



## **DEVELOPMENT OF INDIGENOUS AUTOMOBILE DESIGN AND MANUFACTURING IN GHANA**

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### **Abstract**

The purpose of this paper is to assess the state level of development of automobile design and manufacturing in Ghana. Vibrant automobile design and manufacturing industries have played significant roles in the industrial growth of many countries. Ghana, however, has yet to develop its own automobile manufacturing industry comparable to that of the industrialised countries. There is thus a need to take a close look at developments in the sector to assess progress. A combination of research methods comprising questionnaire, interviews, and personal observations are employed to collect data on both formal and informal manufacturing firms involved in automobile design and manufacturing. The sample size for the survey in terms of individuals, not firms, was one hundred and forty seven. However, in total, one hundred and thirty four questionnaires were returned by respondents and this formed the basis of the analysis. Firms were selected in a simple-random fashion. Data gathered were analysed using descriptive statistics involving frequency counts and means via MS Excel and Stata10. In addition graphs were plotted for visual effect. Key findings of the study are that, most firms do not manufacture to any standards, and perhaps with the exception of two low-volume coach or truck assembly plants, the industry as a whole suffers from a lack of qualified automobile design and manufacturing engineers. In addition it is characterised by undeveloped infrastructure, contributing to its low level of development in terms of low quality and low production quantities of improperly designed parts, components, and structures that cannot compete with high quality, impeccable imported products due to the lack of a standards regime and aesthetic finesse.

**Keywords:** Automobile, design, development, manufacturing, domestic industry

### **1.0 INTRODUCTION**

#### **1.1 Research Purpose and Importance of Automobile Design and Manufacturing**

The purpose of this study is to assess the level and state of development of automobile design and manufacturing in Ghana. The automobile manufacturing industry plays a major role in the socio-economic development of many countries. Ghana has yet to develop its own automobile manufacturing industry comparable to even that of the newly industrialising countries. There is thus a need to take a close look at developments in the sector to assess progress.

In the more advanced countries, the industry is a core part of the overall economy. For example, as Canis (2011) observes, the motor vehicle industry is a major part of the U.S. economy, accounting in 2010 for over 674,000 jobs, or 5.8% of all U.S.



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manufacturing employment. It is estimated that as of 2002, there were 590 million passenger cars worldwide (approximately one car per eleven people).

Wad (2010) describes a standard automobile as a wheeled vehicle for land-transport of people and goods driven by a fossil fuel-based internal combustion engine. An automobile comprises several major systems, each of which contains many subsystems, components, and interfacing parts. For example, parts such as bearings, crankshafts, filters, gears, pistons, pumps, and valve trains make up the engine and their design must be attuned. He is of the opinion that designers must bring together these systems to enable the successful final assembly of the vehicle. Brunnermeier and Martin (1999), on their part, have observed that in well-developed systems the design and manufacturing of an automobile involves various divisions within an original equipment manufacturer (OEM), scores of first-tier suppliers, a number of second-tier and sub-tier suppliers, and tooling suppliers. They note that the number of people, organizations, and functions involved in producing an automobile increases the complexity of the data exchange process and that digital methods of representation of products and parts have replaced physical drawings as a convenient form in which product data are stored, analyzed, and communicated among the people contributing to the design of an automobile. Chun-chih *et al.* (2008) have made similar observations in noting that computer-aid product development has become one of the most important techniques in the industry, and use of concurrent engineering systems, employing integrated CAD/CAE/CAM techniques are now widespread in the industry. These systems greatly reduce product development time and cost, while improving product quality at the same time.

A typical automobile comprises thousands of parts, indicating a huge design and manufacturing potential. In fact, Lee (2011) estimates that one vehicle typically consists of over 20,000 parts, each one of which plays a vital role in developing an economy and creating jobs in a country. Thus a well-developed domestic automobile industry can play a major role in the industrial growth of a country. Countries that have reaped this benefit include South Korea and Malaysia, noting, for instance, that the South Korean domestic automobile manufacturing industry is now one of the largest and fastest growing in the world. Its development started in the 1960s progressing through four main stages; initial accumulation of knowledge about making automobiles, assembling, and then manufacturing using self-developed technology (Lee, 2011).

The first and second stages involved the assembling of automobile systems and vehicles by domestic automobile companies in collaboration with foreign automobile companies (Yang *et al.*, 2006). The third stage involved the domestic manufacturing of parts for vehicles. Vehicles were eventually assembled from these parts. The first three stages were characterised by massive transfer, absorption and diffusion of technology, which benefitted the domestic automobile industry immensely. The last stage of development involved the development of automobiles gained from know-how and research output accumulated over many years within the country. As a consequence of this, there was



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high employment generation for researchers in the domestic industry (Kim *et al.*, 1999). The South Korean Government played a significant role in the development process; the importation of complete cars were prohibited for a period of time and import tariffs on automobile parts and components were removed (Lee, 2011).

The Malaysian automobile industry, like South Korea's, also started in the 1960s with the Government of Malaysia approving six automobile assembly plants for operation within the country. These assembly plants were all joint venture projects between Malaysian companies and European vehicle manufacturers (Bin-Yahaya, 2010). A National Car Project known as the "Proton" was then inaugurated in 1983. Initially, the components of the car were entirely manufactured by the Mitsubishi Motor Corporation (MMC) and Mitsubishi Corporation (MC) of Japan (Abdulsomad, 1999). However, gradually as technologies were transferred and skills were gained, parts produced locally began to be used in the vehicles (Abdul-Hamid *et al.*, 2008).

Worldwide in 2007, 806 million cars and light trucks were on the road; and the numbers are still increasing rapidly, especially in China and India. These developments in the global automobile industry have the effect of increasing competition and on the time it takes to reach the market. In this regard, Chun-chih *et al.* (2008) have noted the positive effects that stiff competition in the automobile industry is having on product development time and other performance measures.

## **1.2 The African Context**

In Africa, two countries that have made strides in their domestic automobile industries are South Africa and Egypt. The industry in South Africa started as an import and assembly activity but has now grown into an import-substitution industry (Ishaq, 2009). As at 1999, there were eight producers of light vehicles in South Africa, assembling about 31,700 vehicles, of which over 80% was for the domestic market (Black, 2001).

The Egyptian automobile industry started in the 1960's with the establishment of assembly plants for the production of passenger cars, trucks and buses under license agreements between Fiat and Magirus Deutz (Askar *et al.*, 2005) and the Egyptian Government. With time, private companies also started assembling vehicles in Egypt. These include General Motors and Al-Nasr Automotive.

## **1.3 The Automobile Industry in Ghana**

In Ghana, several vehicle assembly plants that were established after independence, folded up or were privatized due to poor management and dependence on state funds for survival. These included Gharmot, National Investment Corporation (NIC) vehicle assembly plant and workshop, Fafia Auto Parts, and Neoplan Assembly Plant (Kwakye, 2011). Currently, there are a couple of firms engaged in the activity. They include the Jospong Group of Companies (JGC), which assembles a range of vehicles and trucks from complete knock down (CKD) kits brought in from outside sources, and Neoplan Ghana Limited, which assembles a number of bus models including the Tata Marcopolo



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and the DVL Neoplan for the domestic and West African markets. The Jospong Group of Company (JGC) builds other parts locally to assemble the DONGFENG brand of vehicles and trucks.

As of 2014, nearly all the vehicles used in Ghana are imported, with vehicles that are 5-10 years old constituting about 70 percent of the imports (U.S. Department of State, 2000). In the informal sector, artisans with low levels of technological skills but high ingenuity are able to carry out automotive industry activities such as fabrication of heavy duty truck buckets, articulated truck trailers, production of forged spare parts as well as limited assembly of some vehicles. Most of these artisans work in privately owned shops concentrated in such areas as the Suame Magazine in Kumasi, Kokompe in Accra, and other similar centres in the country. Even though these practitioners demonstrate a level of technological ingenuity in the maintenance and repair of various types of vehicles throughout the country, the engineering methods and procedures they use in carrying out these activities need to be assessed to ascertain their soundness and conformance to international standards.

#### **1.4 Aim**

The aim of the study is to assess the state of development of automobile design and manufacturing in Ghana.

The specific objectives are to:

- i. find out the range of automotive components and parts produced in the sector, and the application of standards to the generation of those inputs
- ii. investigate the soundness of various methods and processes used including the types of machine tools employed in the manufacturing of automotive parts and components in Ghana,
- iii. assess the calibre of technical personnel engaged in the industry.
- iv. determine the factors militating against automobile design and manufacturing in Ghana.

## **2.0 RESEARCH DESIGN AND PROCEDURE**

### **2.1 Questionnaire design**

The approach adopted in the research is the descriptive survey design, directed towards determining the nature of the automobile industry in Ghana as it exists at the time of study. It sought to identify present conditions in the sector and to point to current needs. The goal is to be able to interpret, synthesise, and integrate data to help examine their implications and interrelationships. A mixture of data collection tools was employed to collect both qualitative and quantitative data from respondents in the automobile industry, with the quantitative method predominating. These included structured and semi-structured questionnaires for collecting primary data, which include direct observation, informal discussions, as well as inputs from engineers, technicians, and



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artisans in both the formal and informal sectors. The questionnaire featured a mixture of questions that are common in terms of issues relating to automobile design and manufacturing in Ghana. It had three parts: personnel data of a respondent firm, soundness of various methods employed in the manufacturing of automobiles in Ghana, and factors militating against automobile design and manufacturing in Ghana.

The questionnaire was pre-tested by administering it on twenty-five automotive industry workers at the Suame Magazine, followed by modifications, additions, and removal of errors and ambiguities.

## 2.2 Population, Sampling Procedures and Sample Size

Population is considered at two levels in this section. First the population of firms taking part in the study; and second the population of individuals within the participating firms who were to responded to the questionnaire.

Table 1 shows a breakdown of the number (53) and categories of firms (plants/workshops) visited during the survey.

*Table 1: Breakdown of the Number of Plants/Workshops Visited*

No.	Workshop/Plant Category	Number of shops visited
1	Suame Magazine-Kumasi	50
2	JGC Vehicle Assembly Plant- Accra	1
3	Neoplan Ghana. Ltd-Kumasi	1
4	Apostle Safo Kantanka Auto workshop, Winneba	1

Simple random sampling techniques were used in selecting the sample of 50 firms at the Suame Magazine, where the total population is of an order of magnitude running in the thousands. The three larger firms were added by hand-picking because of their high visibility and/or formal nature.

Table 2 displays the population of individuals within the above firms who responded to questions. Though simple random, purposive sampling techniques were employed in selecting the sample for the study from this population, it was found useful and intuitive to organize the collected data in some kind of stratified fashion as shown in Table 2. This was in done in two ways: one on the basis of engineers, technicians and mechanics/artisans; and the other on the basis of the groupings in Table 2, which shows the adopted sample frame and sample size used for the study. These three main categories of respondents, (Table 2), constituted the target population and basis for the study. They are the Neoplan Automobile Assembly Plant, Kumasi, Jospong Group of Companies (JGC) Vehicle Assembly Plant Accra, and a third set comprising hydraulic mechanics, automotive body builders, automotive chassis builders, and automobile-related machine tool workshops at the Suame Magazine, Kumasi.



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Table 2: Sample Frame and Sample Size.

No	Selected Areas	Population	Sample
1	Neoplan Automobile Assembly Plant, Kumasi	55	48
2	JGC Vehicle Assembly Plant, Accra	13	10
3	Body builders, Hydraulic mechanics, Chassis builders and machine tool shops at Suame magazine, Kumasi	110	86
<b>Total</b>		178	147

Thus, the sample size for the survey in terms of individuals, not firms, was one hundred and forty seven (147). However, in total, one hundred and thirty four (134) questionnaires were returned by respondents and this formed the basis of the analysis.

### 2.3 Questionnaire Administration, Field Observations and Interviews

Quantitative information was gathered using the questionnaire and interviews administered at selected firms. During each visit a check list, made up various automotive components, categorized into engine parts, transmission systems, steering and suspension systems, vehicle body and chassis systems and electrical systems, was used to record observations by ticking in order to establish the characteristics of each items. A similar process was followed in regard to machine tools used for producing automotive items in the workshops and others production centres. Further, observation of the methods used for fabricating tipper truck buckets, articulator trailer buckets, fuel tankers, cargo truck buckets and buses was made to compliment information obtained directly from the respondents. Through this observation process, additional and vital information such as the condition of machine tools and production methods employed, not covered in the questionnaire and interview, was obtained.

The automobile design and manufacturing sector of Ghanaian industry was the subject of study and as such automobile sales and service operators were excluded from scope of the research.

### 2.4 Method of Data Analysis

Descriptive statistics involving frequency counts and means were employed in data analysis.

## 3.0 RESULTS AND DISCUSSION

### 3.1 Number of Automobile/Mechanical Engineers Engaged

Results from the survey indicate that, of the 134 technical people interviewed, only 2% are qualified automotive/mechanical engineers whilst about 41% of them are technicians, and 56% artisans (Figure 1). This finding relates to objective (iii), and to some extent objective (iv) of the study. This lack of appropriately trained and educated professionals hampers development of the sector, and is further confirmed by the more than 94% of the 53 firms visited that say they do not engage the services of qualified engineers and technicians. Figure 2 illustrates this picture from another angle, while tables 3 and 4 present more detailed information. It further comes out that no firm



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engages automobile designers. This may not seem surprising, yet it remains a major deficiency affecting the development of automobile design and manufacturing in the country. The regression models in Figures 3 and 4 make the picture clearer still.

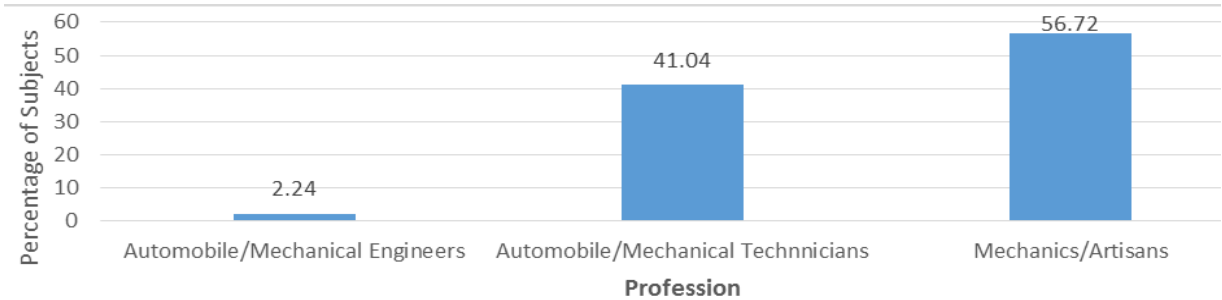


Figure 1: Technical manpower patterns in the automobile industry

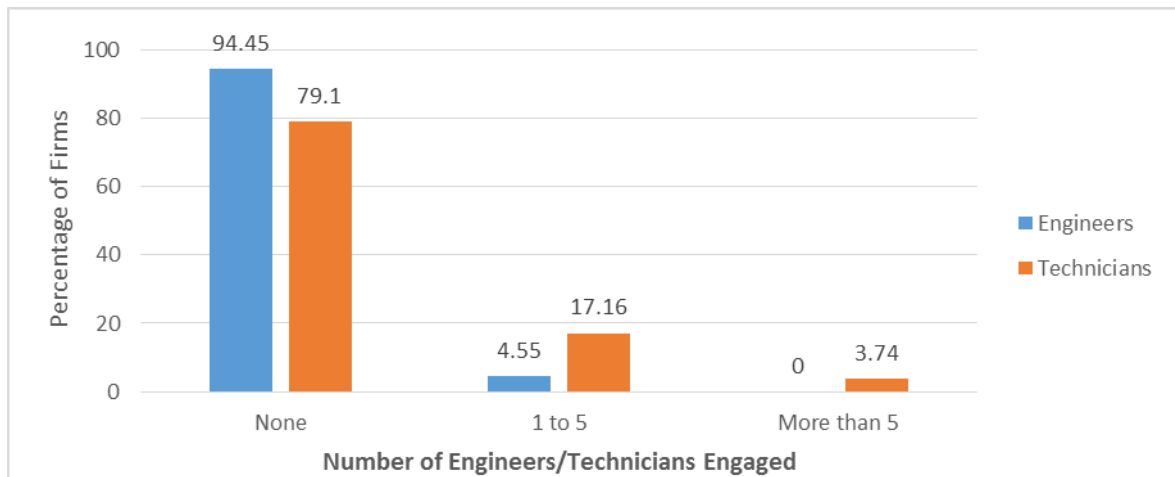


Figure 2: Qualified Engineers and Technicians Employed in the automobile industry

### Regression models

Further insight into trends in the data is obtained from Figures 3 and 4, which display regression models of the data in Tables 3 and 4. From Figure 3 it can be seen that the exponential regression model, though having the same magnitude of *goodness of fit* as the linear model, gives a better fit and description than the linear model of the number of firms employing a specified number of engineers except, where we are interested in firms that employ no engineers, in which case, a better estimate of the number of firms is obtained by summing the two models.



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Table 3: Number of Automobile/Mechanical Engineers Engaged

No. of Auto/ Mech. Engineers in firm	Frequency	Percentage	Cumulative
0	126	95.45	95.45
1	2	1.52	96.97
2	2	1.52	98.48
3	2	1.70	100
<b>Total</b>	<b>132</b>	<b>100.00</b>	

Table 4: Number of Mechanical/Automobile Technicians Engaged in Company

No. of Auto/Mech. Technicians in firm	Frequency	Percentage	Cumulative
0	106	79.10	79.10
1	2	1.49	80.60
2	11	8.21	88.81
3	6	4.48	93.28
4	2	1.49	94.78
5	2	1.49	96.27
10	4	2.99	99.25
20	1	0.75	100
<b>Total</b>	<b>134</b>	<b>100.00</b>	

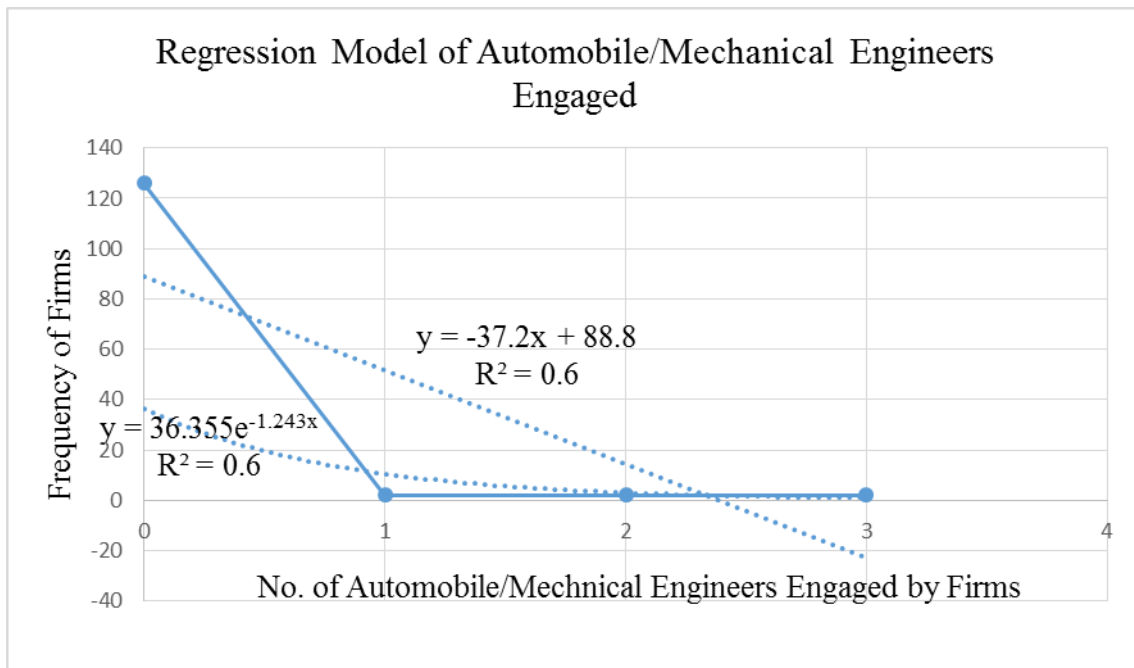


Figure 3: Distribution of Qualified Engineers Employed in the automobile industry

Figure 4 shows similar information as above, but for technicians. Here we have only one best fit, an exponential model which, as can be seen, is better at estimating the





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number of firms employing a specified number of engineers when the number of engineers employed by a firm is greater than zero.

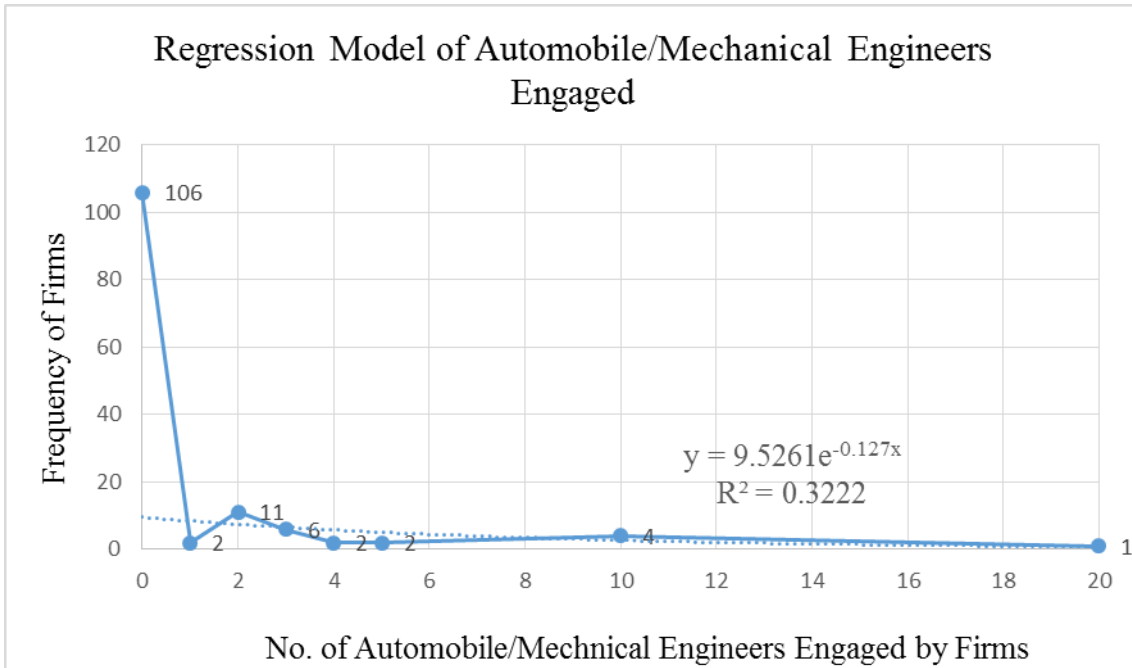


Figure 4: Distribution of Qualified Technicians Employed in the automobile industry

### 3.2 Domestic Manufacturing of Automobile Components

#### 3.2.1 Types of Automobile Components and Systems Produced by Firms

In light of study objective (i), a breakdown of automobile components produced by firms, and the manufacturing methods used in the production of these parts (Table 5), show that of the 134 respondents, 22.4% produce exhaust systems, 14.9% produce bumpers, 6.7% produce cylinder head covers while, put together, 37.3% produce gears, shafts, bushes, and pulleys. However, components such as steering systems and crankshafts did not score any mark, indicating there are challenges of technology in the design and manufacturing these systems.

Table 5: Automotive parts produced and processes used in producing them

PROCESS	AUTOMOTIVE PARTS (%)						
	Exhaust System	Gasket	Gears	Shafts	Engine Blocks, Crankshafts, Pistons	Seats	Body Frame
Machining	-	-	47	26	13	-	-
Welding	15	-	-	-	-	23	45
Forming	-	25	-	-	-	-	-
Casting	-	-	-	-	1.9	-	-
Total	15	25	17	26	14.9	23	45



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### 3.2.2 Welding

Table 5 above also shows that welding along with machining, are the predominant fabrication methods employed in the industry. The predominant welding method used in the industry is the rather rudimentary arc welding process (Figure 5). Inspection of welds is carried out visually, aided by chipping hammers. These are all rudimentary methods that cannot guarantee detection of most weld defects. Almost 70% of the 53 firms doing welding report that they do not weld to any standards, even though Standards remain an indispensable requirement of all competitive design and manufacturing

### 3.2.3 Machine Tools Employed

In light of study objective (ii), general levels of technology employed in the firms visited is low. Majority (93%) of automobile workshops use grinding machines, drilling machines (90.9%), welding machines (80.6%), lathe machines (56.7%) with 20.9% of workshops having band saw machines, 8.2% milling machines, and 3.7% air impact machines, all of conventional types; none of the firms uses computer numeric control (CNC) machine tools. Automation, employing CNC machines, industrial robots and other similar equipment, is a system of manufacture designed to extend the capabilities of machines in performing certain tasks formerly done by humans, and to control sequences of operations without human intervention. Therefore by this absence, many advantages of computer numeric control (CNC) production machine tools such as higher precision and repeatability, greater speed and flexibility, globally standard parts, reduced real cutting time, minimized idle time, among others (Adejuyigbe, 2010), are missed by the automotive manufacturing sector of Ghanaian industry.

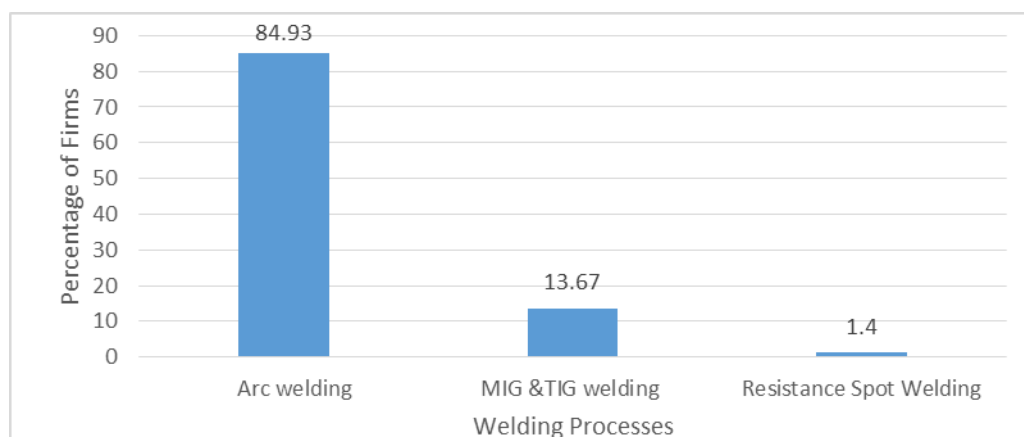


Figure 5: Types of Welding Processes used by Respondent Firms.

### 3.2.4 Kinds of Product Representation Used in Automobiles Design and Manufacturing

About 47% of firms do not use engineering drawings at all in any shape or form for fabrication of parts (Figure 6 and Table 6). Those that use manual drawings exclusively



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are 29.85% while those that using computer aided design (CAD) systems exclusively are 7.49%. This shows that neither CAD nor manual drawings feature prominently in the realisation of automobile components and products in most workshops in the country. This is out of tune with an observed trend of firms in industrialised countries using more and more of concurrent engineering and integrated CAD/CAE/CAM systems to meet the demands of globalization and competition in the worldwide automobile industry. These are tools that greatly to reduce product development time and cost, and improve product quality, while pushing products into the marketplace in a relatively short time (Chun-Chih *et al.*, 2008).

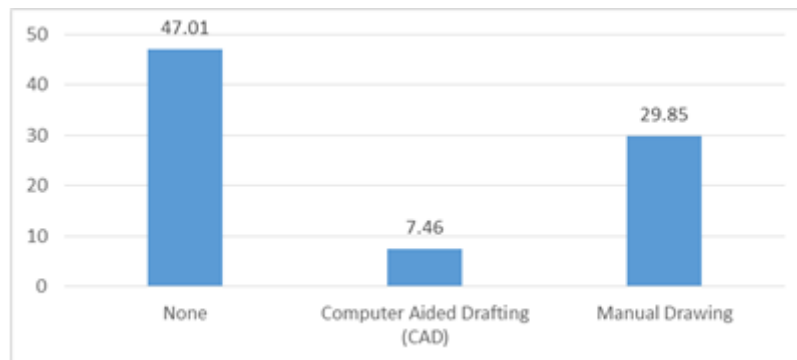


Figure 6: Distribution of Product Representations Used in Respondent Firms.

Table 6: Kinds of Product Representation Used in Design/Manufacturing of Automobiles

Kinds of Drawing/Diagrams	Frequency	Percent	Cumulative
<b>Manual Drawing</b>	40	29.85	29.85
<b>CAD</b>	10	7.46	37.31
<b>Visual</b>	21	15.68	52.99
<b>None</b>	63	47.01	100.00
<b>Total</b>	<b>134</b>	<b>100.00</b>	

### 3.3 Facilities Organisation and other Challenges

Most of the respondent firms lack properly planned plant layouts that can enhance productivity. Machine location and disposition are often dictated by availability of space and convenience. Frequent power outages and breakdowns of obsolete machinery are some of the other challenges facing firms in production. No quality control measures are in place to ensure parts manufactured meet accepted standards.

### 4.0 CONCLUSION AND RECOMMENDATIONS

The factors militating against the growth of automobile design and manufacturing in Ghana are many and include the lack of qualified engineers and technicians, a components manufacturing culture that is based more on experience than on the application of sound engineering principles, unavailability of classified engineering



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materials, labour intensive methods, non-use of engineering drawings, the large-scale importation of complete vehicles, the lack of modern machinery and equipment, and frequent power outages. The general level of technology employed in the firms is low, and many advantages of CNC and robotic production such as higher precision and repeatability, greater flexibility are missed by the automotive manufacturing sector of Ghanaian industry. Production plants are not planned to support large-scale production of parts, and rudimentary manufacturing methods, such as arc welding are being used. With respect to the application of standards, practitioners in the automotive industry in Ghana do not seem to follow any proper quality control regime or standards system; and there is also very little government support for the sector. This is much unlike what happened, for example, in South Korea and South-East Asia, where in the formative stages of their automobile industry, the Government banned the importation of assembled vehicles while encouraging the importation of parts for assembly to promote domestic development of the industry (Lee, 2011). These shortcomings tend to limit the type and quality of components that can be designed and produced.

In conclusion, because a thriving automobile industry generates huge added value to the economy of a country, some analysts consider it as an important measure to gauge the industrial level of a country. The formal Ghanaian automobile industry currently assembles busses and trucks in very small quantities, producing a handful of automotive parts on a very limited scale. Given the long gestation the industry has enjoyed in Ghana, these cannot be said to be great achievements, even in the face of the many challenges impeding the progress of the sector. All these may explain why any modest successes the industry may boast of seem only limited to the assembly of trucks and busses, in which designs and accompanying manufacturing processes are much simpler as compared to smaller vehicles, such as cars.

By way of recommendation,

- 1) As happened in Malaysia, for example, and as noted in the literature review section, Government policy should aim to increase support to the automotive manufacturing industry in terms of subsidies and tax incentives to promote its indigenous development.
- 2) Ghana needs to adopt a strategic approach to the development of its automobile manufacturing industry involving targeting the building of necessary infrastructure and technical skills to support the progressive design and manufacture of key automotive components towards building a critical mass for a world-class indigenous manufacturing of automotive systems.
- 3) Future research could compare Ghana's experience with a more progressive African country, Such as South Africa, for relevant lessons to be learnt.



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