solvent, while Hancock discovered that prior chipping and heating were required in order to ensure that the rubber dissolved completely. Hancock also discovered how to manufacture elastic balls. Finally, in 1842, Hancock came into possession of vulcanized rubber produced by Goodyear, seeking and finding the secret of vulcanization that brought him a vast fortune.

In 1845, R.W. Thomson invented the pneumatic tire, the inner tube and even the textured tread. In 1850 rubber toys were being made, as well as solid and hollow balls for golf and tennis. The invention of the velocípede by Michaux in 1869 led to the invention of solid rubber, followed by hollow rubber and finally the re-invention of the tire, because Thomson's invention had been forgotten. The physical properties of rubber were studied

by Payen, as well as Graham, Wiesner and Gérard.

Finally, Bouchardt discovered how to polymerize isoprene between 1879 and 1882, obtaining products with properties similar to rubber. The first bicycle tire dates back to 1830, and in 1895 Michelin had the daring idea of adapting the tire to the automobile. Since then, rubber has held an outstanding position on the global market.

As rubber is an important raw material that plays a leading role in modern civilization, chemists soon became curious to learn more about its composition in order to synthesize it. In the XIX century, work focused on this objective, soon discovering that rubber is an isoprene polymer.

The Russians and the Germans broke fresh ground in their efforts to synthesize rubber. But the resulting products were unable to compete with natural rubber. It was only during World War I that Germany - pressured by circumstances - had to develop the industrialized version of this synthetic product. This was the springboard for the massive development of the synthetic rubber industry all over the world, producing elastomers.

Natural Rubber

Natural rubber is a solid product obtained through coagulating the latex produced by certain plants, particularly the Brazilian rubber-tree (Hevea Brasiliensis). This raw material is usually tapped from the rubber tree, which is native to Amazonia. Although there a large number of species that exude secretions similar to latex when the bark is cut, only a few produce sufficient quantities of a quality adequate for exploitation on economic bases.

The history of natural rubber in Brazil is a tale that is just as exciting as the Gold Rush in the USA. For almost fifty years - during the second half of the XIX century through to the second decade of the XX century - natural rubber underpinned one of the most important development booms in Brazil. At that time, the Industrial Revolution was expanding rapidly as the world lived through a time of prosperity and discoveries that was reflected in all sectors. Automobiles, trams, telephones, electric light and other innovations changed the landscapes and customs of towns and cities. New markets opened up. This was the Belle Époque period, whose splendor has been portrayed in literature and film for subsequent generations.

Thanks to its multiple applications, particularly in the expanding automobile industry, rubber produced from latex tapped from rubber-trees became a product in demand worldwide. And there was no lack of rubber-trees in the Brazilian Amazon. This brought a boom to Northern Brazil - which at that time was one of the poorest and least-inhabited parts of the country. Eager to work the rubber-groves of Amazonia, leading foreign banks and companies set up shop in the towns of Belém and Manaus.

The capital of Amazonas State become the economic heart of Brazil. It was equipped with water and electricity supplies, in addition to telephones and large buildings such as the Amazonas Theater, still today a symbol of the wealth brought in by Brazil's rubber boom. Thousands of immigrants flowed in, mainly fleeing the drought that assailed Northeast

Brazil during the 1870s, invading the forest to tap the latex and turn it into rubber.

The output of Amazonia reached 42,000 tons a year, with Brazil dominating the global natural rubber market. This euphoria lasted through to 1910, when the situation began to change: rubber exports began to appear on the market from British Colonies, and Brazil was unable to withstand this fierce competition.

In 1876, the British smuggled out rubber-tree seeds from Amazonia to the Botanical Gardens in London. Through grafting, they developed more resistant varieties that were later sent to the Colonies in Asia where massive rubber plantations were established, particularly in Malaysia, Ceylon and Singapore.

The difference between latex production techniques in Brazil and Asia was a significant factor in the development of this business, due to these plantations. While the rubber trees of Asia were set only four meters apart, it was sometimes necessary to walk miles between one tree and the next in Amazonia, limiting the amount of latex collected and increasing its price. Obviously, the well-organized plantations of the Far East resulted in a significant increase in productivity, making them more competitive.

In Brazil, the Government was unwilling to change these methods. It believed that tapping these rubber trees would ensure the presence of Brazilians in the Amazon region, guaranteeing national sovereignty over this largely unpopulated area. It opted for geo-politics represented by human settlements instead of geo-economics that could have produced higher gains.

This relative immobility cost Brazil dear; its exports shrank as they were unable to withstand the competition of Asian rubber, tapped at far lower prices. Consequently, production began to drop, bringing the decades of boom to an end for much of Northern Brazil. The companies that had set up shop in Manaus and Belém left in search of other more productive regions. The immigrants went home, and leading names in the world of the arts no longer performed at the Amazonas Theater. This golden age of opulence slipped into history.

In the late 1920s, Brazil was still attempting to catch up this lost ground with the help of an unexpected partner: US industrialist Henry Ford, who had developed a new scheme - the production line - that was to change the face of industry for ever, and at that time accounted for 50% of the world's vehicle output. In order to loosen the grip of the British Colonies in Southeast Asia on the rubber market - the precious raw material for making tires - Ford planted no less than 70 million rubber tree seedlings in an area covering one million hectares in Para State.

This ambitious project was soon christened Fordlândia by the local residents. It was designed to produce 300,000 tons of natural rubber a year, accounting for one half of global consumption. But the Ford Project succumbed to the hostile environment of the Amazon rainforest and was abandoned, posting huge losses.

Within this context, Asia dominated global supplies of natural rubber with over 90% of the output. However, significant changes redistributed the production among the main competitors. Accounting for one-third of global output in 1985, Malaysia fell back due to

alterations in its production profile, which began to stress non-agricultural investments. Its position as the world's largest natural rubber producer went to Thailand. Based on advantages in terms of available land and labor, Indonesia has maintained a significant share in global output since the 1980s.

Other countries have been successfully deploying their low-cost labor-forces and easily-available lands to expand in this sector, particularly India and China. By 2001, natural rubber consumption accounted for some 40% of the total amount of rubber consumed worldwide.

Synthetic Rubber

The importance of the rubber industry ever since it first appeared and the decisive role that it has played in the development of modern civilization prompted much interest in discovering its chemical composition in order to synthesize this product. Through these research projects, the tire industry saw the possibility of breaking away from the grip of the world's natural rubber plantations.

The drop in natural rubber production in Brazil coincided with World War I (1914-1918), triggering the need for lower-cost products with steadier supplies in order to manufacture tires. The pressures imposed by the conquest of the plantations of Asia by the Japanese prompted the development of a rubber that was able to meet the extraordinarily high demands of the troops at that time, although its structure differed somewhat from its natural counterpart.

This was how GR-S, Buna S, Hycar OS and SBR appeared, which are styrene and butadiene copolymers. The launch-pad for the massive development of the synthetic rubber industry, this product could be vulcanized easily, and became the flagship of the world rubber industry, although its properties did not correspond to all the qualities of natural rubber. But its costs and main characteristics made it into an unbeatable competitor. Although synthetic rubber had been known since 1875, its production had been expensive and almost negligible.

During World War II, a crucial historical episode altered the scenario for this market. On December 7, 1941, the USA entered the War. Three months after the attack on Pearl Harbor, the Japanese invaded Malaysia and the Dutch East Indies, desperate to take over natural rubber production from the allies. This gave the Axis control over 95% of world rubber supplies, plunging the USA into a crisis.

Each Sherman tank contained twenty tons of steel and half a ton of rubber. Each warship contained 20,000 rubber parts. Rubber was used to coat every centimeter of wire used in every factory, home, office and military facilities throughout the USA. There was no synthetic alternative. Looking at all the possible sources, at normal consumption levels, the nation had stocks for around one year. And these reserves also had to supply the largest and most critical industry in the history of the world during a time of rapid expansion: the arms segment.

The response of Washington was rapid and dramatic. Four days after Pearl Harbor, the use of rubber in any product that was not essential to the war drive was banned. The

speed limit on US highways fell to 35 miles an hour, in order to reduce wear and tear on tires countrywide. Rubber chips were sold a penny or more per pound weight at over 400,000 depots all over the country. Even President Franklin Roosevelt's pet dog Fala saw his rubber toys melted. This was the largest recycling campaign ever recorded in history, ensuring the success of the Allies through to 1942.

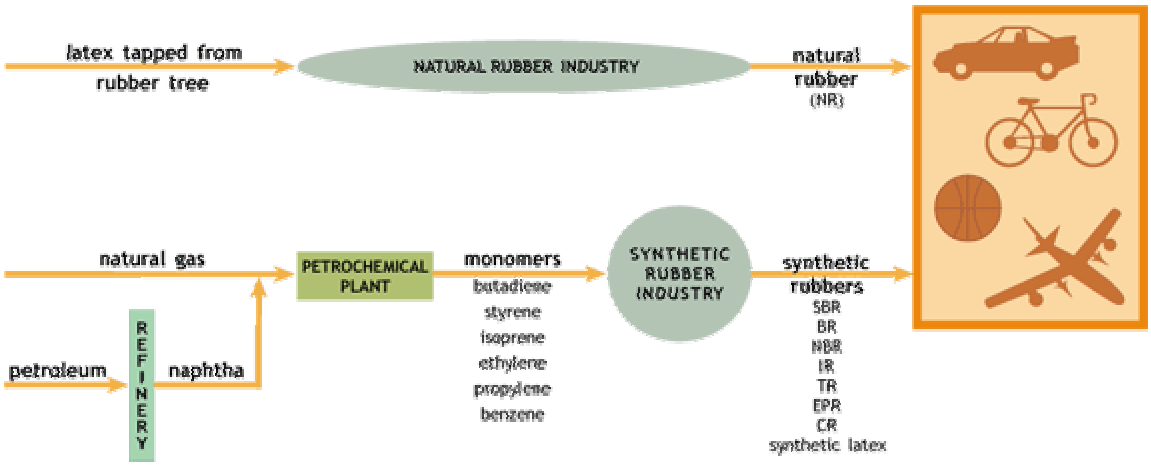
Under these circumstances, an order was sent to all chemists and engineers to develop a synthetic rubber industry. In 1941, the total output of synthetic rubber barely topped 8,000 tons, consisting largely of products not suitable for tires.

The nation's survival depended on its capacity to manufacture over 800,000 tons of products that had barely begun to be developed. There were few detailed instructions on how the factories should organize themselves to produce this vast amount. No facilities had been built, nor was there any way of producing enough raw materials to produce rubber.

The US industrial sector had never been called upon to shoulder such a massive task, achieving so much so quickly. The engineers were given just two years to reach this target. If the synthetic rubber program failed, the capacity of the USA to fight the war would be blunted. This US drive was to help spread synthetic rubber throughout the world's market, even in Brazil as it strove to consolidate its industrial park during the post-War years.

Although synthetic rubber may be obtained in many different ways, most of it is produced through the system shown in the figure below:

Main synthetic rubber production system



A wide variety of synthetic rubbers have been developed since this product was first discovered. As massive investments were required to develop these different varieties, the production technology was heavily concentrated in long-established global enterprises such as DuPont, Bayer, Shell, Basf, Goodyear, Firestone, Michelin, EniChem, Dow, and Exxon.

The use of rubber is widespread, as the characteristics and properties of these elastomers

make them useful in almost all economic sectors: automobiles, footwear, civil construction, plastics, hospital materials and others that are of crucial importance in the daily life of society. As they are most widely used to produce tires, the SBR and BR varieties are the most widely consumed type of synthetic rubber.

Main types and applications for synthetic rubbers

Name	Type of Rubber	Asphalt Modifications	Footwear	Adhesives	Technical Goods
eSBR	Styrene-Butadiene in emulsion	-	X	X	X
sSBR	Styrene-Butadiene in solution	X	X	X	X
BR	Polybutadiene	-	X	-	X
NBR	Nitryl	-	X	-	X
EPDM	Ethylene-propylene	X	-	-	X
IIR	Butyl	-	-	X	X
CR	Polychloroprene	X	X	X	X
TR	Plastics	X	X	X	-
Látex	Various types of latex	X	X	-	X

Name	Type of Rubber	Tires	Treads	Plastic Modifications
eSBR	Styrene-Butadiene in emulsion	X	X	-
sSBR	Styrene-Butadiene in solution	X	X	-
BR	Polybutadiene	X	X	X
NBR	Nitryl	-	-	X
EPDM	Ethylene-propylene	X	-	X
IIR	Butyl	X	-	-
CR	Polychloroprene	-	-	-
TR	Plastics	-	-	X
Látex	Various types of latex	-	X	-