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Tyre Waste Management: Where We Are & Where We Are Headed

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Abstract: ***Motor vehicle ownership has skyrocketed in the previous two decades. The World Health Organization (2015) reports that 53% of motorised vehicles are in middle-income countries and 46% in high-income nations. The latest predictions predict that by 2040, the number of cars made will grow. The worldwide tyre industry, which produces about a billion tyres, using over two-thirds of the world's natural rubber.***
India accounts for 6% of the world's 1.6 billion discarded tyres produced each year. In addition, India imports around three lakh tonnes of tyres for recycling each year. They are subjected to high-temperature thermochemical processes in order to create industrial oil and other derivatives.
This paper attempts to summarise the most important regulations and procedures regarding the reuse and recycling of ELTs that are now being carried out in India as well as in other countries across the world. Additionally, it investigates in depth the option that presents India with the greatest potential for achieving safe end-of-life handling procedures for tyres.
Keywords: end-of-life tyres, recycling, regulations, tyre industry, waste management

I. INTRODUCTION

Over the course of the past twenty years, there has been a meteoric rise in the total number of motor vehicles on the planet. According to the World Health Organization (2015), just 46% of motorised cars are found in high-income nations, but 53% of all motorised vehicles are located in middle-income countries. According to the most recent forecasts, these figures are expected to continue climbing; specifically, by the year 2040, the quantity of automobiles that are manufactured will have increased.

The expansion patterns seen in the global tyre business, which presently produces close to a billion tires, are closely connected to one another and share many of the same characteristics. It is estimated that the tire business is presently consuming close to 12 billion tonnes (WHO 2019), which is equivalent to almost two-thirds of the world's production of natural rubber. The tire industry is the greatest consumer of natural rubber.

Because they require a significant amount of resources, resource-intensive growth models have made it absolutely necessary to give the concerns of sustainable management of natural resources and resource efficiency priority status within the growth agenda. The concept that what we currently consider to be "waste" is actually an untapped resource that could serve as a possible source for secondary raw materials is at the centre of this conversation. End-of-Life cars (ELVs), also known as scrapped cars that have been disposed of, are considered waste on a global scale; nevertheless, this issue is viewed through the lens of "waste as precious resource" in many parts of the world.

The materials found in ELVs, such as steel, aluminium, plastics, rubber, and copper, are collected and recycled. Tires are only one part of ELVs, but due to the way they are constructed, they have an entire economy that revolves around them that can support themselves. Tires, which are manufactured all over the world, are almost always made of high-quality rubber and are regarded as a significant potential source of raw material for the rubber industry. To get an idea of how significant this opportunity is, consider the fact that during the fiscal year 2016–17, an estimated 127.4 million tyres were manufactured. This provides some context for the size of the market (Tinna Rubbers 2017).

The most widespread method of disposal for used tires has been the practice of dumping and stacking the waste. In the most recent couple of decades, numerous governments and tyre producers have become cognizant of the environmental difficulties and the loss of resources involved in the dumping and burning of tyres. This growing problem has resulted in coordinated political action, in which a number of countries have opted to investigate a variety of different approaches and strategies for the management of ELTs.

It is anticipated that the Indian economy will expand at a rate of 5-6% of GDP each year, despite the fact that it will mirror the global trends of rising earnings and will also be linked with aspirational high consumer behaviour. This indicates that the nation is currently dealing with both a higher pace of urbanisation and a higher rate of resource consumption at the same time. The number of people living in metropolitan areas in India will almost double by the year 2030.

The existing urban population of 340 million people would more than double to an estimated 590 million under this scenario. In addition, cities that currently account for 58% of India's GDP will account for nearly 70% of the country's GDP by the year 2030, according to research conducted by the McKinsey Global Institute. This practically means that eight metropolitan areas, including Mumbai, Delhi, Kolkata, Chennai, Bangalore, Ahmedabad, Hyderabad, and Pune, would become home to more than 100 million people and will be under significant demand for resources.

A growth that is consistent but localised in any one sector of the economy is insufficient to support and maintain the growth that is expected for the economy as a whole. The transformation of a developing economy into a thriving one is made possible in large part by innovation, particularly in the infrastructure associated with mobility.

Rapid expansion in transport-related infrastructure involves rapid increase in the infrastructure required to support these vehicles (in roadways, railways, airways, and waterways), as well as rapid growth in the transportation industry as a whole, particularly in the aviation and automobile industries.

Because of this, recycling and the reuse of cars, which are not currently at the forefront of the discussion over expansion, will come to play an essential role in guaranteeing resource efficiency and sustainable development.

There are three main categories of tires:

1) *The Rubber/radial Tyre:* Currently the type of tire that is installed on the vast majority of automobiles. Radial tires are constructed with multiple layers of tyre material, each of which is separated by a layer of steel belt that serves the function of a reinforcing belt. The construction of these tires is split into two pieces, which gives the sidewall and tread the ability to operate separately from one another. The belts of radial tires are constructed out of a mixture of many rubber-coated steel piles. These belts are extremely durable and resistant to being cut.
2) *Nylon/Crossply/Bias Tyres:* Commonly found on vehicles designed for transporting big loads. Crossply tires are distinguished by their singular working unit construction and their diagonally stacked nylon fibres, both of which contribute to the crossply tyres' high level of sidewall stability. Their incredibly robust sidewalls are a direct result of the one-of-a-kind building technology that was used.
3) *Belted-bias Tyres:* two or more layers of bias plies that have stabiliser belts attached directly beneath the tread of the tire. This structure results in a ride that is more comfortable, comparable to that of a bias tyre, while simultaneously reducing rolling resistance because to the increased tread rigidity brought about by the belts. The "belted" tyre begins with two primary plies of polyester, rayon, or nylon annealed as in normal tyres. Following this, circumferential belts at varied angles are added on top of the tyre to increase its performance in comparison to non-belted bias tyres. Steel or fibreglass could be used to make the belts.

II. UNDERSTANDING THE SCALE OF END-OF-LIFE TYRES (ELTS)

It has become common knowledge over the course of time that the garbage produced today can serve as a source of raw materials in the not-too-distant future; in other words, it is feasible to create money from waste. It is common knowledge that junked, discarded, and End-of-Life Vehicles (ELVs) can be mined for secondary raw materials. These resources, which include recycled steel, aluminium, plastics, rubber, copper, and tyres, among others, make up the majority of the haul. In order to manufacture automobiles, massive amounts of rubber are needed.

The kinds and qualities of rubber that are utilised change depending on the component. As a consequence of this, the procedure of recycling also differs significantly.

The most significant amount of rubber used in a vehicle is found in the vehicle's tires. On the other hand, End-of-Life Tyres (ELTs), also known as waste or trash tyres, are tires that have reached the point where they can no longer be used safely due to the level of abrasion that has been caused by normal use. The current estimates suggest that India has already experienced a 125% increase in Annual New Vehicle Registrations, and the projected vehicular growth shows that by the year 2035, there will be approximately 80.1 million passenger vehicles (cars, UVs), and 236.4 million two wheelers (Organisation Internationale des Constructeurs d' Automobiles).

In addition, regulations that prohibit the use of older vehicles in public and private transportation mean that over the course of the next few decades, India will see an exponential rise in the number of tyres, notably ELTs. The country must be prepared for this rise.

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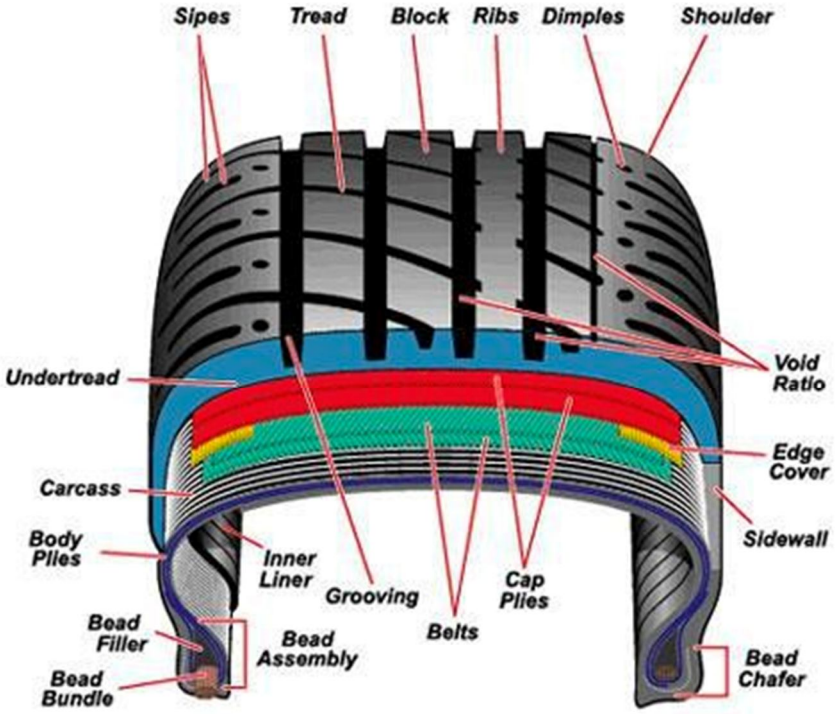

III. SITUATION IN INDIA

Twenty three different hubs, including Uttar Pradesh, Delhi, and Rajasthan, each submitted information regarding the pattern of trash tyres that they discard. Brick kilns typically pay between INR 6 and 8 per kilogram for scrap tyres and receive roughly 40 kilograms of scrap tyres for every ton of tyres that are received by the recycling centre. However, a significant number of these have recently begun to also use coal. The hubs also provided the information that in practice no portion of the tyre is ever really wasted and that there are a variety of uses for those tyres that are not burned.

About 40 or so producers are represented in India's formal reclaim rubber business, which is considered to be rather small. Out of these, India has approximately six to seven key participants in the field of manufacturing tyre recycling and reclaiming rubber products. Tina Rubbers, Gujarat Reclaim & Rubber Products Ltd., ELGI Rubber Company Ltd., Balail Industries, Swani Rubber Industries, Gangimani Enterprise Private Limited, and Kohinoor Reclamations are the companies that have established themselves as the industry leaders in this sector.

The rubber industry looks at tires as a significant potential source of raw material because of the high quality of the rubber used in the production of tires. The recycling sector in India is substantial and is estimated to be worth 914 million US dollars. According to Mishra (2016), in the year 2011, India produced 90,000 metric tons of recycled rubber from waste tyres.

According to the Rubber business Scientific and Research Institute (ISRI), the rubber recycling business in India is estimated to be only second to China in Asia, which is the country that produces the most reclaimed rubber. However, in comparison to China's sector, the scale and volume of the Indian industry are significantly lower. In addition, considering the volume of ELTs that are being produced right now, it is becoming even more essential that we assure the recycling of tyres in a way that is beneficial to the environment.

At the moment, India produces approximately 169 million tires every day while also discarding 2,75,000 of them. It is estimated in a "Comprehensive Literature Review on the use of Waste Tyres Rubber in Flexible Road Pavement" that 0.6 million tons of scrap tyres are being produced every year across the country. It is estimated that India is responsible for 6% of all of the garbage that is generated by ELTs around the world. Observations made at ground level imply that the rate of recycling is significantly higher, despite the fact that certain fractions are not recycled, and it has been observed that they produce a significant amount of pollution (Pasalkar et al. 2015).

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In India, the micro, medium, and small-scale units (MSMEs), which are primarily located in the informal and semi-formal sectors, are the ones responsible for the scrapping of autos at the present. In addition, the majority of tyre recycling units across the country have switched from utilising the water and labour-intensive pan method to adopting techniques that are more efficient and automated. This is done in order to recover rubber from recycled tires. It is essential to make it clear that not all recycled rubber gets repurposed in some way, as this misconception needs to be addressed. Instead, a sizable portion of the scrap rubber that is collected is put to use as a source of fuel in the form of tyre-derived fuels.

Every year, India gets around 300,000 tons of discarded tires from nations such as Australia, where tires are recycled or disposed of. However, these methods are not necessarily safe or environmentally friendly.

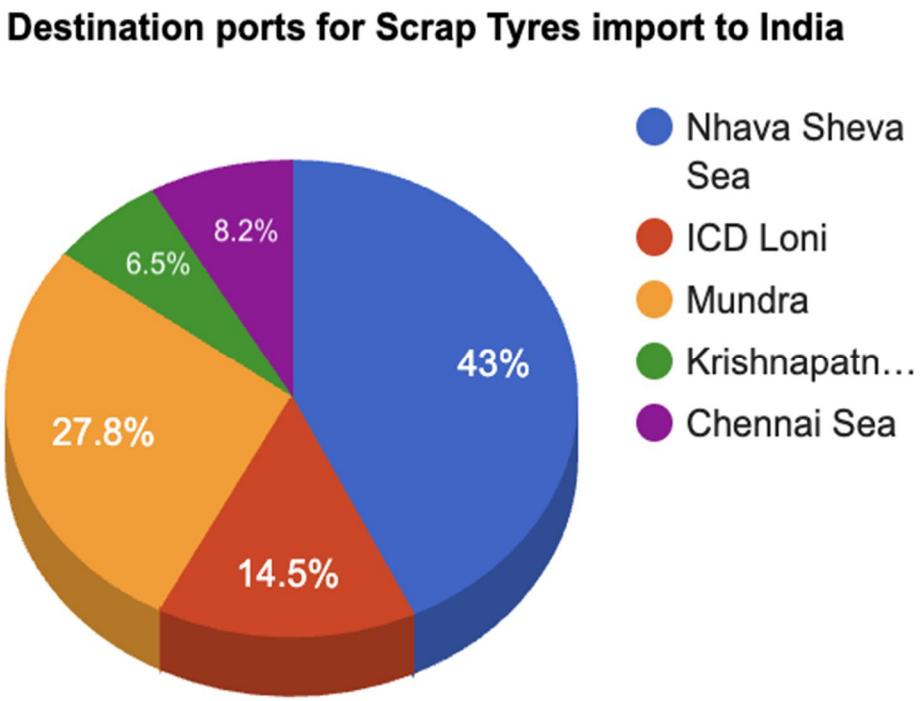
The National Green Tribunal of India (NGT) has filed a petition accusing India of failing to develop effective scrap tire management solutions, which is concerning given that India produces around 6% of total world tire trash. Following the move, the tribunal requested that the Central Pollution Control Board (CPCB) produce a plan to solve the problem of scrap tire control. The directive was submitted last month.

The green tribunal admitted that the tire pyrolysis sector was damaging the environment and endangering human health. Furthermore, the panel stated that some import limitations were warranted.

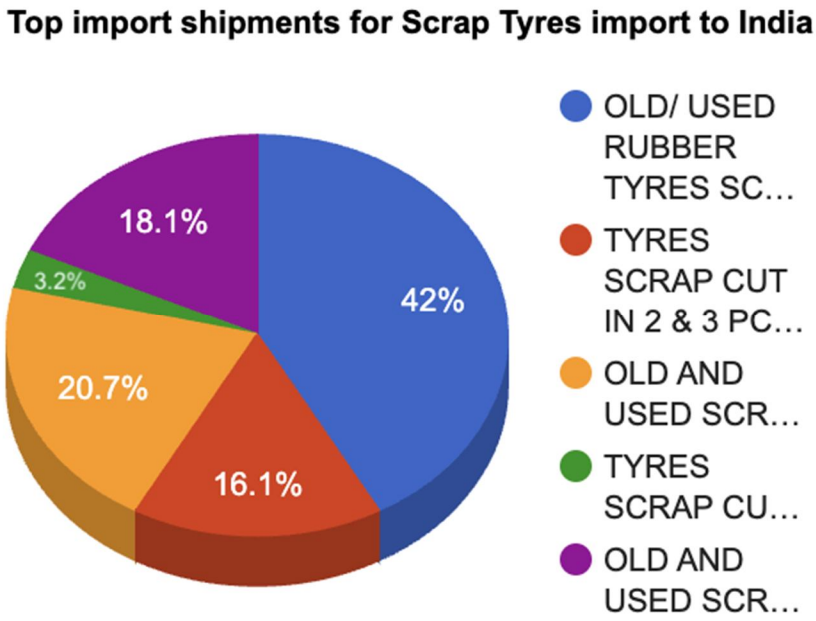
The CPCB was asked to provide rules that would prohibit the import of waste tires into India, where these tires are utilised in pyrolysis plants, because their usage hurts the environment and human health. The NGT emphasised the need of implementing the rules in order to keep India from becoming a "dumping ground" for harmful garbage.

The petitioner, Social Action for Forest & Environment (SAFE), is currently seeking a comprehensive prohibition on the use of waste tires by the pyrolysis sector, citing environmental damage prevention and claiming that the emissions include cancer-causing chemicals.

The Union Ministry of Environment, Forest and Climate Change (MoEFCC) has established a Standard Operating Procedure to address the issue of waste tires; also, a number of authoritative legislations approved previously will be evaluated to address the matter. The CPCB had given its report to the green court, in which it informed the court on the state of regulatory compliance. According to the board, India has 637 tire pyrolysis units, but only 251 are in compliance with the standards. The watchdog also proposed several "corrective measures," including permitting continuous tyre pyrolysis and installing packed bed scrubbers to regulate gaseous emissions.



Source: Connect2India



Source: Connect2India

IV. WHAT IS RECLAIMED RUBBER AND HOW ARE TYRES REUSED?

Reclaimed Rubber is a product that is produced when discarded vulcanised scrap rubber is treated to produce a plastic material that can be easily processed, compounded, and vulcanised with or without the addition of either natural or synthetic rubbers. This treatment produces a material that can be vulcanised with or without the addition of natural or synthetic rubbers. It is common knowledge that the vulcanization process cannot be reversed in its entirety. Nevertheless, a generally accepted definition of devulcanization describes it as a change in vulcanised rubber that leads to a reduction in the material's resistance to being deformed at temperatures that are more typical.

The current patterns of recycling of ELTs in India can be broadly categorised into four different broad groups:

1) Regrooving and Retreading
2) Modification through mechanical means (Rubber-crumbs)
3) Pyrolysis process
4) Tyre-Derived Fuel (TDF)

A. Regrooving Tyres

This procedure takes a significant amount of time and is typically done out by hand. This procedure is carried out using tires that are in good shape overall but with treads that have become worn down as a result of usage. In order to complete the operation, grooves must be carved into these tyres using a specialised knife. In most cases, regrooved tires are sold on the secondary rural market, where they are put to use on low-intensity vehicles like bullock carts or trollies. These vehicles are used for work that focuses primarily on weight rather than speed.

Heavy vehicle regrooved tyres that are offered with the name 'Regrooved Tyre' have a pricing advantage over their original counterparts due to the fact that they are much less expensive. Fleet operators should anticipate decreased overhead expenses as a result of the availability of regrooving tyres in high load vehicles such as trucks and buses. This plays a key part since it lowers the total cost of tyres that will be incurred over the lifetime of the vehicle. The amount of money that may be made from the sale of these regrooved tyres is based on the manufacturer, model, the year they were produced, and the state of the grooves. INR 200–250 would be a reasonable price range for a regrooved automobile tyre of an average quality. The tire would have been purchased in bulk at a price of between 50 and 80 Indian Rupees.

B. Retreading Tyres

There are three main parts to any rubber tire: the tread, the bead, and the side wall. The only part of the tire that is changed or retreaded is the tread. This is a more mechanised process than regrooving. It includes taking off the remaining tread to make the tire crumb, applying the new tread, and then vulcanizing it with special equipment. In simple words, it is the process of replacing a tyre's worn tread with a tread that isn't quite as old. This is done through a series of simple mechanical and semi-mechanical steps.

To retread a tire, the maker needs treads that are the same or similar to the old ones. However, these threads may not always be available. Also, the desire for a certain brand or company of tires is not constant or easy to predict. This means that manufacturers who specialise in retreading also get treads and other parts of tyres that are still in good shape but were thrown away for other reasons and store them. It has been seen that the return on investment for retreaded tyres is better than that for regrooved tyres.

It was observed that a tyre retreading machine was usually small, with no more than 4 or 5 workers. When retreading the tires of tractors, buses, trucks, and other big equipment vehicles, more people were needed. For the process to work, these units for retreading also needed bigger machines and tools. Some of the bigger and more organised companies in the retreading business are Indag Rubber, Midas Treads, Eastern Treads, MRF Tyres, TVS, and ELGI Group of Industries.

C. Reuse of Products: Tread, Bead and Side Walls

When a tyre cannot be reused, its body is manually cut into three parts - the tread, bead and side walls - to obtain secondary materials. The further grinding of these parts results in rubber crumb, which serves as a raw material in the production of several items. With newer available technology and on fine grinding, the same rubber crumb has found greater value and can now be used to make tyres and other value-added products. It is estimated that within the automotive industry 3-5% rubber crumb and up to 10% reclaim rubber is used in the manufacture of automobile tyres (Ram, Adhikari and Sugumar, 2015). The increasing volume of the automotive and tyre industry has meant that the quantum of use of reclaimed rubber is also simultaneously increasing.

The bicycle industry is a major industry in India that uses reclaimed rubber in the manufacture of tyres and tubes. Ralson is a major company in this market and produces about 1,00,000 bicycles and 1,50,000 tubes each day. Radial tyres are designed such that the cord plies are arranged at 90 degrees to the direction of travel, or radially. Fabricators use a special pulley-based contraption to extract the iron strips from within the tyre, which are then sold in the local markets. The best alternative use of rubber crumb is an additive to bitumen for road surfacing, which is superior in properties as compared to regular bitumen.

D. Pyrolysis: Thero-chemical and Combustion

Pyrolysis is the chemical decomposition of organic material at elevated temperature in the absence of oxygen or any other reagents. It is used to reprocess tyres into fuel gas, oils, solid residue (char) and low-grade carbon black, which cannot be used in tyre manufacture.

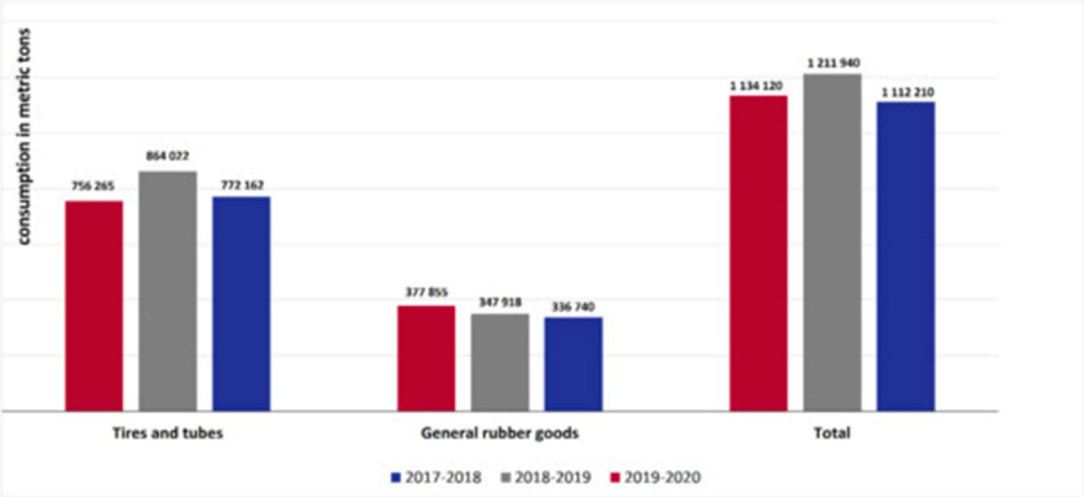
The smaller molecules of rubber polymers created by pyrolysis eventually vaporise and exit the reactor, which can be burned directly to produce power or condensed into an oily type liquid. 40% of minerals (by weight) that are part of the tyre are removed as solid ashes. About 40-45% of the recycled material obtained in the pyrolysis process is pyrolysis oil, with a flash point between 66 degrees Celsius. 30-35% of the total quantity is carbon black or charcoal, which is specifically used for industrial and commercial use. Metal wires found in tyres can also be separated from the carbon black by using magnets and this metal can be resold in the market.

E. Tyre as Fuel

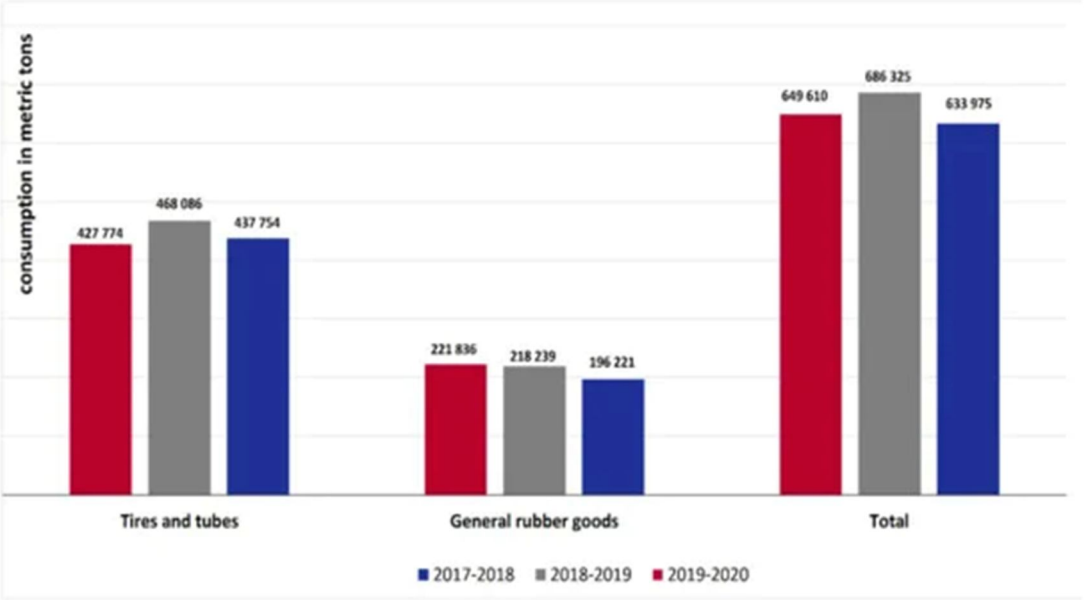
India is one of the largest brick producers in the world, with a yearly production of 200 billion bricks. Fuel expenses make up half of the total cost of making a brick, with 1,25,000 kilns in the country using 35-40 million tons of coal per annum. ELTs are a cheap fuel supplement for coal or gas kilns, and scrapped rubber and ELTs are easy to access and a cheap source of warmth in the winter months.

Chintan observed that small shredded pieces of leftover tyre parts were manually cut down into pieces which were then used by local farmers to produce sugarcane – jaggery. The use of ELTs as a source of energy is a common practice worldwide.

Scrap rubber and ELTs are readily available and inexpensive sources of heat locally during the winter. The residual tyre bits were manually cut into smaller, more specialised-sized pieces from small, shredded fragments. Local farmers then employed these fragments to create sugarcane-jaggery. With the use of a device known as "Kohlu" and "Kalesar," the residual rubber was crushed into little bits. This business only sees demand during the winter because it is a seasonal one.



Source: Statista



Source: Statista

V. ENVIRONMENTAL CONSEQUENCES

While discussing tyres, it is equally crucial to grasp the issues and repercussions of discarded tyres ending up in landfills or stacked. Due to the high volume and non-biodegradable nature of tyres, discarded tyres soon take up a lot of room. In all, around 60% of discarded tyres are dumped or burnt, producing land degradation in both urban and rural regions (Gupta, Chopra, and Kumar 2013). Tyres also trap methane gas, causing them to float and/or bubble to the surface. The 'bubbling' effect has the potential to destroy landfill liners, which are erected to help keep waste toxins in check, potentially contaminating not just the ground surface but also groundwater.

Despite the fact that contemporary tyres are primarily rubber goods, they are a complex blend of natural and synthetic rubbers, as well as different structural reinforcing materials such as metals, nylon, and other chemical additives. Because of this complication, storing, dumping, and diverting used tyres to landfills exposes local populations to significant environmental and health dangers. Water stagnation, for example, is rather typical in stacked tyres, and they serve as excellent breeding grounds for mosquitoes and rats. In regions where there are stored tyres, mosquito and rodent outbreaks like malaria, dengue, and yellow fever are frequently encountered.

Stockpiling has also been linked to the leaking of harmful compounds into the soil over time. Long-term chemical leaching studies demonstrate that tyres become dangerous when they come into touch with specific materials and react over time, causing poisons to seep into the surrounding soil and water bodies. Clause 33 of the Basel Convention emphasises upon the difficulties in determining the eco-toxicity of used and waste tyres. The findings of several research on toxicity and human health concerns differ greatly.

An experimental investigation aimed at finding hazardous components that leak when tyre rubber is in extended contact with water discovered that the chemical additives used in tyre rubber have a significant impact on the toxicity of the leachate. Furthermore, "some literature on the potential of chemicals to leach from used tyres concluded that the impact of used tyres on the subsoil of roads or surface water under neutral environmental conditions was negligible with regard to groundwater and surface water quality, as well as the aquatic environment" (Basel Convention 2013).

Birkholz's 2003 research in California utilising rubber pieces collected from a tyre disposal site revealed toxicity for bacteria, crustaceans, fish, and green algae. After three months, additional samples were analysed, and the toxicity levels reported in prior tests were reduced by 59%. Long-term research indicates that some types of tyres, such as those with a high aromatic oil content, may leach considerable amounts of polycyclic aromatic hydrocarbons into the aquatic environment under certain conditions, influencing the population dynamics of wood frogs, for example. Tyres do not spontaneously combust, but they are prone to heat retention, and stored tyres enhance the danger of fires due to their open structure. It is important to remember, however, that once sparked, these flames are exceedingly difficult to manage and extinguish. Furthermore, the residue left in the soil after a fire increases the likelihood of generating two types of pollution. The first is pollution caused by liquid breakdown products infiltrating the soil, and the second is slow pollution caused by ash and other unburned wastes seeping. Both forms of pollution, i.e., immediate and cumulative, are primarily generated by rainfall and water penetration at the site (Basel Convention 2013).

There have been no confirmed occurrences of fires particularly caused by stored tyres in India, although there have been several reports of flames at landfills in various regions of the country. Stockpiled tyres and scrap rubber in waste dumps and landfills contribute to the toxicity of the gases. The biggest fire in Welsh history occurred in 1989, near Heyope. It was created by 10 million stored tyres and burned for over 15 years (Rowe 2002). In the recent past, for example, 9,000 residents living near a "toxic cloud" from a burning tyre waste outside Madrid, Spain, were advised to vacate their houses in May 2016 (BBC 2016). An environmental tragedy at a tyre pile in Virginia 30 years ago aided in the advancement of fire-monitoring technologies and sparked a recycling revolution (Ritter 2013). To avoid such an environmental disaster, India must ensure that it can generate revenue from discarded tyres.

VI. CIRCULAR ECONOMY OF TYRES

Given the increasing global need for raw materials, there is a growing recognition of the need to consider ELTs as possible sources of raw materials, and hence the need to enhance ELT recycling. This awareness is especially obvious in resource-constrained developed countries, which must import not only basic resources such as minerals, but even rubber. As a first step, the commitment to tyre recycling has resulted in regulations governing the disposal of old ELTs in landfills. The form of regulation ranges from express prohibition, as in the case of the European Union, to partial prohibition throughout many nations and regions, as in the United States and Australia. Automobile ownership has increased at a faster rate than the global population. It surpassed 1 billion units in 2010 (Sousanis 2011). As autos have grown in popularity across the world, obsolete vehicles, or ELVs, have become a global problem. Tyres, as previously said, are merely one component of ELVs; nonetheless, as established in Section 2, tyres maintained an entire economy around them. Because of increased material usage and global increases in raw material costs (steel, copper, aluminium, etc.), ELVs and ELTs are increasingly viewed and treated as a valuable resource for a variety of raw materials, rather than as trash. As a result, the primary objective at hand is to recover as many secondary raw materials as feasible through effective recycling procedures (Sakai et al. 2014). Tyres are also an excellent illustration of high resource use, especially given the tyre's post-consumption economy. It is critical in the tyre economy that this resource loop be closed, i.e. that the post-consumption economy is fully used. To do this, there is a need for the integration of both ELT management practices and systems, which must also be led by both the government and the industry.

Many industrialised nations, like the European Union (EU), have recognized this need and have established an organised, methodical, and contemporary recycling and recovery business. These economies' ELT management industries and policies are distinct from those of ELV management and policies. In contrast, emerging economies have some waste management and disposal rules, but no waste recycling and recovery models, particularly for ELV and ELT management policies and systems. At the same time, these emerging economies tend to play a significant role in rubber recycling and reuse by entangling themselves in international commerce connected to recycling and trash recovery.

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VII. SITUATION AROUND THE WORLD

The European Union has been a pioneer in ELT management and presently has the greatest rate of ELT recycling. In 1994, the percentage of tyre recycling in this country was only 25%, but by 2013, it has risen to 96% (ETRMA 2015). This has been made feasible by the government's deliberate harmonisation of policies with their ELT management plans. ETRMA is the European Union's trade organisation for the tyre and rubber sectors.

There are three basic approaches for controlling ELTs in the EU:

1) Extended Producer Responsibility
2) Free Market Model
3) Government Responsibility (tax system).

Extended Producer accountability refers to a producer's complete or partial operational and/or financial accountability for a product that extends to the post-consumer stage of the product's life cycle. This therefore means that, under this arrangement, the original tyre manufacturer must accept responsibility for ensuring that the tyre made by them is eventually disposed of appropriately. This strategy successfully shifts the burden of accountability for waste generation from the customer to the manufacturer.

Under this architecture, ELT may be managed in a variety of ways. A single ELT management organisation might handle the collecting and handling of ELTs across the country. In nations such as Portugal, the Netherlands, and Sweden, this is the favoured model. Other nations, such as Italy, France, and Spain, choose to handle the procedures through various ELT management organisations. Countries such as Hungary, on the other hand, believe that it is the individual producer's obligation to guarantee proper waste tyre disposal (ETRMA 2015, 8). Systematic and mandatory reporting to national government bodies has contributed in the establishment of dependability and traceability requirements.

The EU's experience with extended producer responsibility has shown that tyre manufacturers appear to prefer this arrangement in the presence of a favourable political climate. As of today, Extended Producers' Responsibility is the most widely used system in Europe, with 21 countries (the majority of the EU's 28 member states, Norway, and Turkey) adopting this legal framework, which assigns responsibility to producers (tyre manufacturers and importers) to organise the management chain of ELTs.

The free market is a liberal system in which no particular group/industry/person is defined as being accountable for ELT management. Rather, under this system, the law establishes the goals to be achieved, and all operators in the recovery chain contract under free market circumstances and work in accordance with the law. Austria, Switzerland, and Germany are EU member states that, like the United Kingdom, choose to function under a free market framework. In other circumstances, the liberal system may be bolstered by voluntary collaboration among businesses to encourage best practices.

Government Responsibility: This approach is primarily funded by taxes collected on tyre manufacturers, which are then passed on to consumers, while the project is championed by the government. As a result, each country is now in charge of ELT administration. Denmark and Croatia are two EU member countries that have decided to manage their ELTs using this tax mechanism.

Some nations have also imposed a partial prohibition, such as California, Florida, and Oregon State in the United States, as well as Western Australia. In the United States, waste policy is set by the state, hence the attitude on the disposal of tyres in landfills differs by state. Under the California Code of Regulations (CCR), Title 14, discarded tyres may not be landfilled in a solid waste disposal facility in various states of the United States, including California, unless they are permanently decreased in volume prior to disposal. In the states of Florida and Oregon, tyres must be reduced in bulk by slicing or shredding before being disposed of in landfills.

While in Australia, the Environmental Protection Regulations 1987 allow for the burning or alternative disposal of tyres. Setting the borders for a Tyre Landfill Exclusion Zone (under Schedule 5 of the same Act) in specified locations guarantees that these landfills are largely prohibited for tyre disposal in Western Australia. In areas where the disposal of tyres as landfill waste is permitted, there are specific disposal requirements that must be met, such as burial of batches of tyres at a landfill with a minimum cover and separation distance between tyre batches to minimise fire risks.

Additional criteria may include:

a) Prior written consent from the Department of Environment Regulation's Chief Executive Officer when disposal happens inside the Tyre Landfill Exclusion Zone
b) Disposal in a local government jurisdiction that is not part of the Tyre Landfill Exclusion Zone

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A. Transboundary Initiative: The EU's International ELT Trade

Since 2006-07, the EU has been motivated to tap into potential secondary raw resources inherent in garbage, and this has led to recycling and reuse regulations. This concept basically subscribes to the notion that there is a market for garbage, rather than solely recycling for the sake of the environment. As a result, the policy and system intentionally approaches trash as a possible source of cash and marketable goods.

Currently, the EU is the world's largest exporter of non-hazardous waste meant for recovery (recycling), outpacing both the US and China. 34% of the EU's worldwide waste exports are non-hazardous waste meant for recovery, whereas 20.3% of global imports are non-hazardous waste destined for recovery (European Commission 2015). India gets the second highest exports of non-hazardous trash for recycling and recovery from the EU, after only China (30.7%).

There are chances provided in some market systems (liberal and government responsibility) to trade ELTs as valuable waste commodities aimed for recycling and recovery with nations such as India, Pakistan, and Malaysia. In the case of international waste trade, additional laws in REACH or Registration, Evaluation, Authorisation, and Restriction of Chemicals standards must be followed to ensure that these exported ELTs meet the EU's waste shipment norms and are also subject to the same environmental standards as in Europe.

While maintaining strong ethical and environmental standards, the EU is today the leading dealer of recycled goods. REACH, or Registration, Evaluation, Authorisation, and Restriction of Chemicals, is an ethical policy statement that has been in effect since June 2007.

REACH is a European Union legislation that was enacted to better the protection of human health and the environment from the hazards that chemicals can cause, while also increasing the competitiveness of the EU chemicals sector. It also encourages alternate approaches for assessing the hazard of compounds in order to decrease the number of animal experiments.

Apart from Europe, even Australia has taken steps to safeguard the waste management of rubber tyres. Sustainability in Australia Victoria is a statutory organisation formed by the Sustainability Victoria Act 2005, with a board selected by Australia's Minister for Environment and Climate Change. The Environmental Protection Act of 1970 also requires this agency to provide state-wide waste management and planning. Despite being driven by the national government, this project enjoys support and patronage from both state governments and business.

The goal of this program is to increase the market for tyre-derived goods and/or fuels while decreasing old tyre stocks. The essence of this program is the realisation that improved ELT management would result in fewer tyres ending up in landfills, hence decreasing environmental and health problems while offering significant market growth prospects. Sustainability Victoria accomplishes its mission through two major programs:

1) Tyre Stewardship Australia

This is a joint endeavour of the state government and industry to execute the Tyre Product Stewardship Scheme by supporting the creation of a sustainable market for ELTs. Tyre Stewardship Australia is made up of people from all parts of the tyre supply chain, including merchants, manufacturers, recyclers, and collectors. It aids in the collection, recycling, and reuse of tyres.

2) National Market Development Strategy for Used Tyres

The Victorian Market Development Strategy for Recovered Resources (Strategy) aims to overcome resource recovery difficulties and maximise the economic potential of resource recovery prospects.

The method is founded on the premise that resource recovery allows for government involvement within a market-based economy. The strategy's focus is also on ensuring that, while addressing the demand for resource recovery, they simultaneously maintain the environment, community amenity, and public health.

China ($13.4 billion), Thailand ($5.47 billion), Germany ($4.9 billion), Japan ($4.26 billion), and the United States ($3.92 billion) are the leading rubber tire exporters for the period ending 2020.

For the same time period, the top importers were the United States ($13.2 billion), Germany ($6.04 billion), France ($3.23 billion), the Netherlands ($2.44 billion), and Mexico ($2.43 billion). Tires were the world's 36th most traded product in 2020 (with a total trade value of $71.6 billion) as per TechSci Research.

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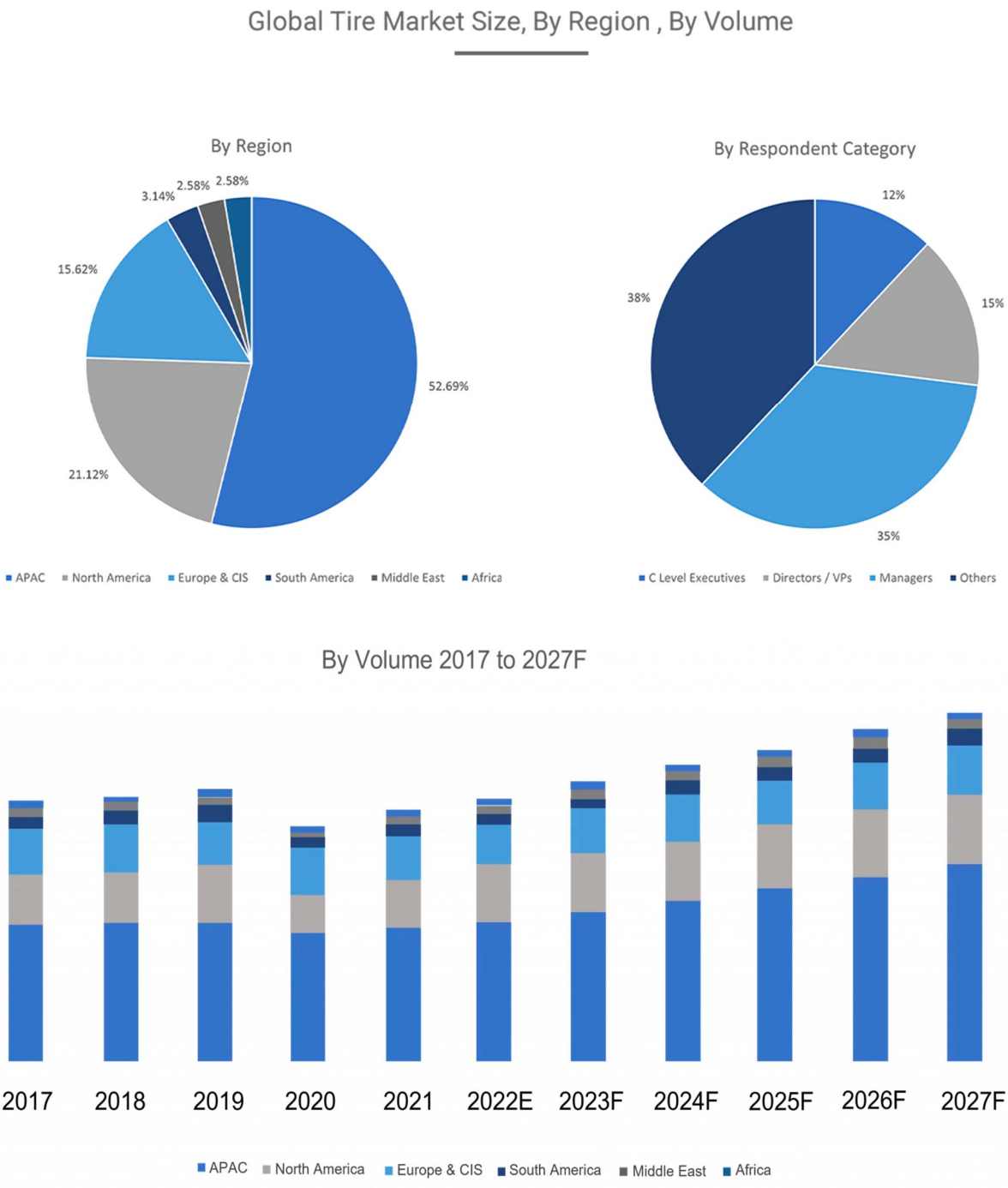


Source - TechSci Research

According to data supplied to the United Nations by customs departments, international trading in discarded tyres has nearly quadrupled in the last five years, producing millions of dollars in revenue across the supply chain.

The most important and fastest expanding trading route is from the United Kingdom to India, where authorities are increasingly concerned about the nasty business of converting waste rubber into oil, a process known as pyrolysis.

Reuters questioned dozens of waste tyre industry actors in India, Malaysia, the United Kingdom, Singapore, and Dubai, including garages, collectors, exporters, and end users, to find out who profits from waste tyres.

3) Sellers and Collectors

Garages in the United Kingdom, the world's leading exporter of waste tyres, charge motorists roughly 2 pounds ($2.50) to remove their tyres and then pay collectors around 1 pound to take them off their hands.

When the tyres are collected, they are wrapped into bales, which allow around 3,000 to fit into a 40-foot shipping container, ready for export. Exporters pay roughly 260 pounds per container for the baled tyres.

Exporters then negotiate sales with Indian importers. Despite their low profits (approximately 60 pounds per container), these companies transport hundreds of containers each month.

Importers in India and Malaysia told Reuters that they spend between $1,500 and $2,500 per container of tyres, with the transportation cost accounting for around 75% of the total.

4) Purchasers and Burners

When the tyres arrive in India, they are divided among recyclers who shred them for use in road construction or sports fields, enterprises that burn them as inexpensive fuel to produce cement or bricks, and pyrolysis operations that convert the discarded rubber into low-quality oil, carbon black, and scrap metal.

According to plant operators, backyard pyrolysis operations may produce roughly $2,500 worth of oil, $300 worth of steel scrap, and $200 worth of carbon black for each container of tyres. This equates to a profit of $500 to $1,500 per container.

Given that basic Chinese-made pyrolysis units can be purchased for as low as $30,000, backyard enterprises may quickly recoup their investment.

The difficulty is that the low-cost devices are also quite polluting. According to local officials, more advanced technology that limits emissions and waste might cost 10 times more in India.

VIII. METHODS TO REUSE RUBBER TYRES

Aside from government legislation (both EU and each member state) that promote ELT management, systematic innovation and research on potential recycling prospects are being conducted. The entire reuse of ELTs in the automobile and tyre industries would be ideal, however this is not always achievable. As a result, suitable alternatives are thoroughly evaluated prior to adoption based on usage characteristics and economies of scale. This section aims to provide an awareness of some of the feasible alternatives that are now available and/or being investigated in the EU. The EU acknowledges that expanding the rubberized asphalt/CRMB industry is a creative solution to reintroduce rubber from ELTs into the new tyre manufacturing process. This alternative, according to some, solves both the dispute over optimal resource reuse and the debate over economies of scale. As a result, this is acknowledged as the optimum way back into the circular economy of ELTs (Turer 2019).

A. Use in Roads

Tyres as complete or chopped tyre sections are occasionally utilised in different ways on roadways. They can, for example, be employed to maintain slope stability or as a landfill alternative. At times, they are employed beneath the road to increase stability. Large chunks of shredded tyre components are directly employed as lightweight filler material on embankments. ELTs are utilised for drainage around building foundations, erosion management for rainfall run-off barriers, wetland formation, and crash barriers along racing track sides without much alteration.

CRMB is created by breaking down old tyres into rubber crumbs, which are then mixed with bitumen and crushed stone, which are generally used to manufacture asphalt. The material used in the EU is rubberized asphalt, whereas it is known as Crumb Rubber Modified Bitumen (CRMB) throughout the rest of the globe, and it is used to build, repair, and replace existing roads and highways, as well as to create new ones. CRMB as rubberized asphalt is popular in Europe, but the rest of the globe has yet to adapt on a large basis. As a result, the worldwide CRMB market has significant development potential.

Rubber crumbs have been utilised not only in asphalt and road-way constructions, but are also an excellent raw material for making athletic tracks, sports equipment, and playing fields. There are now tests and a few initiatives underway in the United States and Europe where sports tracks are made from 100% recycled ELTs. Sports surface producers Aliapur and Technisol have pioneered this approach. These tracks have been shown to meet athletes' expectations by absorbing stress, deformation (flexibility), and sliding (grip) (ETRMA 2015). The surface is created by blending rubber crumbs derived from ELTs with several other polymers and chemicals.

The Gauthier stadium in Clermont-Ferrand was created by ASM Omnisports after being proven in the laboratory using this technology. It was sponsored by Michelin. This stadium had a 16-mm thick surface and a total surface size of 3,800 square metres, including a 400-m circuit with 5 lanes, 6 straight sprint lanes, a semi-circle for the high jump area, and a run-up track for the long jump and triple jump. The track was built in 2012 with 40 tonnes of granules from 9,000 passenger car tyres.

Crumb rubber is being utilised in an increasing variety of goods and applications across a wide range of sectors. The following list is intended to serve as a guide to the markets and end-use applications that can or are presently using tire-derived crumb rubber. It is by no means exhaustive.

Athletic surfaces and fields, Agrimats and equestrian footing, Automotive parts and tires, Construction/indoor, Landscape, trails and walkways, Moulded and extruded products, Playground and other safety surfaces, Rubber modified asphalt and sealants, and Rubber and plastic blends are some of the major markets for crumb rubber.

B. Rubberized Cement

Rubberized cement has the ability to lower its weight while increasing its tensile strength. Rubber integration into concrete improves its performance by enhancing its resistance to cracking and decreasing its capacity for deformation (ETRMA 2018). As a result, there is a drive to put rubberized cement in roads that are currently employing concrete since it has many of the same advantages as rubberized asphalt, such as flexibility, higher tensile strength, and improved drainage. Given the size of the European concrete industry, which exceeds 39.4 million cubic metres, extensive research and development on the use of recycled/reclaimed rubber is being done throughout Europe. Rubberized concrete of this type is especially effective in earthquake-prone locations, and tests on the use of rubberized concrete as an earthquake protection strategy is currently underway. Steel cables embedded in tyre layers have comparable effects to steel layers embedded in an elastomeric isolator. ELTs, on the other hand, are beneficial for creating post-tensioned elastic walls and would serve as a handy and inexpensive raw material for the same objectives.

C. Rail Transport

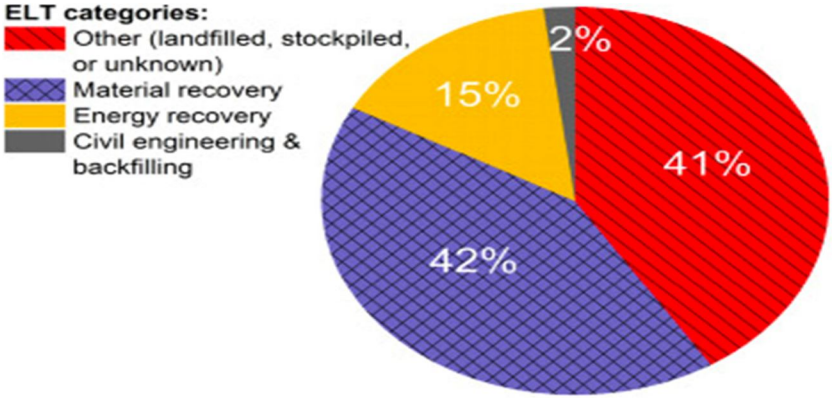
A large portion of the material obtained from ELTs may be utilised in the rail and tramway sectors. There are several initiatives throughout the world that employ tyre reuse to benefit the rail and tramway sectors (ETRMA 2018). Recycled rubber can also help to reduce noise and the effect of rail tyres on the rails into which they are bedded.

D. Rubber Use to Reduce Noise Pollution

Initially, the usage of rubber decreased noise pollution by -5dB, but since 2000, there has been tremendous innovation in this field, and current noise pollution reduction has improved by four times to -20dB (ETRMA 2018). Using the inherent qualities of rubber to decrease noise pollution has meant that the Swiss National Rail has decided to utilise recycled rubber base in its design since 1978. In Europe, STIB, the Société des Transports Intercommunaux de Bruxelles, has lined both sides of the tramway with 97% recycled rubber infill blocks since 1998. It has been employed consistently in several regions of Europe throughout time and has been shown to minimise tramway noise pollution (ETRMA 2018).

Overall, recycled rubber is seen as a valuable and realistic long-term alternative for reducing noise pollution, from incorporating it into urban places such as highways to constructing screens and guards, among other things, particularly in heavy traffic regions.

The graph below represents the 2019 data of the recycled end-of-life tyres out of the total amount of tyres produced worldwide.



Source: Science Direct

IX. INDIAN POLICY ON RUBBER WASTE MANAGEMENT

India is the world's third biggest producer of natural rubber and fourth largest user. According to one assessment, the car sector is the greatest consumer in the country. According to Business Standard, India manufactures 6.5 lakh tyres each day.

India accounts for 6% of the world's 1.6 billion discarded tyres produced each year. In addition, India imports around three lakh tonnes of tyres for recycling each year. They are subjected to high-temperature thermochemical processes in order to create industrial oil and other derivatives.

According to the new draft notification, all makers and importers of new tyres would be required to recycle all of their goods by 2024-2025, beginning with 35% and then 75% of their products for the first two years, and reaching 100% by 2024. The notification also prohibits the importation of used tires solely for the purpose of creating pyrolysis oil or char.

Furthermore, all manufacturers and importers will be required to register with the CPCB and receive a 'EPR certificate' in the name of a certified recycler for all items recycled. Recyclers, including pyrolysis facilities, will be required to furnish the CPCB with monthly reports on the number of waste tyres utilised, end products created, and EPR certificates sold in this respect.

The Ministry of Environment, Government of India's rules on the recycling of ELTs keeps with the international Basel Convention-UNEP guidelines. Hence, the mandate is on the reuse of those tyres which have not been completely worn out and can serve their original purpose. The focus thereafter is on material reuse of rubber by either retreading tyres or using rubber crumb in various applications and lastly through recycling and reuse of reclaimed rubber. The Ministry of Environment, Forests and Climate Change also recognizes that shredded rubber can be used for energy recovery purposes as a TDF.

The Hazardous and Other Wastes (Management and Transboundary Movement) Rules, April 2016 recognizes waste tyres and ELTs in the country as 'Hazardous Waste' (MoEFCC 2016). The Act stresses on recycling and/or on resource recovery of ELTs, rather than disposing of ELTs by dumping them in landfills or burning them. The new rule puts a ban on the import of waste tyres for direct reuse purposes though it allows for the import of waste tyres specifically for pyrolysis and recycling. In this regard, the Ministry of Environment clarifies that the import of waste pneumatic tyres is permitted for three main applications - for crumb rubber and downstream products, utilisation/co-processing in cement kilns, and for extracting of Tyre Pyrolysis Oil (TPO).

The Government of India is in the process of preparing a new set of guidelines to manage waste tyres wherein the large part of the onus of responsibility is on the tyre companies as well as dealers, i.e., extended producer's responsibility. The new guideline draws largely from the EU's circular economy approach towards dealing with the issue of ELTs. To understand the extended producer responsibility in the draft plan, it's important to grasp the concepts of the Integrated Waste Tyre Management Plan (included within it are the authorised waste tyres collection and storage centres) and the course of action involved in cases of breach of responsibility.

The draft guidelines in the Waste Tyres Management Rules 2017 state that tyre companies would be expected to prepare and execute an 'Integrated Waste Tyre Management Plan' which would include within it the "operational mechanisms for collection and disposal of waste tyres equivalent to its annual production and/or import quantity" In other words, an individual extended producer responsibility approach is taken wherein the tyre makers will need to follow through with their own waste management plan and comply with it within a given time.

Tyre dealers will have to accept waste tyres in lieu of new ones bought by customers and will be responsible for disposing them off. The draft emphasises that the customers, while purchasing new tyres, would have the option to leave the waste tyres with the tyre retailer/dealer from whom the new tyres are purchased. The tyre retailer/dealer thereof, may "choose to provide an adjustment value to the consumer as it may deem fit on the value of the new tyres purchased for the equal number of waste tyres collected". This valuing of the old tyres will depend on their condition.

However, the tyre retailer can only accept as many waste tyres as new ones bought by the customer and will only be responsible for sending the waste tyres collected from the customers to the Authorised Waste Tyres Collection and Storage Centres. According to the Act, at any time a dealer/retailer shall not stock more than "250 numbers or 5 tonnes of waste tyres, whichever is more". Under this rule, the customer can also give the waste tyres directly to the 'Authorised Waste Tyres Collection and Storage Centres', but they would not be paid anything for these ELTs.

Thus, tyre manufacturers would need to provide an assessment of the quantities and types of tyres that are produced or imported and would eventually become waste tyres. They are also required to indicate how the waste tyres will be managed. This plan will also provide options for the recycle and reuse of the waste tyres and/or recovery of the energy from the waste tyres as well as identify the mechanism to ensure that this will be achieved.

Included within it is not just a detailed design plan but also the cost-benefit model and the details of the circular economy of collection, management, reuse, recycle and the b0 processes of plugging back of the loop. There will also be a detailed demarcation of responsibilities and obligations of the various actors in this economy.

Additionally, the new policy also emphasises the need to indicate the méasures which will be put in place by the producer to address the stockpiles of waste tyres and indicate the percentage of the stockpile that the producer will be taking responsibility for.

A. Breach of Responsibility

Under the new rules, non-compliance will attract fines of up to IN 1 lakh. If the contravention continues, then a fine of up to INR 5000/day for as long as the contravention continues can be levied. If the contravention continues beyond a year, the offender can face simple imprisonment up to a year.

B. Industry Response to the Act

Given its emphasis on extended producer's responsibility, this draft has not found much favour with tyre manufacturers. This is specifically so, since the tyre producer will "not be allowed to produce, import, distribute and/or sell new tyres, unless it complies with the relevant provisions of these rules". Additionally, the new policy also emphasises the need to indicate the measures which will be put in place by the producer to address the stockpiles of waste tyres and indicate the percentage of the stockpile that the producer will be taking responsibility for.

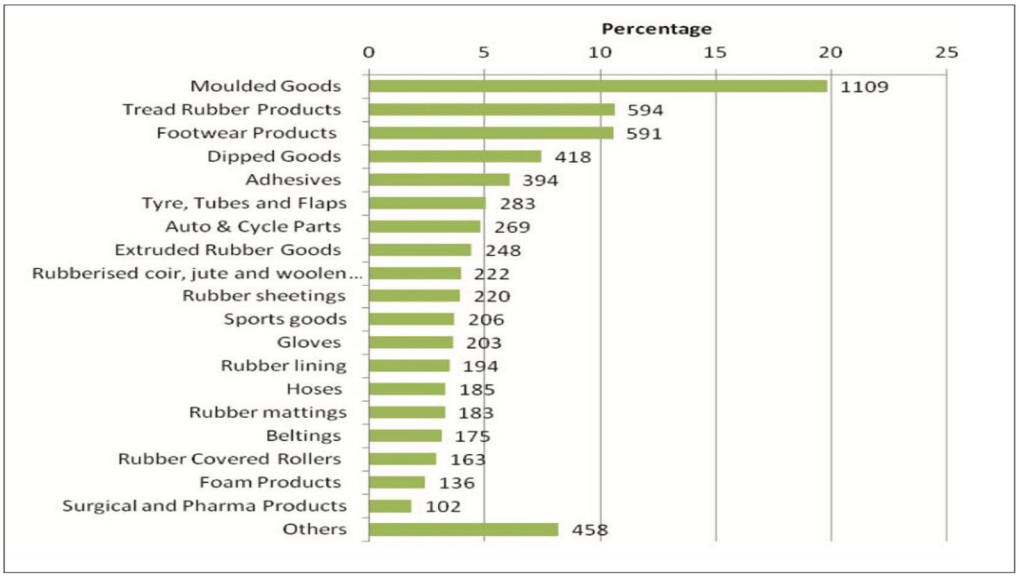
C. Recycling Options for ELTs in India

The Rubber Skill Development Council of India estimates that the Indian rubber industry has a current turnover of INR 32,000 crores (2014-15) while providing employment to more than 3.70 lakh persons. From the overall demand for rubber, it is estimated that from the non-tyre industry. The Rubber Council of India notes that the non-tyre industry is currently largely focused on the crumb rubber related manufacturing industries. Thereby, the focus has been on the manufacture of moulded goods, tread rubber products, footwear, dipped goods and adhesives.

D. Production of Crumb Rubber and Reclaimed Rubber

As discussed in the various sections of the report, by being available for versatile use within the rubber economy, reclaimed rubber plays a significant role in the plugging back of the loop. Moreover, given the property of reclaimed rubber, in certain situations, it is more us§ful than natural rubber and with the aim of improving productivity; reclaimed rubber is often mixed with natural rubber. The biggest advantage of reclaimed rubber comes from the fact that it has a low consumption of power during breakdown and mixing. During manufacture, reclaimed rubber has already been thoroughly plasticised, so when compared to virgin rubber, it breaks down and mixes more quickly. Due to the cross-linked structure of reclaimed rubber, its compounds are less thermoplastic than virgin rubber compounds and therefore when extruded and cured in open stream, they tend to hold their shape better (Rubber Board 2002).

Figure 7: Non-Auto Tyre Rubber Sector (India)



Source: State of Indian Non-Tyre Manufacturing Industry (RSDC 2016)

The Rubber Board of India predicts that recovered tyre production and consumption have fallen slightly from around 1,29,000 metric tons in 2014-15 to 1,19,000 metric tons in 2015-16. Overall demand and consumption for recycled rubber from car tyre manufacturers is estimated to have fallen just significantly from 51,398 metric tons in 2014-15 to 48,613 tons in 2015-16 (Rubber Board 2016).

There is now only about 10,000 metric tons of gap between the production and consumption of recycled rubber. Given the industry's size, it is felt that there is plenty of room to grow and exploit this area.

The Indian government's policy for rubber recycling and reuse lays a strong focus on the manufacture of crumb and recovered rubber. The Ministry of Environment's primary issue in the manufacturing process is the need to transition from the existing partial mechanisation process to a more completely automated one. The safety procedures outlined in the official document on ELTs of November 24, 2015 focus on not only decreasing but also avoiding environmental contamination and ensuring worker safety. There is now a necessity to install extra safety guards to guarantee worker safety in circumstances where any machine processes (such as the de-beading machine, strip cutter, and chip manufacturing machines) require manual involvement.

Similarly, to prevent air pollution, suitable arrangements must be in place in the grinder/ pulveriser machines to collect fibres and tiny particles (through suction and bag filters). Finally, there is a greater emphasis on the need of having a sufficient ventilation system, as well as necessary fire and environmental safety procedures, in the production and vulcanization processes.

Between 2010 and 2015, India's exports of floor coverings and mats increased by 103%, averaging a 25.7% annual growth rate. In 2014-15, this segment's export was worth IN 389 crores (USD 63 million). India's exports to the US were the largest, accounting for 27% of total exports. This was followed by the United Kingdom (16%), the Netherlands (6%), Russia (6%), and Ireland (6%).

The raw material for the exported floor covering and rubber mats originated from ELTs bought from the EU, which was a new component of India's sale to EU nations. Over the years, numerous businesses have taken advantage of the EU market for recycling and recovering rubber from ELTs by becoming ISO and REACH certified.

Fishfa Rubbers Ltd is a well-known company in the field of depolymer and butyl rubber reclamation, as well as a significant exporter to the EU and the United States. Fishfa Rubbers Ltd, like other big reclamation rubber enterprises, has taken 45 years to reach its current capacity. The company has expanded as a result of utilising the recycling potential of recovered rubber and obtaining the relevant certifications (including the numerous ISOs, REACH, and other quality assurance certifications). Fishfa Rubbers Ltd is currently a well-established and publicly traded Public Limited Company. Currently, more than 90% of their output is exported to 22 nations, including the United States, the United Kingdom, and Europe.

In the current context, there is a need to keep an eye on the tariffs levied on the import and export of rubber goods, particularly raw materials and finished products. This will aid in ensuring the product's financial viability for export. Enterprises must also be able to connect with appropriate government initiatives, such as those run by the Rubber Skill Development Corporation, Make in India, Skill India, and Mudra Yojana.

After China, Europe, and the United States, India has the world's fourth largest tire market. It sold 182 million units in 2021 and is predicted to sell 221.8 million units by 2027, thanks to a CAGR of 3.59% from 2022 to 2027. Demand is being driven by two end-user segments: OEMs and replacements. Clearly, the replacement market accounts for the majority of overall sales. While new vehicle sales fuel growth in the OEM segment, use patterns and replacement cycles drive growth in the replacement sector.

The top ten manufacturers control over 80% of the entire market share in India's tire market. MRF, Apollo Tires, and JK Tires are among the industry leaders. The export business is expanding rapidly, fueled by international demand for high-quality tires. According to a recent press release from the Commerce Ministry of India, India's tire exports increased by 50% year on year to INR 21,178 crore in FY22.

The recycling of discarded tyres that are no longer acceptable for use on cars owing to wear or irreparable damage is known as tyre recycling. Because of the high volume produced, the longevity of the tires, and the ecologically hazardous components in the tire, these tires are a difficult source of trash.

Tires can take up valuable landfill space since they are exceedingly durable and non-biodegradable. Newer technology, such as pyrolysis and devulcanization, has made tires ideal candidates for recycling in the current context, despite their weight and resistance. Aside from fuel, the primary end use for tires is ground rubber.

Every year, around 1.6 billion new tires are produced, with approximately 1 billion discarded tires. The recycling business, on the other hand, barely handled 100 million tires each year. The tyre is intricately built with multiple complicated procedures, making it indestructible in nature and complicating tire recycling. However, major tire recyclers are investing heavily in advanced technology and equipment that may aid in the recycling of tires for diverse applications while also protecting the environment. While India produces around 1.5 million tons of ELT every year. The formal sector recycles just 450,000 tons.

Expansion of vehicle fleet, surge in new vehicle sales, and a thriving construction industry are the primary drivers projected to drive tire demand in India in the future years. Furthermore, increasing urbanisation and increased disposable income are expected to drive development in the country's tire industry through 2023. More significantly, the rising use of recycled materials to conserve scarce natural resources and reduce CO2 emissions is driving the development of novel techniques to dealing with such difficulties. Recycling discarded tires is proving to be an excellent strategy for lowering environmental pollution while also strengthening the country's economy.

Rubberized asphalt road construction is proven to be the greatest solution for recovered scrap tires. The significant obstacles, however, are the collection and recycling of all tires, as well as the prevention of unlawful landfills, sensitive ecosystems, and abandoned locations. Furthermore, shredding techniques to separate steel wire from rubber are exceedingly sophisticated, limiting tire recyclers' profit margins. The lack of standards for recycled tire products, as well as the complexity involved in recovering and recycling automobile tyres, are further impeding the growth of the tyre recycling industry.

In today's world, recycling is the only option to achieve the Sustainable Development Goals (SDG) through overall social, economic, and environmental progress. As a result, India's recycling sector plays a critical role in terms of economic production, job creation, and contribution to resource sustainability.

X. SUGGESTIONS

With the spectacular expansion in the number of vehicles in India in recent years, the need for tyres as original equipment and replacement has also surged, rising from 22,846 thousand tyres in 1990-91 to 31,213 thousand tyres in 1994-95. Because every tyre is intended to enter the waste stream for disposal/recycling/reclamation, regardless of whether it has been retread, the quantity of worn tyres wasted will skyrocket. Timely action on recycling used tyres is required to handle the problem of disposal of used tyres in light of rising raw material costs, resource restrictions, and environmental issues such as fire and health dangers connected with stockpiles of used tyres.

The issue has piqued the interest of planners, environmentalists, consumers, and business in industrialised nations such as Western Europe, the United States, Japan, and Australia, where billions of worn tyres are stockpiled. These stockpiles represent a direct loss of energy and resources, as well as a fire and health threat and other environmental concerns. In this paper, in this section, I attempt to provide some suggestions to reuse waste tyres in sustainable ways.

With the rising pace of automotive manufacturing, which is predicted to more than triple in the next few years based on current projections. Efforts must be taken to recycle used/scrap tyres in order to prevent the challenges that the developed world is currently experiencing with scrap tyre disposal.

Overcoming the preconception that retreaded tyres and recycled-material goods are inferior. Encourage the usage of recycled items in a variety of settings. Educate people through the media on the importance of tyre care, such as proper inflation and loading. To maintain correct vehicle suspension and alignment. These will have an impact on fuel efficiency and tire life. As a result, the number of tyres that need to be changed and discarded is reduced.

Retreading of old tyres before the tread wears out and the tyre must be discarded. This is necessary for safe driving and also prevents premature tyre scrapping, resulting in resource and energy reduction. The procured or 'cold' technique of retreading is capable of improving tyre life to roughly 85-90% of the life of a new tyre while costing less than half the cost of a new tyre.

Tyres that are unsuitable for retreading tires may be exposed to -

1) Use as entire tyres for erosion control, tree guards, and so on (small applications)
2) Scrap tyre shredding and crumbing

Using crumbs as an asphalt modifier in road building. Tyre crumb offers a lot of potential in this industry. Regulatory support, similar to that offered in the United States, is necessary in India. To use crumb as an asphalt modifier, suitable amendments to specifications for the construction of asphalted roads are required to be incorporated in the schedules of items of work prepared by various government agencies such as the Ministry of Surface Transport, Indian Roads Congress, CPWD, PWDs, MES, Directorate General Border Roads Organization, International Airport Authority of India, and so on.

a) To utilise tyre crumb as a polyurethane modifier in the preparation of sports fields.
b) To employ tyre shedding as a fuel source in cement kilns and boilers. Steel, zinc oxide, and other byproducts are examples.
c) To regain the "reclaim" rubber, utilise tyre shredding/crumb. Rubber reclaimed from complete tyres also yields cord and steel.
d) Pyrolyze tyre shredding to produce end products such as fuel gas, fuel oil, carbon black, steel, and so on.
e) Tyre shredding can be used to produce low density landfills.

c) Other small tyre applications, such as shoe bottoms, gaskets, tonga wheels, hand carts, and so on.

Initiate research and development initiatives in the field by industry and government for useful recycling and disposal of discarded tyres. Lastly, Government Departments should set objectives for the use of retreaded tyres on vehicles that are not commonly driven on roads, such as municipal corporation vehicles, water supply vehicles, official jeeps (excluding defence services), and so on.

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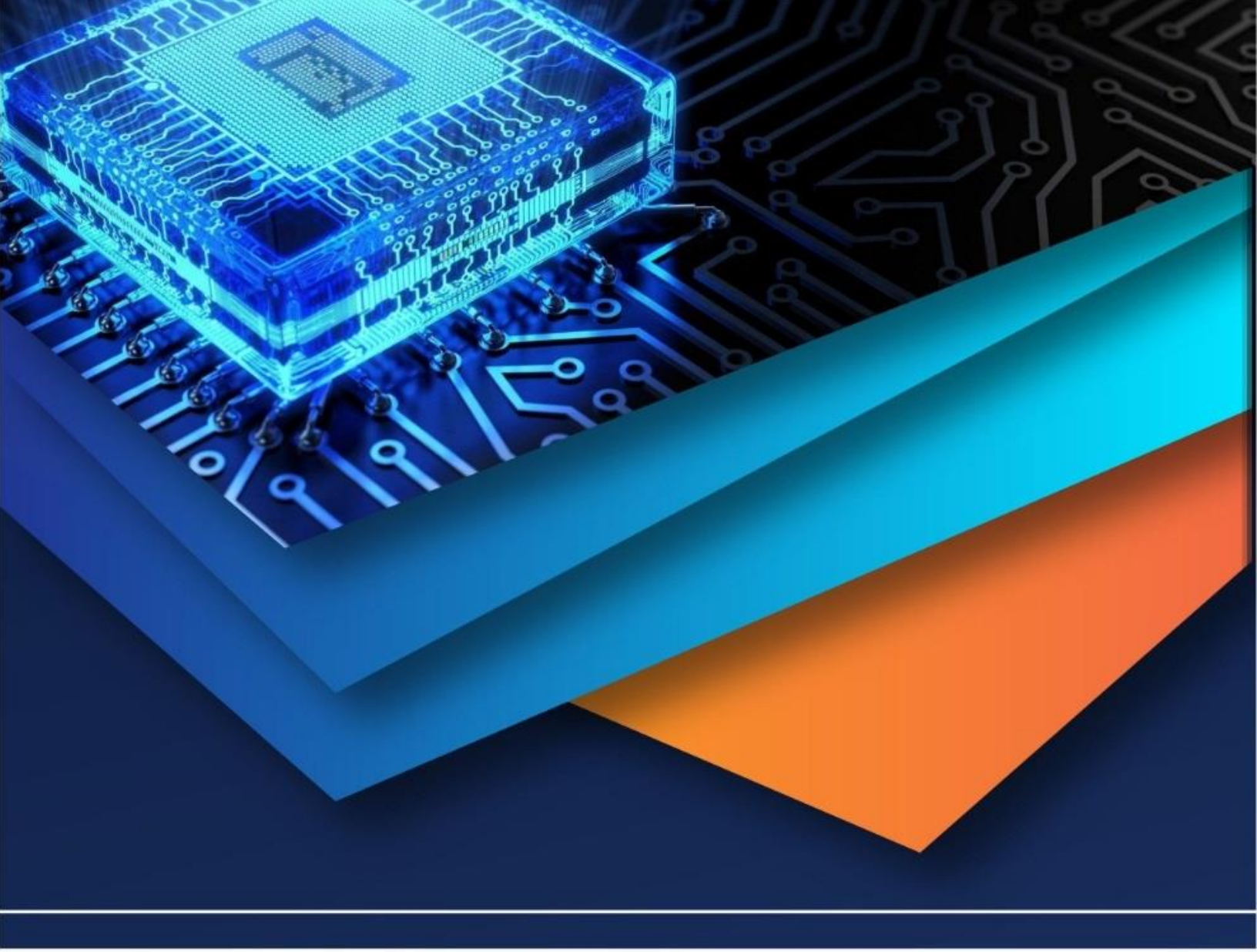

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