

# Muri: Cause Analysis and Reduction Strategies

## Case of Tyre Industry

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**Abstract**— The market size for off the road tyre industry is increasing owing to the use of technology and heavy machinery in the field of agriculture, mining & construction. With growing competition, companies are competing to increase their bottom line without increasing the cost of operation which can be achieved by eliminating Non value adding activities and three types of lean waste which are Muda, Mura & Muri in the manufacturing process. Reducing wastage will help in ramping up productivity-increasing production with the available resources

**Keywords**— Muri (Overburden), NVA (Non-Value Adding), VA(Value Adding), GT (Green Tyre), OTR (Off The Road)

### I. INTRODUCTION

A tyre is one of the critical components of an automobile and has utility ranging from steering, carrying the load to transmitting rolling motion. Accordingly they are distinguished into various segment as shown in figure no.1. Manufacturing tyre is critical and must pass through various stages in production. There are different types of tyres available in the market and each type require a different set of process plus they vary in size, groove, and weight. We will try to narrow down our focus on OTR (Off the Road) tyre. These tyres are heavyweight and manufacturing them is a cumbersome process and involve excessive strain on the operator leading to reduced productivity. Our research is focused on how the cause of Muri (Excessive Burden) can be reduced.

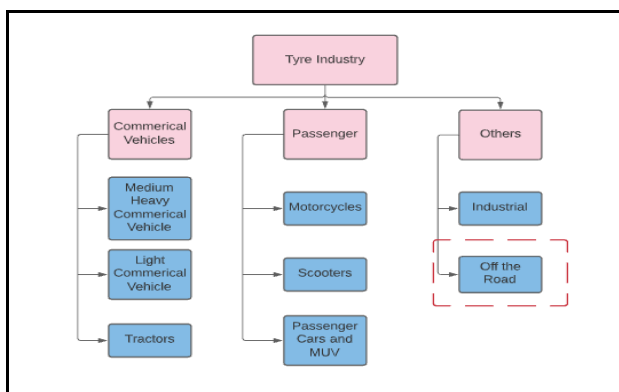


Fig.1. Types of Tyres as per Utility

### II. LITERATURE REVIEW

The Indian tyre Industry is worth around Rs. 600 billion. With 41 tyre companies and 62 tyre manufacturing plants, this sector produces the largest variety of tyres in the world. Tyre

demand originates from two end-user categories -- OEMs and the replacement segment. Demand from the replacement segment dominates the Indian tyre market contributing about 55 per cent of the total volume.

OTR tyres or off-the-road tyres are made up of resistant compounds to offer good grip on uneven or rough surfaces, mud, stones, or sand. The tyres have in-depth and strong treads which can be deployed to any vehicle. They are generally designed to use in extreme conditions and offer safety, high performance, and quality. The OTR tyres are used in large machinery at mining, agriculture or construction areas where there are no roads but rough surfaces. The rising population worldwide and increasing demand for higher food production are fuelling the demand for tractors and agriculture equipment vehicles, thus increasing the demand for OTR tyres. A rise in the preference for employing modern equipment for agricultural activities has encouraged tractors' adoption, which drives the growth of the OTR tyres market. The severe weather conditions and customization resulted in high research and development expenditure, which is likely to hamper the OTR tyres market. The OTR Tyres Market is expected to grow at the rate of 3.4% CAGR by 2026.

From the manufacturing perspective starting from Raw material which includes steel, chemical, rubber & textiles. Steel is used for making steel belts and bead wire, chemical is extensively used to reduce the wear and tear & increase the life cycle of the tyre. The rubber used is natural rubber extracted from trees and then formed into a large block which is an input for feeding machine for the mixer (Raw material mixer) lastly textile include rayon, nylon, polyester which is used in making cords.[1]

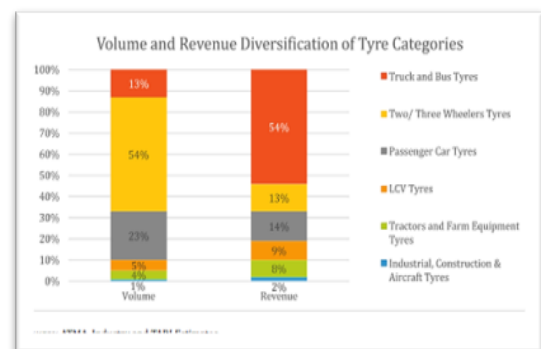


Fig.2. Volume and Revenue Diversification of Tyre

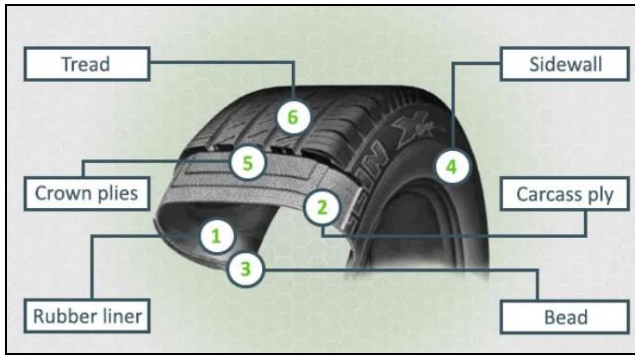


Fig.3. Sectional View of Tyre [2]

Apart from raw material another major is energy and heat utilized in manufacturing tyre, which form a big chunk [3] which add to tyre cost. It is estimated that the production of tractor tyre which is one of the applications of OTR tyre is set to increase to 8,97,000 nos. [4] With the rising demand and less cushion on raw material cost in the advent of growing competition, the controllable factor lies in manufacturing where productivity needs to be increased with available resources. One of the cost-effective ways is using a lean methodology which states that the three enemies of the lean are Muda (wastage), Mura (Unevenness) & Muri (Overburden) and over the period identifying and removing 3M (Muda, Mura, Muri) has helped organizations to improve their productivity. [5]

Thus, owing to the increase in demand, reducing Muri (Overburden) in the critical process of curing in tyre manufacturing will help to improve productivity and reduce strain on the operator.

### III. OTR TYRE

OTR tyre are of two types as shown in Table 1 Radial and Bias out of which radial tyre holds significant market share due to extensive use in heavy machinery and tractors. Second, the margin is high in these products and the growth potential is high owing to increasing pent up demand for use of new machinery in agriculture and infrastructure development.

**Radial tyre:** In this type of tyre the steel belt runs perpendicular to the thread angle. Due to which there is low sidewall and more contact with the ground. [1] It can increase crop production by minimizing compaction, which further boosts the radial tyre segment growth.

**Bias tyre:** In this tyre, the nylon belts run at a 30-to-45 degree angle with a thread angle. The multiple overlapping rubber piles in the tyre connect with sidewall and thread.[1]

The radial tyre has higher steel utilization due to which the cost is higher compared to the bias tyre.

TABLE I. TYPE OF OTR TYRE

Segment	Sub – Segment
Tyre	<ul style="list-style-type: none"> <li>• Radial</li> <li>• Bias</li> </ul>

#### OTR Tyre Market based on Vehicle Types [7]

- Loaders
- Dump Truck
- Graders
- Cranes
- Dumpers
- Tractors
- Forklifts
- Others

#### OTR Tyre Market based on End Use [7]

- Construction and Mining
- Industrial
- Agricultural
- Others

#### OTR Tyre Market based on Geography [7]

- North America
- Europe
- Asia Pacific
- Rest of the World

Based on the vehicle types, the market is segmented into loaders, dump trucks, graders, cranes, dumpers, tractors, forklifts, and others. Among all segments, the tractors segment is expected to hold the highest share in the market. There is an increasing demand for the tractor in the agriculture sector as this tyre reduce soil damage and yield-robbing.



Fig.4. OTR Tyre

Based on the end-user segment, the market is bifurcated into construction and mining, industrial, agricultural, and others. The construction and mining segment is having a significant share in the OTR tyre market growth. This is because of growing advancements in construction and mining equipment such as automation and electrification, which have supported the fleet operation to use equipment in many shifts.

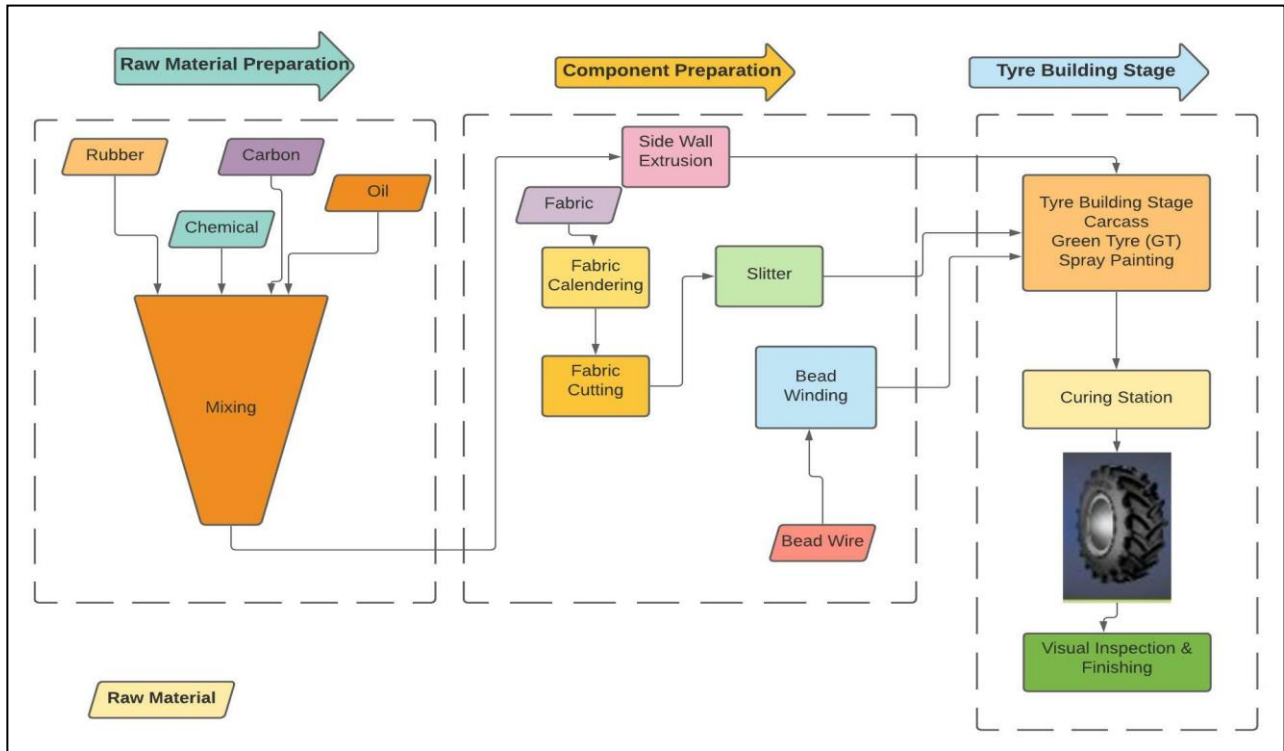


Fig.5. Tyre Manufacturing Process

Based on the geographical analysis, the Asia Pacific region will have the highest share in the market. The major share is ascribed to the increased purchase of off-road vehicles in this region's few major countries. Moreover, in few countries such as China and India, agriculture is the backbone of the economies since agriculture machinery procurement is also a significant factor to support the growth of the market in this region.

The rapid increase in off-road vehicles such as tractors, agricultural machinery, and others worldwide is projected to fuel the global market growth rate. The rise in the usage of heavy vehicles in the agriculture and construction sectors is also influencing the market's growth. The deployment of the monitoring systems for the tyre among the commercial sectors is also escalating the OTR tyre market growth rate.

As observed, majorly the OTR tyre have a prominent role in the agricultural and construction & mining sectors since agriculture is the backbone of the few countries and owing to the increasing demand for construction and mining from the developing countries.

#### A. Manufacturing Process for OTR tyre

The manufacturing process is divided into three stages shown in figure 5:

1. **Raw Material Preparation:** The process starts from mixing raw material in adequate proportion considering the characteristics of different model sizes and shapes, raw materials for tyre include rubber, oil, fabric, carbon and chemical and the final product of this stage is called a compound.

2. **Component Preparation:** This is the intermediate stage where different part of the tyre is prepared simultaneously which includes bead wire rolling and cutting, sidewall preparation which includes extrusion process starting with the

input of compound from raw material preparation stage and then rolling into the desired thickness of the sheet in required dimension followed by cutting into adequate length. This stage also includes fabric cutting and slitting process by type of tyre produced means if a radial tyre is to be made the different shape of fabric is cut if bias then different. Finally, all the components prepared are then sent to the tyre building stage. Which is the stage where the tyre starts taking its shape.

3. **Tyre Building:** Components are assembled on a roller where bead wire, inner liner, sidewall is assembled in the order mentioned at this stage the output is called "Carcass", post these stage different layers of fabric and extruded compound are rolled upon carcass until desired thickness of the tyre is achieved at this stage the tyre is in the soft form which is also called as "Green Tyre (GT)".

The GT is painted with a spray gun on inner walls so that it should not stick to the curing machine, the curing machine consist of the mould of the desired tyre size and shape, GT is placed inside the mould and then hot steam is passed through the mould for a specified time with specific pressure, due to which GT take the shape of the mould and tyre to become hard.[6] Post curing tyre is inspected for any damages, marks and if ok is send to further process in the supply chain which includes warehousing and distribution to the customer.

Our focus area is the process of handling green tyre (GT) which causes muri to the operator which directly impact his productivity and thus output is affected.

#### B. Curing Process:

The precursor to the curing stage is the painting station where the green tyre (GT) is painted. Post that following are the set of operations at the curing station which is also mentioned in Fig.6.

1. Vertical trolley movement to curing machine.
2. Tyre lifted and tilt by 90 deg. by the operator to push in horizontal trolley.
3. Aligning horizontal trolley below machine Jaw.
4. Machine jaw picks the horizontally positioned tyre and places it in the mould.
5. Post curing operation the Finished Hot tyre is removed manually from the machine by the operator.
6. Another Set of Green Tyre (GT) is loaded into the machine.
7. The finished tyre is rolled to the inspection station and the process is repeated.

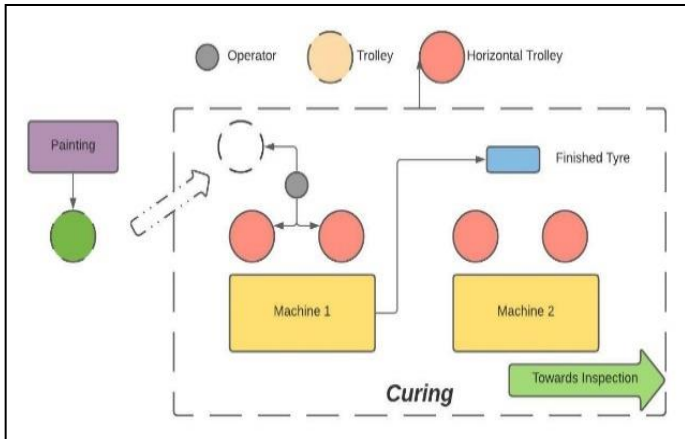


Fig. 6. Operation at Curing Station

#### IV. MURI (OVERBURDEN)

Muri is a Japanese term meaning “overburden or unreasonable”. It is one of the three types of waste (Muda, Mura, Muri) and a key concept in the Toyota Production System.

In other words, you create Muri whenever you put your team under stress by demanding unreasonable or unnecessary work that exceeds their capacity. Muri can drastically decrease your team’s productivity and efficiency.

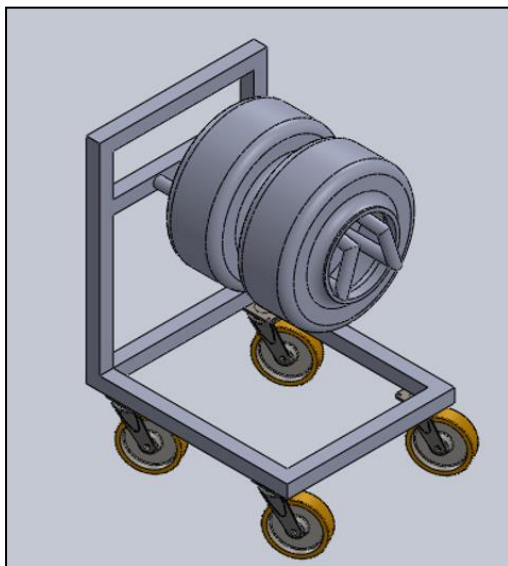


Fig.7. Vertical Trolley

Muri in this context meant overburden caused due to excessive load given to operator beyond their limit. To meet the production requirement; operators tend to quickly load and unload the GT in the machine due to which, they use their hands and roll and push the tyre from vertical trolley as shown in Fig.7. into a horizontal base and they repeat this action continuously. Repeating the motion around several times causes strain on his back and shoulders. If observed, the process of lifting the tyre by the operator doesn’t contribute much to the final product which also means this activity is a pure NVA (Non-Value Adding) and needs to be corrected. Accordingly, basis further observations the following categorization of activities were made.

Table 2 indicates NVA (Incidental) means which doesn’t add value to the product but it is a necessity that needs to be done. Also, when the green tyre (GT) is bought from the painting station to the curing station on a vertical trolley due to the soft nature of GT it gets slag in its shape and turns oval due to its weight therefore, the operator tends to tilt GT such that it regains its circular shape because without it could not fit in the circular mould inside the machine.

TABLE II. Bifurcation of VA/NVA

Sr. No.	Activity	VA/NVA
1.	Rotate & bring The GT Vertical Trolley near the horizontal trolley	NVA
2.	Roll the tyre & push the tyre on horizontal Trolley	NVA
3.	Load tyre on Machine jaw	VA
4.	Use hand and push finished tyre from machine	NVA (Incidental)
5.	Visual Checking of the Finished tyre	VA
6.	Fill the details of the Finished tyre on Logbook	NVA (Incidental)

#### V. SOLUTION

The root cause for the strain is in rolling and lifting the Green Tyre (GT) from the trolley and at the end horizontal trolley is used at the machine. If horizontal trolley itself is maintained from downstream operation until curing, then that would directly eliminate the NVA for the operator at the curing station. The constraints would be space utilized and quantity of tyre carried by vertical trolley in comparison with horizontal trolley.

Considering all aspects, a better trolley design was conceptualized, which fit in all the constraints and provided relief in handling the green tyre for the operator.

The concept in Fig.8. can easily carry two tyres. When the upper tyre is lifted by the machine jaw the holding plate of the upper tyre changes its horizontal position and becomes vertical as it is spring-loaded also meaning that only when the weight is applied on the upper plate it becomes horizontal and normal rest position of the same plate is vertical. This is very critical as the lower tyre can only be lifted once the upper plate is vertical because at that position only the machine jaw can pick the tyre.

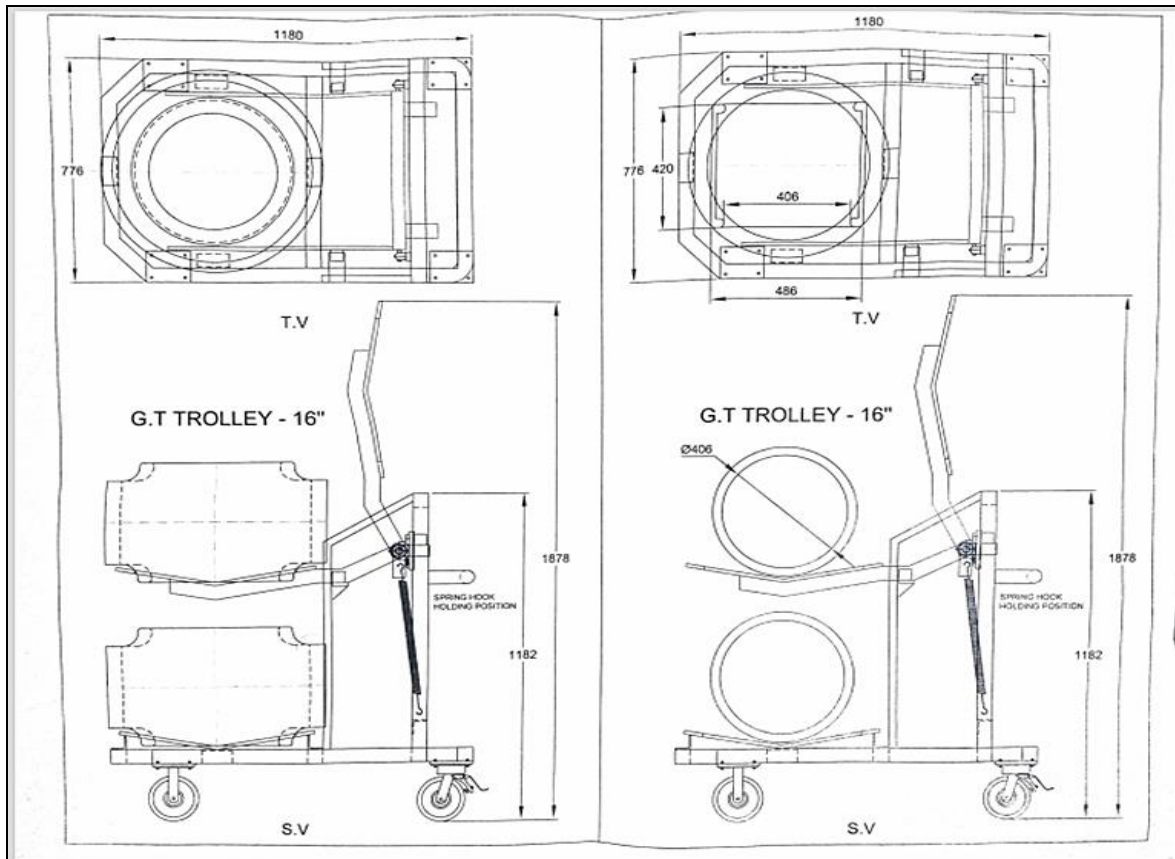


Fig.8. Layout of Horizontal Trolley (Concept)

Thus, with the use of the new trolley, the motion of the pick and place of the green tyre (GT) is eliminated for the operator, and the subsequent time which used to be consumed can be utilized for other productive work.

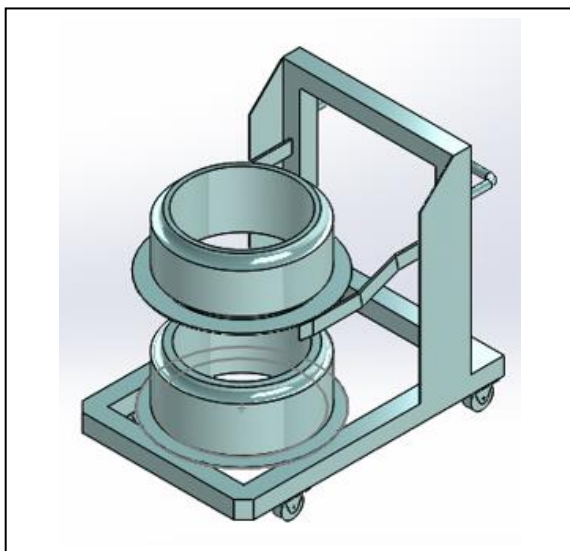


Fig. 9. Horizontal Trolley

## VI. CONCLUSION

Usage of the horizontal trolley as shown in figure 9. with two green tyre (GT) carrying capacity will eliminate NVA at the curing station wherein the operator can utilize his time to increase production, upskill himself. Eliminating wastages in our case Muri (Overburden) is a win-win situation for both the operator and manager as the production will increase substantially and the operator won't be totally drained during work leading to better productivity.

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