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Business Opportunity of Wheel Rim Manufacturing in Ethiopia

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ABSTRACT: There are different designs and configuration of wheels or rims. They must be strong enough to support the vehicle and withstand the forces caused by normal operation. The wheel rim should be as light as possible to minimize the weight to a minimum. Wheels are made up of different materials such as cast aluminium alloy, magnesium alloy, glass fibers and steel wheels. The most popular wheel materials are alloy because of their lighter weight and appearance. Nowadays the cast aluminium wheels are most common with a larger market share worldwide. The wheel configuration can be wire spoke wheel, steel disc wheel and light alloy wheel. The Wheel rim manufacturing process reviewed in this paper are Casting and Forging processes. Types of forging processes include One Piece Rim, Two Piece Rim and Three Piece Rim. Recently the number of car assembling companies is increasing in Ethiopia. This is a big opportunity for rim/wheel manufacturing companies to enter to the new market. Rim is being imported free of tax as part of semi knocked down vehicle due to the absence of local manufacturing companies. The main methodology followed in this study is identifying the current vehicle assembling companies and their annual production capacity. This includes light vehicle, bus truck & trailers, fabrication and assembling companies. There are a total of eight light vehicle assembling companies with a total yearly overall demand determined in the result and analysed from actual data acquires on 2021.

KEYWORDS: Wheel rim, Light Alloy Wheel, vehicle, wheel material, forging, casting

I. INTRODUCTION

V Sathrudhan Choudhary and et al in their journal defined a rim of a wheel as the outer circular design of the metal mounted on inside a vehicles tire. Wheel rim is highly stressed component that is subjected to bending and torsion loads [1]. Cast aluminium alloy, magnesium alloy and steel are some of the basic materials for wheels' fabrication. Most wheels' configurations have ventilation holes in the flange which makes the air to circulate through the brakes. Materials like aluminium is a better conductor of heat and alloy wheels can dissipate heat from brakes and tires more effectively than steel [2]. Wheel rim layout is a full mechanical connection of tire rim-rotors-brakes and then to main differentials [3].

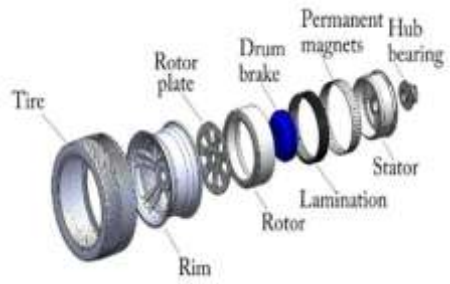

Figure 1: Wheel rim and tire layout

1.1 Development of wheel rim

The first light-alloy sheet aluminium car wheels were used in Daimler-Benz and Auto-Union racing cars in 1930s. Porsche began the batch production of sheet wheels in the 1960s and the first mass production of sheet wheels in Europe started in 1979. The production of three-piece aluminium and composite wheels reached their peak of application in the 1980s. The forged one-piece wheels were very expensive during that time. The production of light forged wheel developed and introduced originally in 1995 by Otto Fuchs [4]. Today, cast

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aluminium wheels are most common with a market share of more than 80% in North America, more than 90% in Europe and close to 100% in Japan. The share of forged wheels was about 15% in North America and 5 % in Europe only. The weight reduction requirements for each design present a good chance for the further growth of forged aluminium wheels [4].

1.1.1 Construction of rim/wheel

The construction of wheel rim consists of the following parts. A rim is part of a wheel and is the most wheel outer edge to which a tire is attached. A disc is a part of the rim where it is fixed to the axle hub. Offset is a space between wheel mounting surface where it is bolted to hub and centre of the line [5]. The flange is a part of rim which holds both beds of the tire and bead seat. It is in contact with the bead face and is a part of rim which holds the tire in a radial direction. It is a bump what was put on the bed seat for the bead to prevent the tire from sliding off the rim while the vehicle is moving well is a part of rim with depth and width to facilitate tire mounting and removal from the rim.

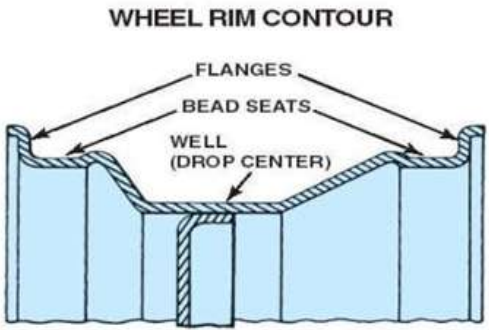

Figure 2: The wheel-rim profiles [6]

The barrel gives the shape and surface for mounting the tire and its surface helps in maintaining and retaining the air pressure inside the tire. Bolt hole is an area created for the lug bolt and it varies as per the vehicle and manufacturer design. The valve mechanism in the car is to evaluate and monitor the air pressure inside the tire and the centre cap is the centre area of the wheel where all spokes come together. Lugholes are the holes around the centre bore and it is for passing bolt to attach wheel with the axle. Some manufacturer depending on their design type uses 4 lug holes and some use 5, 6, and 8. The outer side of the wheel after fixing with the vehicle is the outer face and its main purpose is to improve the aesthetics of the vehicle. Wheel offset refers to how the wheels mount in your wheel wells and it defines how much space you have on either side of the wheel. This is an important factor to get this right because a wheel with the wrong offset can rub and cause problems with the suspension, brakes and even body parts, like fenders. Practically there are three types of offsets namely zero offset, positive offset and negative offset [7].

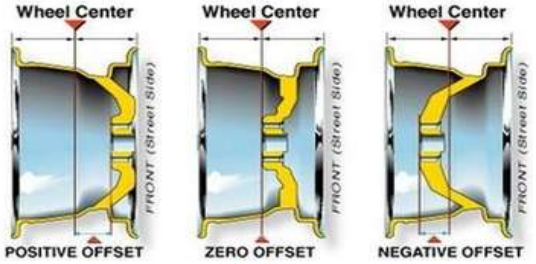

Figure 3: Types of Wheel offsets

1.1.2 Type of wheel rim shapes (Dimensional)

The drop centre of a rim is used to mount and dismount the tire which makes the process more easier and a typical rim shape of a vehicles is shown below;

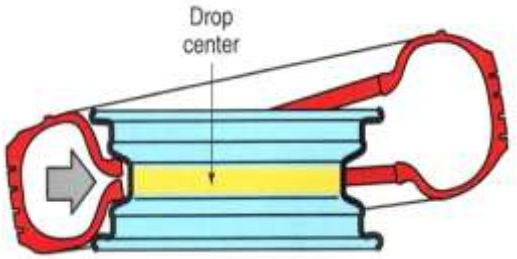

Figure 4: Wheel rim drop centre

a. Drop centre rim

Drop centre rim is the actual profile of the rim shape that found on the wheel. The purpose of this design is that the tubeless tire can be used safely and can be filled with a large volume of air.

b. Wide Drop Centre Rim (WDC)

Wide drop centre rim is the same as drop centre rim and the width of the rim, with a slighter well and a lower flange height, this rim is mostly applied to low aspect ratio tires mostly for passenger vehicles.

c. Wide Drop Centre Rim with Hump

This design has a bump on the beginning of the bead seat area and the bump prevents the bead sliding down and air outflow from the rim due to the horizontal force applied to the tire when a vehicle tubeless tires runs at high speed [6].

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1.1.3 Types of wheel rim material

Steel and light alloy wheel rim are the main materials used in a wheel however some composite materials including glass-fiber are being used for special purpose wheels. These unique developments made the competitions among material and manufacturing processes. This may be due to the product cost, weight and performance. Wheels made from Magnesium were originally used for racing but their popularity during 1960s lead to the development of other die-cast wheels particularly aluminium alloys [1].

Figure 5: Forged wheels offer a variety of design variants Photos: Otto Fuchs [4]

a. Wire Spoke Wheel

Wire spoke wheel is where on the outside edge part of the wheel (rim) and the axle mounting part are connected by numerous wires known as spokes and this type of wheel is still used on classic vehicles. Light alloy wheels have developed in recent years and the design on emphasis of spoke effect is to satisfy users fashion requirements [1, 8].

b. Steel Disc Wheel

This is steel-made rim joined by welding and used mainly for passenger vehicles especially original equipment tires. Steel wheels are made with an alloy of iron and carbon. They are heavier but they're more durable and can be easier to repair and refinish. The steel wheel can be used for heavy loads and traction services, such as truck and train [1, 8].

Figure 6: Steel wheels/rims

c. Light Alloy Wheel

Light alloy wheels based on the use of light metals such as aluminium and magnesium has become popular in the market [4, 8].

d. Aluminium Alloy Wheel

Aluminium wheels (sometimes called alloy wheels) are built with a blend of aluminium and nickel in addition to this they are lightweight, strong and withstand heat well. They are produced in a very wide variety of finishes and sizes. Aluminium wheels are good choice for a balance of performance, aesthetics, gas mileage and cost [4, 8].

Figure 7: Aluminium alloy rim/wheel

e. Magnesium Alloy Wheel

Magnesium alloy is lighter than aluminium by 30% and is excellent for size stability and impact resistance however its use is mainly restricted to racing due to its features of lightness and high strength. These alloy wheels is receiving special attention due to the renewed interest in energy conservation [4, 8].

f. Titanium Alloy Wheel

Titanium is an excellent metal for corrosion resistance and its strength is about 2.5 times stronger than aluminium but it is inferior due to machine design, processing and high cost. Titanium alloy is still in the development stage although there is some use in the field of racing [1, 5].

g. Composite Material Wheel

The composite materials wheel is different from the light alloy wheel and thermoplastic resin which contains the glass fiber reinforcement material is developed mainly for low weight applications. Composite material wheel has insufficient reliability against heat and for their strength however the development is continuing [1, 5].

1.1.4 Wheel rim technical parameters

The design and manufacturing of rim/wheel should fulfil the following technical conditions.

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Table 1 Wheel technical conditions

Parameter	Description
Stiffness	When designing an aluminium wheel, structural stiffness is the basic value to consider in order achieving at least the same vehicle behavior as with an equivalent steel wheel [4].
Static behavior	Yield strength is considered to avoid deformation under maximal axial efforts (accelerations and braking) and radial ones (plus turning) [4].
Fatigue behavior	This is the most important parameter for dimensioning with finite element software is systematically used during design in addition to this rotary bending and rim rolling tests are used to verify these calculations.
Crashworthiness	Mainly linked to stress/strain curves in large displacements and crashworthiness can be simulated during tests. However impact tests systematically check the resistance to accidental collisions such as pavements impacts.
Thermal aspects (Cooling)	Whether the wheel is cast, forged, mixed, and wrought-cast, aluminium dissipates heat more quickly than steel. This results in a significantly improved braking efficiency and a reduced risk of tire overheating.
Style – weight saving	Reduction of weight of the unsprang mass of vehicles is a key priority.
Dimension and tolerance	A perfect mass balance is a key parameter to avoid significant vibrations. Lightness also reduces vibrations of aluminium sheet wheels.
Corrosion resistance	There are various surface treatment options for aluminium wheels for appearance and durability of wheels. The cast and forged wheels are painted after chemical conversion. Strip wheels can be polished and also painted.

1.2 Wheel rim manufacturing process

The types of wheel used in automobile are disc wheel, wire wheel and light alloy wheel. The steel disk wheel and the light alloy wheel are the most typical designs and light alloy wheel becomes popular in recent years [1, 4]. The manufacturing method for the light alloy wheel is classified into two namely the cast metal or the forged manufacturing methods. Both methods are used to manufacture aluminium alloy wheel and the casting manufacturing method is used as for the magnesium alloy wheel and three methods of manufacturing for aluminium alloy wheel [1, 4].

1.2.1 Casting processes

Casting is made by pouring molten aluminium into a mold which is shaped the same as the wheel final shape.

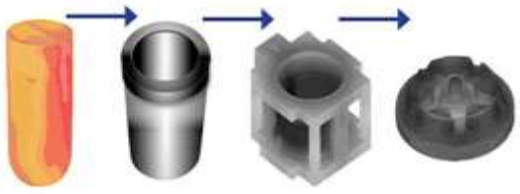

Figure 8: Aluminium casting process [9]

The main advantages this process compared to steel or other aluminium wheels are: a high styling versatility, Weight (equal or less than steel without styling), Dimensional accuracy (mass distribution), Recycling ability, Static and dynamic behaviour.

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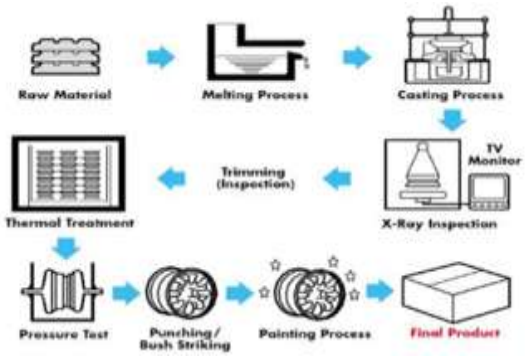

Figure 9: Casting method

Major casting processes for wheels

- Low-pressure die casting (mainly used)
- Gravity permanent mold casting type (less used)
- Squeeze-casting process type (marginally used)

Some other processes which rarely used are; casting-forging (Coba press), Counter pressure die casting, and Thixo casting. After casting, wheels are inspected by x-ray and then eventually heat-treated prior to machining. It is followed by a pressure tightness testing before drilling valves and bold nut holes. Wheels are then painted or varnished after a cosmetic inspection. This operation includes pre-treatments such as degreasing, phosphatizing and chromating. 3D dimensional controls, dynamic balance checking, bending and rim roll fatigue as well as impact tests are statistically performed.

1.2.2 Forging process

A solid billet of aluminium is shaped into the wheel form pressurized for added strength and machine cut into the final wheel design. Theses forged aluminium wheels are one-piece wheels formed from a single block of metal by hot forging, hot or cold machining and spinning operations. The forging process permits flexibility in design of the styled disk, similar to cast wheels. The standard alloys used are the heat- treatable wrought alloys:

- EN AW-AlSi1MgMn (6082) in Europe
- AA-6061(AlSiMgCu) in USA

Figure 10: Aluminium forging process [9]

The manufacturing process permits a maximum brake caliper room in combination with tight tolerances, low weight, high strength and toughness. Aluminium forging aligns the grain structure along the direction of the material's flow. This permits exploitation of strength and toughness properties of the alloy to the maximum extent.

In relation to castings forged materials exhibit decidedly higher fatigue resistance due to absence of pores and because of a fine, homogeneous microstructure. Cast wheels are performing according to the same load and endurance specifications as forged wheels, the latter are more tolerant to overloads as may be experienced in sports cars. The dense wrought microstructure permits high gloss diamond machining and polishing of the decorative hub faces.

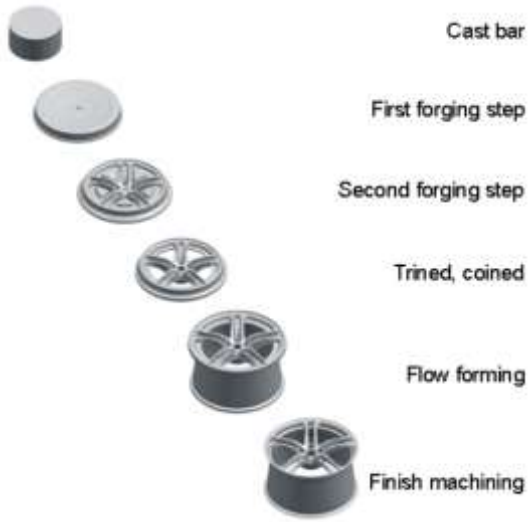

Figure 11: Production steps for light weight forged wheel Source: Otto Fuchs

The wheel is forged as a disk with a centre and a flange of metal around the outside this then split and rolled outward to form the rim halves. It is similar to the flow forming (rim rolling) process used for cast wheels as shown in the Figure 11. The centre is formed by coining and piercing in line with the forging process. The wheel formed in the process is then solution heat treated and aged. Finishing steps are machining, deburing, drilling, diamond turning and finally surface pre-treating and painting. The aluminium billet is prepared and subjected to large forging presses, ranging up to 50,000 tons and extensive heat treatment and curing processes for optimal wheel strength [4].

The traditional wheel forging concept included several forging operations. We use rough machining, splitting, flow turning, heat treatment, final machining and numerous additional finishing

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steps, depending on design requirements. On the other hand, if low weight and low costs are prime targets, then fabrication technologies must dictate the styling limits. A production concept "Light Forged Wheel" was developed (Otto-Fuchs Metallwerke) and these wheels are used by Audi, BMW, DaimlerChrysler, Jaguar and Volkswagen. Several millions of these wheels have been produced since 1995, with the following steps [4]:

- 1-step forging, coining, piercing
- Flow turning (hot spinning)
- Solution heat treatment and ageing
- Machining, drilling and debarring
- Etching and painting.

1.2.3 Types of forging processes

a. One Piece Rim

This is a method of the casting or the forge at the same time by one as for the rim and disc [1].

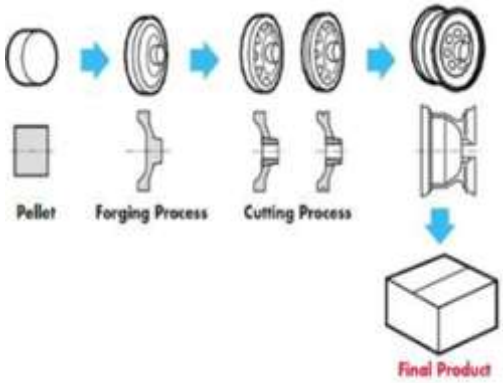

Figure 12: Forging method (one piece rim)

All cast wheels are one piece and they are manufactured quickly.

Figure 13: One piece rim [9]

b. Two Piece Rim

The two piece methods separately manufacture the rim and disc similar to the manufacture of the steel wheel and these components are welded afterwards [1]. The 2-piece sheet metal process begins with cutting a strip of sheet metal to the required length then into a round with the ends butt welded together using a pressure welding machine. After removal of the weld flash, the rims are shaped in a series of rolling operations.

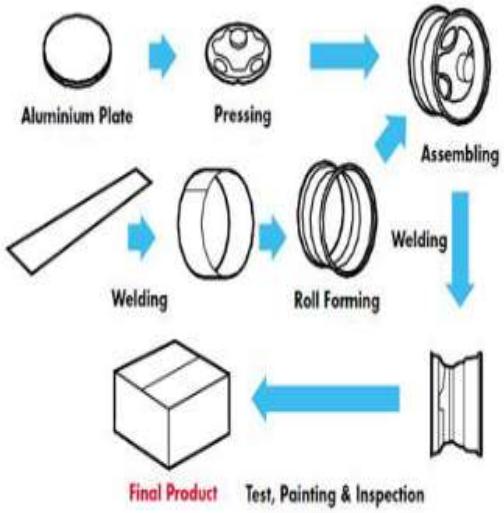

Figure 14: Forging method (two piece rim)

Generally they are made of centerpiece with spokes and the rims. It is more flexible and typically forged. The wheel nave is formed in several steps on a transfer press using a deep drawing process or stamped on a forging machine. Joining the rim to the nave is done by means of a pulsed MIG process. After joining, the wheels are surface treated, i.e. pre-treatment to produce a conversion coating followed by an electro-dip coating.

Figure 15: Two-piece rim and two piece forged wheel with Ti bolts (Source: BBS)

Today, there are different options for two-piece wheels in the market. The two-piece wheel designs are generally cheaper. Some two-piece wheels have

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the centre bolted into a cast or cast and spun rim section. Other manufacturers press cast or forged centers into spun rim sections and weld the unit together.

c. Three Piece Rim

This is a method to manufacture each flange separately and combining later to the disc by welding.

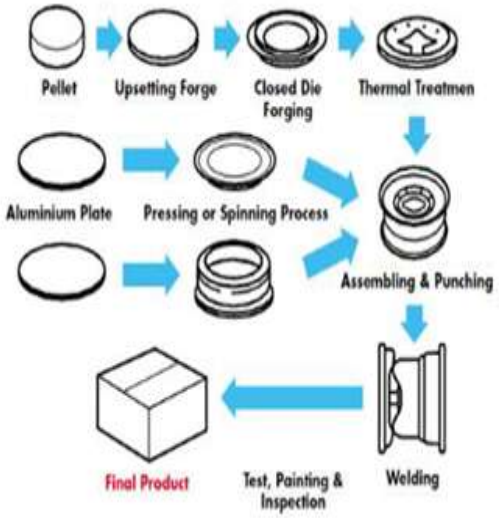


Figure 16: Forging method (three piece rim)

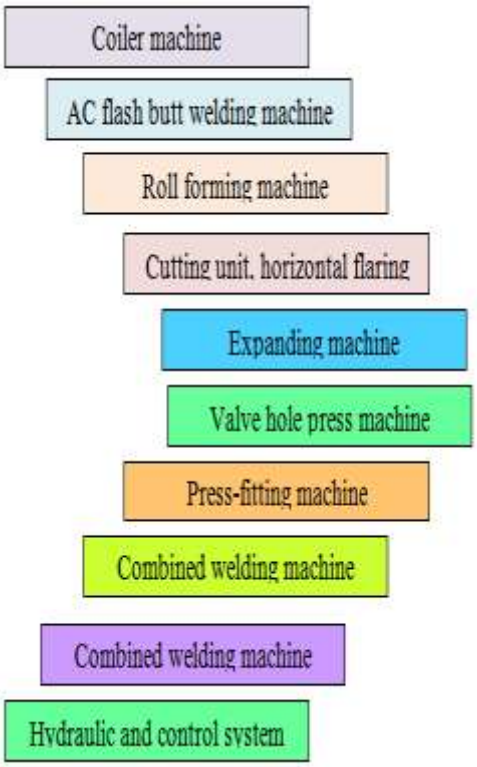
Figure 17: Three piece wheel rim [9]

They could be forged and then bolted to rims with the help of other production methods which made them have lower cost with the required strength and weight. Before forged one-piece wheels were very expensive. The rim sections for three-piece wheels are spun from aluminium disks. The rim sections are bolted to the centre and normally a sealant is applied in the assembly area to seal the wheel [10].

1.3 Factory process requirements

1.3.1 Machinery required

The steel wheel/rim manufacturing line from sheet inputs mainly includes;



The wheel/rim manufacturing process using casting system requires all machineries and equipment's for smelting, casting, machining, cooling, other similar facilities [4, 5].

1.3.2 Heat Treatment Process

After the die casting, hub punching and burr trimming is applied to complete the hot forming operation. The aluminium alloy wheels are conveyed directly into a tunnel type continuous solution furnace where they are heat treated to a uniform temperature. Quenching time varies depending on the thickness and diameter of the wheels [4, 5].

1.3.3 Manpower requirement

Semi-automatic production line, need around 10-12 workers at single machine operation mode where as automatic production line require around 3-5 workers [4, 5].

1.3.4 Design requirements

The aluminium wheels have good characteristic features such as styling flexibility and cosmetic appearance even if after long term use. Reduced weight is another important factor which is related to low rotary moment of inertia and the reduction of the overall vehicle mass also helps reduce fuel consumption. During aluminium wheel design

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phase, the following characteristics must be considered [4];

Table 2 Characteristics of aluminium wheel during design phases

Stiffness	
The structural stiffness is the basic engineering parameter to be examined when designing an aluminium wheel.	The structural stiffness is determined by the final shape of the wheel;
Static performance (Strength)	
In order to avoid any deformation under maximal axial and radial stresses, the yield strength of the material must be considered.	An additional, important factor is the temperature resistance, i.e. the wheel must be able to tolerate.
Fatigue behavior	
The fatigue performance is the most important parameter for wheel dimensioning. Simulation methods also used during design.	Service stresses and multi-axial stresses are considered. The rotary bending and rim rolling tests are used to verify these calculations.
Crash worthiness	
Numerical simulation methods are more used for the design of wheels for crash worthiness.	The impact tests are systematically carried out to check the resistance to accidental collisions.
Thermal aspects	
Whatever type of wheel (cast, forged or mixed wrought-cast) is used, aluminium dissipates heat more quickly than steel.	Low thermal aspect significantly improved braking efficiency and a reduced risk of tire overheating.
Style and weight saving potential	
The reduction of the weight of a vehicle is a key priority in any design consideration.	Styling aspects are generally a decisive factor for choosing an aluminium wheel.
Dimensional tolerances	
To avoid mass unbalance to avoid vibrations of the wheel in both cast and forged aluminium wheels, they will be machined.	Compared to steel wheels, the aluminium sheet wheels also reduce the intensity of vibrations.
Corrosion resistance	
Wheel appearance and durability are acquired by surface treatment.	Galvanic corrosion even at the uncoated iron/aluminium hub interface is not noticed.

1.3.5 Surface treatment

Polished aluminium is one of the most popular choices available but it requires more work. Painted wheels are an easy-care option that is meant to be very durable and live up to whatever your day-to-day drive entails. Powder-coated wheels are easy to care and are extremely durable. They are one of the most environmentally friendly metal finishes available. Anodizing is chemically integrates color into the surface of the wheel metal which allows different range of custom color choices [9]. Cast and forged wheels are often painted or polished and lacquered with a clear coat after a chemical conversion surface treatment. This extreme care is taken in the machining and finishing processes.

1.3.6 Wheel Rim Production Line

The wheel rim production line mainly consists of the basic tasks performed in the production line as shown below which is used for non skid pattern.

Table 3 Tasks in wheel production

Flanging edge	Final expanding	Valve hole punching	Bolting rim
Press disc in to rim	Welding rim and disc	Fattening wheel joint	Flash butt welding
Trimming welding slag	Planishing welding seam	End cutting	Re-rounding
Initial flaring	1st roll forming	2nd roll forming	3rd roll forming
Wheel cooling	4th roll forming	Welding slag	Bolting disc

Other process may include polishing the front side and vent hole drilling, flanging, treading,

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bore machining, rim profiling, inner side rear copy machining, defeating, leak testing, spray painting, baking, finish copy machining and bush inserting. Finally the wheels are then passed down to the automatic inspection line where they are checked for correct dimensions such as rim circumference and thickness, thickness and height of the flange, concentricity and diameter of the bore, location of hub with reference to rim, hub wall thickness, rotundity and plate thickness. The rims of the wheels are ultrasonically inspected to evaluate their internal quality [4, 8]. The production line must be very particular with all the purpose, dimensions and size of the wheel. In this modern era, the existence of robot helps us much in the production of wheel as well as other factory productions.

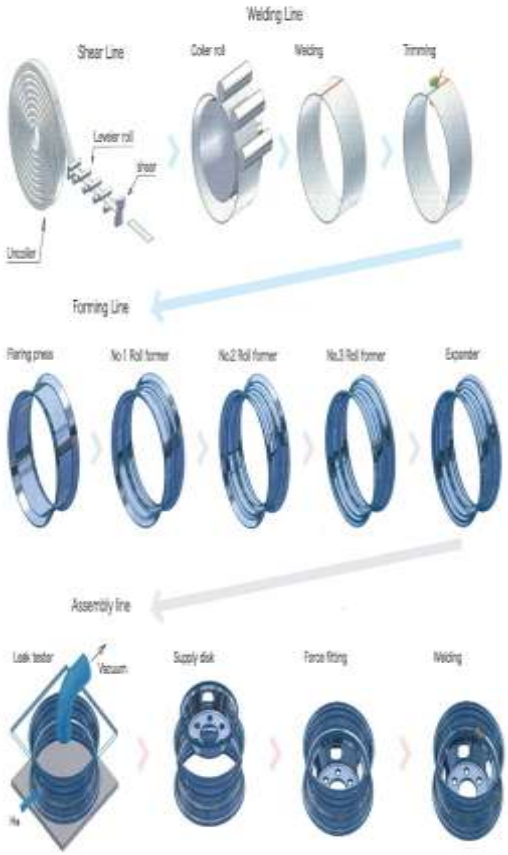

Figure 18: Automotive rim production lines [11]

1.4 Design simulations

Each designs of wheel rim are simulated for different mechanical properties. Modelling and analysis of car wheel rim using ANSYS and CATIA [12]. Results for Aluminium/steel wheel rim stress intensity and dynamic displacement are given below.

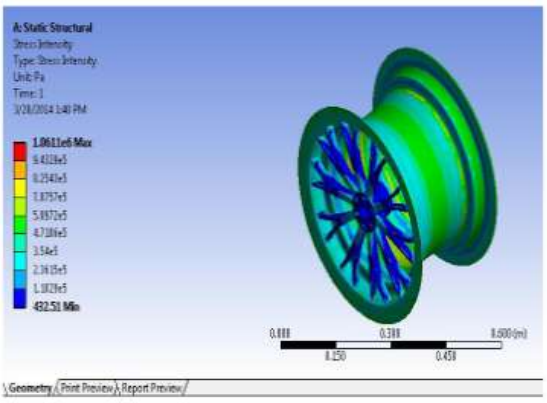

Figure 19: Result for aluminium wheel rim stress intensity [12]

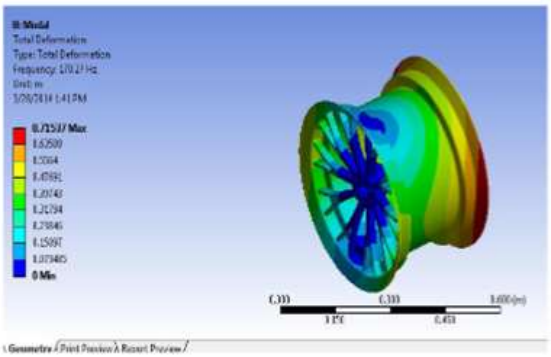

Figure 20: Result for aluminium wheel rim dynamic displacement.[12]

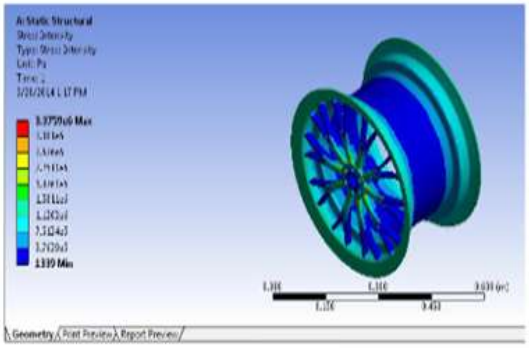

Figure 21: Result for steel wheel rim stress intensity [12]

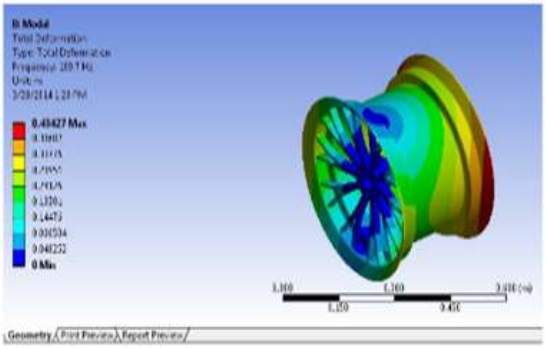

Figure 22: Result for steel wheel rim dynamic displacement [12]

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II. METHODOLOGY

Recently the number of car assembling companies is increasing in Ethiopia. This is a big opportunity for rim/wheel manufacturing companies to enter to the market. Currently rim is being imported free of tax as part of semi knocked down (SKD) vehicle due to the absence of local manufacturing company. The main methodology followed is identifying the current vehicle assembling companies in Ethiopia and their annual production capacity. This includes for light vehicle, bus truck and trailer fabrication and assembling companies is as shown below. The light vehicle assembling companies includes the minibuses. The actual data are collected on 2019 from Metal Industry Development Institute (MIDI), automotive association and from the respective companies.

III. RESULT AND DISCUSSIONS

There are a total of eight light vehicle assembling companies with a total yearly designed capacity 24,144 pieces. Considering two axle and four wheel vehicle the total rim/wheel demand is 96,576 pieces per year.

Table 4 Light vehicle assembling companies

S/N	INDUSTRY DESCRIPTION	PRODUCTION CAPACITY
1	Abay technical and trading sc.	2,400
2	Belayab motors plc	2,500
3	Bishofitu automotive industry	4,944
4	JIN BEI motors plc	500
5	Marathon motors engineering plc	5,150
6	Mesfin industrial engineering plc	2,400
7	Tamrin international trading plc	2,000
8	Yangfan motors plc	4,250
Total		**24,144**
For two axle with four wheels		**96,576 pieces/year**

3.1 Bus assembly

Two operational industries are already performing bus assembling with a yearly designed capacity of 2,275 pieces per year. In case of bus assembly the number of axles may be more than two and the number of wheels may be more than four. But considering the minimum amount the total yearly rim/wheel demand is 9,100 pieces.

Table 5 Bus assembling companies

S/N	INDUSTRY DESCRIPTION	PRODUCTION CAPACITY
1	Ada bus assembling and steel engineering	475
2	Bishofitu automotive industry	1,800
Total		**2,275**
For two axle and four wheels		**9,100 pieces/year**

3.2 Truck assembly

There are five active truck assembling plants with a total yearly capacity of 4,155.Hence considering the minimum amount two axle and four wheel, the yearly demand for wheel/rim is 16,620 pieces.

Table 6 Truck assembling companies

S/N	INDUSTRY DESCRIPTION	PRODUCTION CAPACITY
1	Bishofitu automotive industry	1,248
2	Frankun ET automotive engineering plc	335
3	NA metal industry and engineering	600
4	AMCE(Automotive manufacturing of Ethiopia)	100
5	Mesfin industrial engineering	1,872
Total		**4,155**
For two axle with four wheels		**16,620 pieces/year**

3.3 Trailer fabrication and assembling industries

Though the trailer types may vary from company to company here are twenty six/26/ active trailer body fabrication and assembling companies in Ethiopia with a total yearly capacity of 9,562 pieces. Following the same fashion like the above assumptions two axle and four wheel systems the wheel or rim demand is 38,248 pieces per year.

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Table 7 Trailer fabrication and assembling companies

S/N	INDUSTRY DESCRIPTION	PRODUCTION CAPACITY
1	Abenco general construction industry and trading plc	100
2	Alami industrial engineering	185
3	AMCE (Automotive manufacturing company of Ethiopia sc.)	375
4	Ami metal engineering	100
5	Asnake engineering	200
6	Belaynehe Kindie metal Engineering complex	220
7	Bridge metal & wood shop business plc	100
8	Dagim Kennedy general trading plc	260
9	Fasil Mesfin Derso manufacturing	110
10	Frankun ET automotive engineering plc	300
11	Habtom G/Egziebher Woldehawaryat	350
12	HH engineering plc	760
13	KG Engineering	125
14	Kifle Mekonene importer trade in iron & steel manufacturing	100
15	Maru metals industry plc	700
16	Mesfin industrial engineering plc	2880
17	NA metal industry and engineering	1250
18	Nehemmiah engineering plc	126
19	NKG Engineering	650
20	Ocfa metal manufacturing plc	100
21	Pasqua Giuseppe plc	48
22	Rahel Dagnachew Gelaye	310
23	Techale Haile metal industry plc	N/A
24	Tsegazab Gidey Zemo metal engineering	43
25	Tsehay industries sc.	120
26	Zede engineering plc	50
Total		**9562**
For two axle with four wheels		**38,248 piece/year**

3.4 Market demand forecasting data

Table 8 Year of 2019 demand capacity

TYPE OF COMPANY	2019
Light vehicle assembling	96574
Bus assembling	9100
Truck assembling	16620
Trailer fabrication and assembling companies	38248
TOTAL	**160542**

Table 9 Estimated demand capacity of three years

ORDER	YEAR	CAPACITY
1	Dec-17	85245
2	Feb-18	120134
3	Apr-19	160542

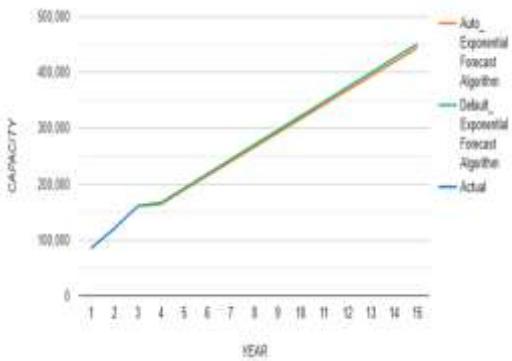

Figure 23: Fifteen years of demand projection (Forecast)

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SUMMARY AND CONCLUSION

Overall demand

Considering all capacities of light vehicle assembly, bus assembly, truck assembly, trailer fabrication & assembly the overall rim/wheel demand whether it may be steel or aluminium alloy type is 160,544 pieces per annum for 4,136 vehicles.

Other opportunities

We can conclude that, the overall demand is best opportunity for manufacturing firms but the market from new vehicle assembly demand such as for vehicle repair activities and automotive owner's needs is higher which is not covered in this study. In addition to this the nearby neighbouring countries will be big markets besides local market.

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