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A Review on Automotive Industries and Foundries in Nigeria

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Abstract. The Federal Government of Nigeria has taken different precautions to support domestic vehicle assembly industries as part of the Nigeria Industrial Revolution Plan (NIRP) to diversify the economy from oil and gas sector to other sectors. The potentials of foundry industries in Africa and most especially in West-Africa Sub-region are under-utilized unlike in the developed countries. Most of the Foundries in Nigeria are operated by Small Scale Industries (SMI) and are not being able to contribute significantly to the automotive industries in the country. This paper is aimed to review several works done by different researchers in the automotive and foundry industries with the view to study the contribution of foundries in the development of automotive industries in Nigeria.

Keywords: Vehicle Assembly, Component Parts, Government, Foundry and Metallurgy

1. Introduction

According to the Global Auto Industry report ^[1], Africa is considered to be the second fastest growing market for vehicle sales on earth. This is as a result of increasing population, which has been forecasted to grow to 1.25 billion by 2025 and to 2.4 billion in 2050 ^[2]. Moreover, over the past decade, six out of the ten fastest growing countries were from Africa with GDP of 4.7% growth in the Sub Sahara region as of 2013 ^[3,4]. In 2014, Africa imported four times more automotive products than it exports, with automotive imports worth \$48 billion and exports worth only \$11 billion ^[5]. The major sources of used vehicles in Africa are the United States (US), Europe and Japan ^[6]. The statistical detail of vehicle in use in Africa is as shown in Figure 1. Despite this enormous potential, Africa has not played a major role in automobile production unlike United State with over 11 million, Japan with over 10 million, Germany and China with almost 6 million each ^[7]. The total automobile production in the year 2004 from Africa was not up to 600 thousand and was from South Africa and Egypt ^[7].

Iron and Aluminium are the most commonly cast metal parts used in the automotive due to low cost, ease of machining, ease of casting into complex shapes and desired physical properties ^[6,3]. Therefore, iron and aluminium foundries are highly incorporated into the supply chain for a wide range of products automotive industries ^[8]. There has been reported demand increase in the world for aluminium castings particularly in automotive applications because of their good recycling characteristics, relative strength, and lightweight. The camshaft, crankshaft, gearbox, engine block, automobile suspension, cylinder head and steering systems are some of the casting products from foundries in used automotive industries.



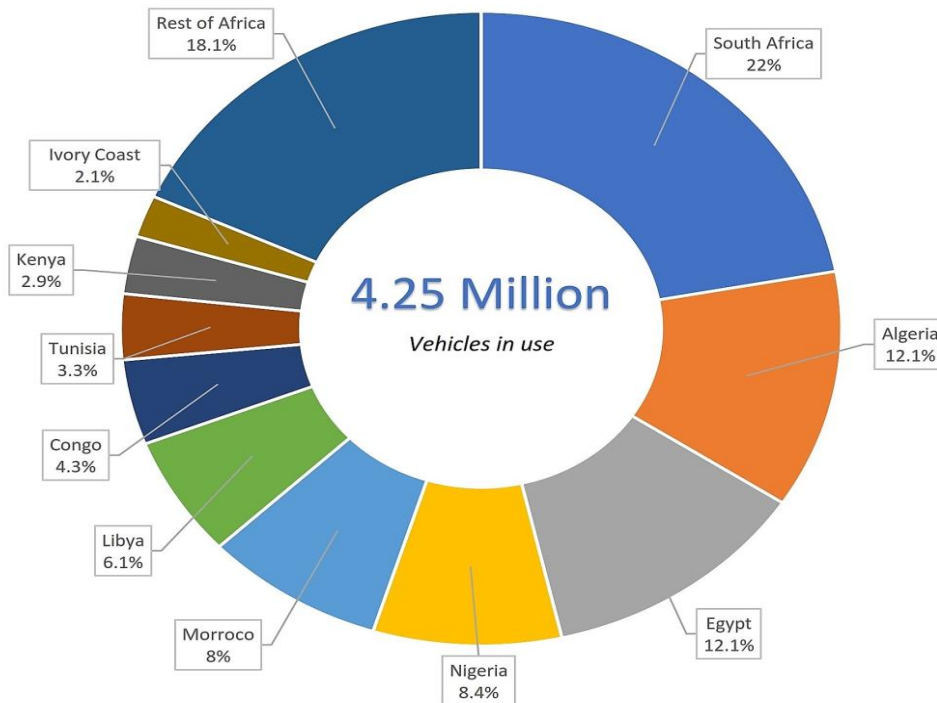


Figure 1: The statistical detail of vehicle in use in Africa [7]

The commonly used foundry automotive components are shown in Table 1.0 [9, 10]. Although the foundry industries in other continents are well developed and has contributed enormously to the development of automotive industries in such countries as the United States, China, India, Mexico, Japan, Germany [11- 14] however, foundries in African countries particularly Nigeria are underdeveloped and do not have enough capacity to contribute significantly to automotive industries in the continent. The purpose of this work is to review the role of foundries in the development of automotive industries in Africa especially in Nigeria.

Table 1: Commonly used Foundry Automotive Components [9, 15, 16, 17]

S/N	Components	Area of Utilization	Material
1	Brake Disc	Front axle	Gray cast Iron
2	Brake drums	Rear axle	Steel Casting
3	Flywheel	Engine	Steel or Gray cast Iron
4	Crankshaft pulley	Engine	Steel or Gray cast Iron
5	Water pump pulley	Engine	Steel or Gray cast Iron
6	Rocker arm bracket	Engine	Ductile cast Iron
7	Admission Valve Seats	Engine	Ductile cast Iron
8	Exhaust valve Seats	Engine	Ductile cast Iron
9	Push rod	Engine	Ductile cast Iron
10	Valve guide	Engine	Ductile cast Iron
11	U-bolt spacer	Engine	Ductile cast Iron
12	Bus Landrail Support	Body	Aluminium alloy
13	Bus door hand parts	Body	Aluminium alloy

14	Passenger door nail bracket	Body	Aluminium alloy
15	Door Hinges	Body	Malleable iron or steel
16	Cylinder sleeves	Engine	Cast Iron
17	Crankshaft timing sprockets	Engine	Cast Steel
18	Camshaft	Engine	Cast Steel
19	Engine Support	Engine	Aluminium Alloy
20	Rear Axle Support	Front axle	Aluminium Alloy
21	Seat slide (Adjuster)	Seat	Aluminium Alloy

2. Foundry and Economy Development

Foundry is one of the main industries prompting the development of world economy. The foundry industry is a main feeder to major manufacturing sectors that drive technological growth and most world economies usually depend on the stability of foundry and steel industries ^[18, 19]. Foundry is made up of 16-21 process steps depending on the category of castings produced from casting design to pattern making to materials/alloy selection to sand preparation to moulding to melting to casting to fettling and to heat treatment and quality control processes that includes all the production line in Foundry operations ^[20-22]. The importance of the foundry technology in technological development cannot be underscored and the impact on the economic development of any nation with its high value adding possibilities. Therefore, in the quest for technological development of a country, the foundry industry should be considered a high-value adding possibility ^[19]. It is described as “the Mother of all Industries” ^[23-24]. It produces major components for agricultural machines, machine tools, automobile, textile industries, power plants, industrial machinery, oil and gas equipment, cement manufacturing equipment, mining and quarry industry, railway equipment, construction industry and defense equipment ^[23, 25]. During the Bronze Age, Egypt was believed to have ruled the Western civilized world (nearly 2000 years) due largely to its casting skills that promoted its wealth creation capacity ^[26]. In the middle age foundry products consisted of baptismal fonts, bells, grave plates, temple portals and war equipment like cannons. The invention of low-melting non-ferrous metal casting technology also led to major breakthrough in the industry.

There have been significant changes in the world map of the greatest casting producers in the last decade. Variations of foundry production in different countries have caused transformation of economic systems in their countries ^[27]. Automotive industry has been reported as the driving force of the foundry engineering in the world ^[28]. The automotive industry is the major consumer of the foundry products, which requires quality castings produced by means of practically all available technologies and casting materials. Other industries include; Railways, Power Sector, Tractor Industries, Earth Moving Machineries, Pumps, Compressors, Pipes, Valves, Pipe Fittings, Electrical, Textile, Cement, Agro Machinery, Machine Tools, Engineering Industries, Sanitary Castings and Engineering Exports ^[19, 26]. According to the census of world casting production, the current estimation of the world’s casting production was carried out globally by considering factor encompassing countries of the given continent as shown in Table 2 ^[27-31].

Table 2: World's Annual Casting production (Total)- in Kiloton's and Indexes illustrating Changes in Production Volume ^[27- 31].

Annual Casting Production Volume (total)- in Kilotonnes								
Country	Group	1991	2001	2002	2003	2004	2001:1991	1991:2001
							quotient	% change
USA	I	8839.3	11871.0	11811.7	12069.6	12314.1	1.343	+34.3
Russia		18000.0	6200.0	6200.0	6200.0	6300.0	0.344	-65.6
China		10750.0	14889.0	16261.6	18145.9	22420.4	1.385	+38.5
Japan		7958.7	5841.2	5751.8	6111.4	6386.5	0.735	-26.5
Total (group I)		45548.0 (70.2%)	38801.2 (61.6%)	40025.1 (60.3%)	42526.9 (61.9%)	47421.0 (62.8%)	0.851	-15.0
Germany	II	4336.7	4643.4	4595.4	4722.6	4984.5	1.071	+7.1
France		2351.3	2527.1	3918.2	2484.5	2465.6	1.075	+7.5
Great Britain		1307.7	968.2	886.3	1221.5	1273.0	0.740	-26.0
Italy		1881.5	2393.3	2440.6	2441.0	2442.3	1.224	+22.4
Spain		832.7	1572.3	1628.6	1149.7	1309.2	1.895	+89.5
Total (group II)		10709.9 (16.5%)	12104.3 (19.2%)	13469.1 (20.3%)	12019.3 (17.5)	12473.6 (16.5%)	1.130	13.0
India	III	-	3155.0	3267.0	4038.0	4623.0	-	-
Brazil		1228.9	1760.0	1970.6	2249.4	2829.9	1.432	+43.2
South Korea		1452.5	1683.2	1713.5	1783.8	1857.3	1.159	+15.9
Taiwan		1454.6	1209.6	1441.4	1468.1	1451.8	0.832	-16.8
Mexico		847.0	1680.0	2030.0	1822.9	2185.2	1.983	+98.3
Turkey		553.8	905.8	921.6	955.0	982.0	1.197	+19.7
Total (group III)		5536.8 (8.53%)	10393.6 (16.5%)	11344.1 (17.0%)	12317.2 (17.9%)	13929.2 (18.4%)	-	-
Czech Rep.	IV	1327.0	471.9	441.15	477.1	522.4	0.356	-64.4
Poland		815.8	745.2	660.1	729.4	804.5	0.913	-8.7
Romania		850.5	36.5	36.5	36.5	207.0	0.390	-61.0
Hungary		93.6	121.6	136.8	253.0	164.9	1.299	+29.9
Total (group IV)		3086.9 (4.76%)	1703.7 (2.70%)	1603.65 (2.40%)	1822.0 (2.70%)	1698.8 (2,30%)	0.552	-44.8

Recently, the largest producer of different types of castings of any country in the world is China, with excess of 44.5 million metric tons 2013, which is almost five times the U.S. production and about 40% of the world production. Since 2001, there has been a consistent increase in Annual Output of Chinese Foundry Products as seen in Figure 2 ^[13, 32]. China has more than 30,000 foundries as of 2008 with average production per foundry of 883 tons per year compared to 5,943 tons per foundry of the 2,017 foundries in the U.S. Foundries in China are now producing iron castings of 145 mt and steel castings of 520 mt, more than any U.S. foundry taking care of the automotive industries and domestic requirements. Only 4% of total casting productions are for exports, leaving 96% for domestic consumption. China imports about 1% of its castings, mostly of very complex alloys ^[13, 32, 33]. As of 2011, Foundry capital investment in China were 62 flask type molding machines, 201 flaskless molding machines, 307 no-bake mixers and over 500 electric melt furnaces. These state-of-the-art foundries provided consistent, high quality castings ^[13]. It has been projected that China would have the largest economy in the world by the year 2030 as a result of the foundry capacities ^[34].

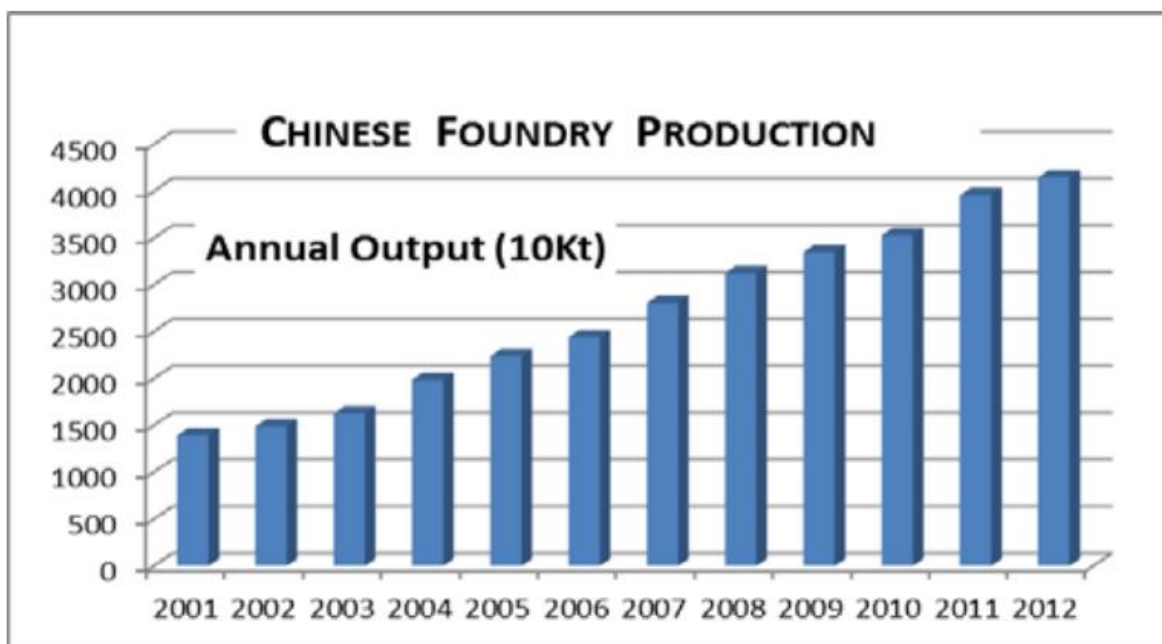


Figure 2: Annual Output of Chinese Foundry Products ^[13]

However, Indian foundry has been reported in recent research as the second largest in the world ^[13]. Out of more than 6,000 foundries in India, almost 90% fall under the small and medium scale category and are located in clusters in 19 areas ^[13, 35, 36]. India tied with the United States as the second largest producer of castings in total weight. Approximately 32% output of Foundry Industry in India drives automotive sector and the rest to downstream Engineering Sector ^[37]. The consumption of casting in India as % of total production is as shown in Figure 3

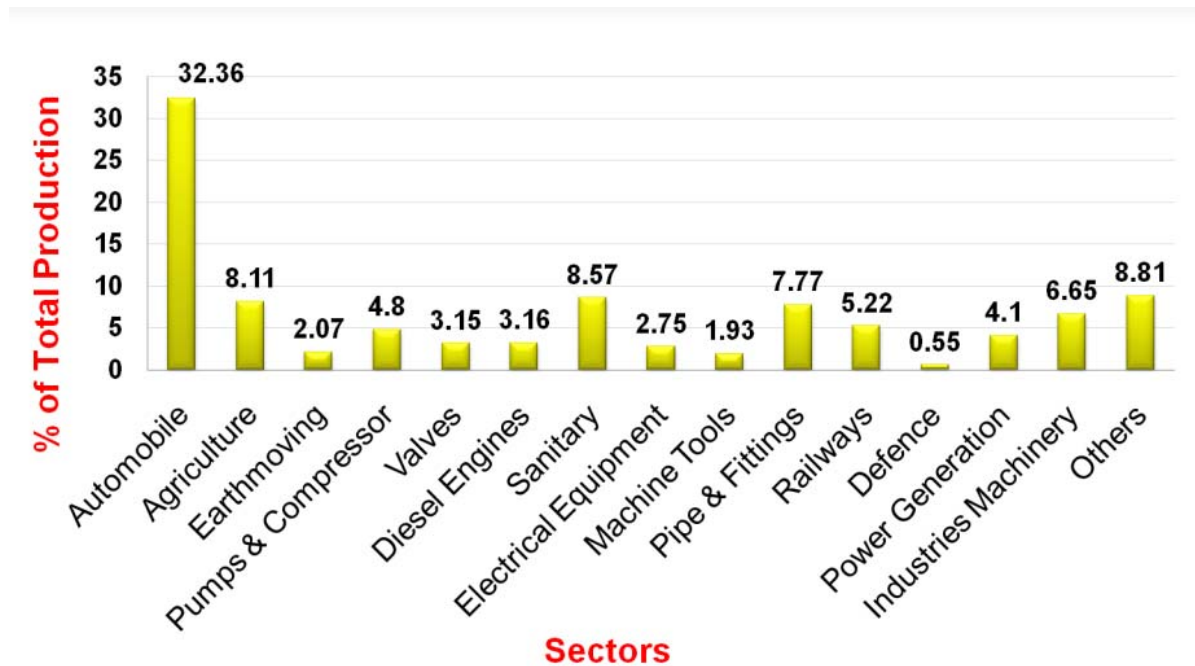


Figure 3: The consumption of casting in India as % of total production ^[37]

3. Automotive Industry in the World

Auto industry is stated to be synonymous to industrial development in many aspects ^[38]. This is because of the important role it plays in enhancing research and development, on various technologies associated with the manufacture of automobiles, thereby stimulating technological advancement ^[38].

Automobile industry in India was rated the seventh largest in the world with an annual production of over 2.6 million units in 2009 and also emerged as Asia's fourth largest exporter of automobiles ^[37]. According to Global Automotive Executive Survey 2017 by KPMG, India may reach around 33 million orders of sales that are predicted for China in 2030 ^[39]. The country is expected to lead the world in car volumes with approximately 611 million vehicles on the nation's roads by 2030 ^[39]. In order to benefit from these predictions, the Foundries in India must increase their % total volume production casting for Automobile industry ^[37]. According to the Folk group ^[13], 2014, India has an automobile building mandate to produce vehicles not only for domestic use but also for export. The India Foundrymen Association estimated that in order to meet this projected mandate the country must increase its casting capacity in the next five years ^[13].

After China and Canada, Mexico is the third largest supplier of castings to the U.S. Engine blocks and automotive castings are the biggest portions of castings from Mexico's foundries ^[13]. With its foundry capacities, Mexico has been ranked as the principal export market for U.S. auto parts overall and ranked the seventh major vehicle manufacturer in the world in 2015. According to 2016 Top Markets Report Automotive Parts, 2016 ^[40], Mexico was rated the sixth largest auto part manufacturer in the world with 2,559 auto parts companies with this casting volumes from Mexico continue to increase ^[13, 40]. Foundries in Canada export about 9.8% of their castings to U.S. Europe has more efficient foundries with very high quality castings and about 350,000 tons of cast products from Europe are exported per year ^[13]. The automotive and automotive parts producing countries such as United State, Europe, Japan and Korea for consumers around the world are known for the well-equipped and standard foundries ^[40]. However, as

important as the foundry industry appeared in developed countries, the industry's potential is being under-utilised in Africa especially in Nigeria ^[41].

There is enormous potential for the consumption of steel, aluminium, chrome and PGM in metal castings from foundries in the automotive industry. Aluminium is used to make cast and forged products, such as rims, while stainless steel (that includes chrome) and PGM are used extensively in various components of the exhaust system, particularly in catalytic converters ^[42, 43, 44].

Algeria, Egypt, Morocco and South Africa with recognized and rapidly emerging automotive industries responsible for close to 80% of overall new vehicle sales in 2015 ^[5]. These countries have sizeable automotive assembly and manufacturing sectors. However, fewer than 900 000 vehicles were produced on the continent, which accounted for just over 0.9% of global production in 2015 ^[5, 45]. This may be as result of limited numbers of local foundries in Africa that are capable of supplying such automotive industries with cast products leading to over dependence of such industries on imported castings ^[64]. Even though domestic vehicle production and assembly may have helped African economies, and could serve as a catalyst for industrialization and economic diversification ^[5]; the lack of adequate foundry industries in the continent has jeopardized such development.

It has been reported that the number of foundries in South Africa has reduced drastically from 450 in the 1980s to just over 200 in 2003 and 170 in 2015 ^[43- 47]. The industry is very small compared to its global competitors such as China and India with 30,000 and over 6,000 foundries respectively. The estimated annual production of castings dropped from 506,000 metric tons in 2003 to 375,240 metric tons in 2013 ^[46, 48] unlike China with an excess of 44.5 million metric tons per year. Approximately 40% to 50% of these casting were used as automotive components, while about 85% of all aluminium castings were for use in the automotive industry ^[43, 48] Although according to Centre for International Development, 2016 South Africa accounted for three-quarters of Africa's automotive exports with 15% of imports in 2014 ^[5, 12]; it could be deduced that automotive industries in South Africa depend largely on the imported castings to survive. In Egypt the improvement of the aluminium casting quality has increased the competency of the industrial society in the country ^[49]. The foundries in Egypt have the potential to produced aluminium automotive cast parts for automotive industry worldwide yet need to improve on quality ^[50- 53]. The targeted industries in the country for castings produced in the Foundries are automotive industry and spare part industry. The iron foundries in Egypt though present a significant asset to the country's economy; the cast parts are being used in water and drainage, construction, marine application with little or no use in automobile applications ^[27]. It has been reported that there is a significant prospect for developing casting industries in Egypt but there are a lot of technical challenges such as lack of modern technologies in small Egyptian foundries limiting this development ^[49].

4. Automobile and Foundry Industries in Nigeria

The automobile is deriving about 75 % of its weight from various metals and alloys. In the Iron, Steel and Aluminium industries, Foundries played a significant part in the success of the automotive industry, in the world. One of the main causes for the slow pace of development of automotive industry in Africa, especially in Nigeria in comparison to the developed countries and countries like Korea, India and Brazil, is that the Foundries in Africa are yet to contribute significantly to the growth of the industry. Research showed that only a few local foundries in Nigeria meet up the International standards of producing auto components castings and forge fittings ^[54]. Ajaokuta and Delta Steel companies were unable to supply requirement of over 1000 tons of castings and forges required by Peugeot Automobile Nigeria (PAN) as of 1992 ^[54]. The research survey commissioned by the National Agency for Science and Engineering Infrastructure (NASeni), in 1995, showed that Nigeria has about 160 foundries, out of these 60 are registered commercial and they produce at an average capacity of 55%, accounting for less than 30% of the nation's required castings ^[23].

According to Okundaye, 1995^[55], the National Demand for cast metal products in Nigeria increased steadily from 72, 000 tonnes to 292, 000 tonnes (1985) to 425,000 in (1990s) and 794, 000 tonnes by the turn of the century, for which the National Committee on Foundry Development estimated 40% of these requirements as automotive components^[25, 55]. In Nigeria, 120,000 tons of foundry products is required to meet industrial demand and at present only four foundries have managed to survive out of the sixty registered active ones as of 1995 to cater for this huge demand^[19, 56]. This gap (over 70%) in casting products supply has only been met through importation over the years^[23, 57]. Oyinlola, 1991, predicted that the actual net demand of castings by the end of the century would be 794, 600 tonnes in Nigeria which is even far less than what China is producing^[13, 25, 36, 59]. This may not be possible due few Foundries present in the country. Ekundayo 2015 stated that there will be a strong demand for all major foundry products by the year 2020 due to Government determination to boost farming increasing the demand by the manufacturing and agricultural sectors^[25].

Currently installed vehicle assembly capacities in Nigeria stands at more than 70,000 vehicles per year, in total 7 companies have started to assemble vehicles. According to Global Auto Industry Market Report 2015, automotive industries where Vehicles are assembled such as Stallion Motors assemble vehicles for Hyundai, Nissan, Tata and Ashok Leyland at the former Volkswagen of Nigeria (VON) plant in Lagos, which the company took over in 2012 and Nissan have increased their sales from around 1,000 new vehicles in 2012 to around 6,000 in 2014 assembled in the country^[1]. Innoson Vehicle Manufacturing (IVM) has an installed capacity of 10,000 vehicles. Peugeot Automobile Nigeria (PAN), currently targeting to assemble around 3,000 vehicles, but having much space for growth at its plant in Kaduna which was originally built in the 1980s. Also assembling passenger cars, Dana Motors, which is part of Nigerian Dana Group revealed current capacities plans to assemble the whole Kia range of passenger cars in 2015. The company assembles Kia Rio, Cerato and Optima at its plant in Lagos. Also, Anammco, Leventis and Sinotrucks Nigeria are assembling trucks in the country^[1]. The total vehicles capacity in Nigeria as of 2014 was 78,000 with Truck assembly capacity of 3,000 and car and bus assembly capacity of 75,000^[1]. This just accounted for 8.7% of the vehicles produced on the continent and 0.078 % of global production in 2015^[6, 39, 59]. This production is negligible for a country of 170,000,000 people with the largest economy in Africa; the country GDP of \$520bn in 2013 as compared to \$350bn of South Africa as the continent's number two^[60].

Today almost every fifth African is a Nigerian; by 2050 Nigeria is projected to have 440 million inhabitants, overtaking the US with an estimated population of 400 million^[61] making the country a potential for the automotive industry. Without the proper development of foundries, there would be no engineering subsystem and consequently no realistic automotive industrial base; therefore there would be no end to excessive importation dependence to make such an industry economic self-reliance^[23, 62]. It was recorded that only a few foundries could supply components to Automotive Plants Nigeria^[54] because casting products are not of quality and did not meet up with International Standards of producing auto components. It was also reported that there are no advanced technologies to improve the quality of the casting products produced in the Nigeria Foundries^[65]. Only sand system out of other processes in casting has been mechanized to a great extent in few foundries in Nigeria, making the Foundries in the country not geared towards mass production^[9]. These may explain the reasons for the choking of the automotive industry in Nigeria and Africa at large.

5. Conclusion

The Nigerian government initiative is aimed at diversification of Nigerian economy from oil industry by developing other sectors including the automotive industry. The Government has taken different precautions such as increasing the import duties on imported vehicles, confiscating the imported used cars to support domestic vehicle assembly industries as part of the Nigeria Industrial Revolution Plan. This may not lead to remarkable breakthroughs in the vehicle assembly industries, if the government did not develop foundry industry and other auxiliary industries which are the sister or complementary industries

to the automotive industry in Nigeria. The foundries have not been contributing significantly to the development of automotive industries in Nigeria due to lack of adequate attention to the development of the industry by the government.

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