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Analysis of the Hardware and Software Weaknesses of Mechanical Tool Technology in Agricultural Mechanization: Case of SONALIKA Brand Tractors in Cameroon

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Abstract: The level of agricultural mechanization in Cameroon for the past decades has faced an improvement though not significant and despite repeated attempts of the government to improve the sector. One of these attempts was the recent distribution of SONALIKA brand tractors of different horse power (DI 60, DI 75, DI 90) to farm operators in order to improve the level of farm mechanization. Unfortunately, a certain number of these tractors (30%) were found abandoned after a short period of time in the field due to numerous constraints such as the lack of proper training of drivers, the scarcity of spare parts, the poor quality of the machine and the poor land preparation, just to name a few. This study seeks to contribute to the improvement of the shelf life of SONALIKA tractors in the five Agro-ecological zones of Cameroon by identifying and prioritizing the primary causes (hardware link or software link) of tractor breakdown and proposing solutions to main faults on the hardware and software components. Questionnaires were administered to respondents (tractor operators and mechanics) and data collected was analysed using SPSS and Microsoft office excel. Interviews were carried out to get root causes of breakdown then prioritized using Pareto chart. Organization of root causes was done using ISHIKAWA diagram. Results revealed five primary factors; (Material, Machine, Manpower, Method and Environment) responsible for the operational weaknesses of SONALIKA tractors. Prioritizing of these factors showed that there are three vital few factors (Manpower, Machine and Environment) which if tackled could solve 90 % of the problems of premature failure of tractors and thus avoiding the perpetuation of the existing situation.

Keywords: Breakdown, ISHIKAWA, Maintenance plan, Pareto chart, SONALIKA tractor.

I. INTRODUCTION

Agriculture exists as one of the chief sectors in every African economy and plays a central role in achieving development. Farming represents 32% of continental African gross domestic product (GDP) and subsistence farming alone employs over half the population of Sub-Saharan Africa [1].

In Sub-Saharan Africa (SSA) specifically, 65% of farm power is hand power, 25% is animal power, and 10% is engine power meanwhile, in Asia, Latin America, North Africa and the Middle East, the farm power is 25% hand power, 25% animal power, and 50% engine power [2]. According to the same authors, the reason behind this low level of agricultural mechanization in SSA include population growth, land scarcity, climate change degrading ecosystems, and under investment in agricultural research, infrastructure, and technology. According to [3], farm power in African agriculture, especially sub-Saharan Africa (SSA), relies to an overwhelming extent on human muscle power, based on operations that depend on the hoe and other hand tool technology. Such tools have implicit limitations in terms of energy and operational output in a tropical environment.

Past efforts to mechanize African agriculture such as sharing of tractors and their implements have produced mixed results [1]. Compared with other regions, Africa has not had the large-scale investment in agricultural infrastructure, such as irrigation or other agricultural inputs needed to intensify crop production. This is partly because Africa is fragmented into relatively small countries, unlike countries such as Brazil, India, or China. In many cases where governments established tractor hire schemes to serve small-scale farmers, planning was very short term, and management was poorly trained and poorly supported [4]. Such schemes, though relatively few across the continent, failed miserably, denting the image of agricultural mechanization in general [5].

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The low level of mechanization in Cameroon (0.1 tractor available for 1000 ha compared for example to Algeria 11.4 tractors for 1000 ha) is still a thorny problem to be solved. Hand tools are highly dominating in most farming systems with approximately 92% in small-scale farming and 72% in the exploitations of great importance and agricultural processing industries [6]. The animal haulage is employed mainly in certain areas, about 13% in the Far North, North, Adamaoua and 2% in the North-West [6]. In large scale farms, the majority of the mechanized operations are dependent on the activities of postharvest (42%), and in a less proportion (15%) with ploughing ([7], [8]). In Cameroon, the actions towards the development of agricultural mechanization are most often punctual and do not lie within the scope of a general thought. Indeed, authorities have reflected thoroughly on the way of leading the development of agricultural mechanization vis-a-vis the national challenges as regards improvement of production and agricultural productivity in Cameroon. However, the reasons for the disappointing performance and low contribution of mechanization to agricultural development have been the fragmented approach to mechanization issues. According to ([9], [10]), this can be attributed to poor planning by government agencies, over-reliance on unpredictable or unsuitable, one-off, aid-in-kind or other external mechanization inputs. Lack of teamwork or coordination within and between government departments and inherent competition with private sector business initiatives in mechanization services have not helped the situation [11].

The most recent initiative carried out by the Cameroon government in order to boast agricultural mechanization, was the introduction of 1000 tractors of brand SONALIKA with adequate equipment via a contract signed by the Cameroon and Indian Government in 2011 under the project called 'PERIZ-MAIS' with the objective to increase maize and rice national production to reduce importation. This initiative has induced a non-negligible interest in farm mechanization by farm operators who equally acquire such technology from importers suppliers who have benefited from tax exemption on importation enabled by the government. However, due to failures in the proper management (software) and also to some extent the make-up (hardware) of these tractors in the field, some of the tractors have been abandoned due to various reasons. It's worth mentioning that this initiative led to the increasing number of farm operators or users of tractors of SONALIKA brand obtained from the government or form personal investment ([12], [13]). The objectives of this article are thus threefold, firstly it seeks to evaluate the causes of the premature failure of the management of SONALIKA brand tractors Cameroon. Secondly, it intends to group and prioritize the causes using maintenance tools that could help to identify hotspot areas of intervention and consequently lengthen the shelf life of these tractors and thirdly provide key solution to most of the failures identified both on the software and hardware components.

II. METHODOLOGY

A. Study Site

This research was carried out from August 2018 to March 2019 within the five (05) agroecological zones that count Cameroon (fig 1). These zones are characterized by diverse and distinct ecosystems with specific pedo-climatic parameters. The agricultural equipment in general and motorized machines in particular face different challenges within these zones and consequently, different nature or types of failures could be observed differently in these areas.

Cameroon is located in the African continent and covers 472 710 km^2 of land and 2 730 km^2 of water making it the 54th largest nation in the world with a total area of 475 440 km^2. It is located between latitude 1^o 650' and 13^o 070' North and between longitude 8^o 490' and 16^o 190' East. Its topography makes Cameroon a very fertile ground for mechanization though, some natural barriers to mechanization do exist in some parts of the Country.

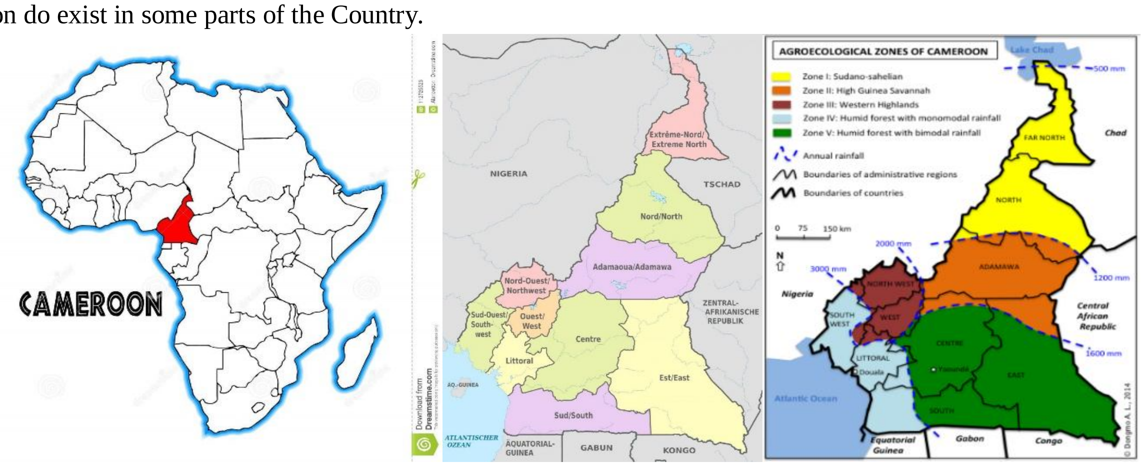

Fig 1: localization and presentation of Cameroon

B. Target Population

The study population involved in this project were SONALIKA tractor owners and/or users that either obtained their tractors via the Cameroon government as a grant or via personal investment by purchasing it from importer-suppliers located in or out of Cameroon. Based on the significant sparsely distribution of tractor users in Cameroon, the research team had to work with a representative number of SONALIKA users which was obtained via sampling.

C. Sampling Technique and Sampling Size

Simple random sampling technique was used to determine the sample size for this investigation. This technique was used because, firstly, tractors users in general are found throughout the country in all the agro ecological zones and are all users of SONALIKA brand tractors. Secondly, the same type of information was assessed from the various tractor users.

It was calculated using the formula (1) proposed by [14]. It's important to highlight that this formula holds only when the total beneficiaries in all the zones are known. This information was suitably obtained from field assessment together with inquiry from some local administrative authorities (Ministry of Agriculture and Rural Development, Ministry of livestock Ministry of Economy Planning and Regional Development, town councils).

$$\textbf{Sample size, n} = N * \frac{\frac{Z^2 * p * (1-p)}{e^2}}{\left[N - 1 + \frac{Z^2 * p * (1-p)}{e^2}\right]} \qquad (1)$$

Where: n = sample size, = critical value (90%), Sample proportion (0.5), e = marginal error (5%), N = total population size of tractor beneficiaries (1 174). The sample size calculated and retained for this study was 80.

However, it's worth mentioning that, the number of tractor users retained per agro ecological zone was made proportional to the density of tractor users in the corresponding research areas. Simple proportion was used to proceed to the redistribution of the sample size.

D. Data Collection

A questionnaire was design to collect all the necessary data from the field. They made up of both open and close questions which were handed to the various respondents to collect their views on the causes of tractor frequent breakdown. Brainstorming with focus groups were equally carried out to come forth with a converging view of the root causes of breakdown. Two months were necessary to cover the entire target study areas.

E. Data Analysis

The data collected from the field was analyzed using SPSS (Statistical Package of Social Sciences) version 20 and Microsoft Excel spread sheet software. Both spread sheets were used to clean for irregularities. The cleaned data were then summarized into descriptive statistics in the form of frequencies and percentages. A qualitative analysis was then done for the various parameters obtained.

III. RESULTS AND DISCUSSION

A. Identification and Prioritization of Primary Causes of Breakdown

1) *Identification of primary causes of operational weaknesses of SONALIKA tractors:* Data obtained from survey permitted to identify various faults responsible for tractor breakdown. These faults were categorized under five primary factors presented around the 4M and E (Machines, Methods, Materials, Man, and Environment) as presented on table 1. 4M and 1E was used as a friendly basic compass to appreciate the elements responsible for the operational weaknesses of SONALIKA tractors and time spend on maintenance.

Table 1: Summary of the Frequency of Primary Causes of SONALIKA Tractor Weaknesses

Primary factors	Designation	Frequency of breakdown occurrence
Machine	Problem link to the constitution or design of the machine	35
Material (product)	Problem link to type of products handled by machine	5
Method	Problem link to the technology used	15
Man	Problem link to users	40
Environment	Problem link to climatic conditions	25

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Though all these aspects are highly influential as primary causes of operational weaknesses of tractor breakdown, there was a need to use maintenance tools in order to prioritize the causes so as to ease maintainability of these tractors with an objective of increasing the shelf life thus improving its productivity and reducing the time and resources spend on maintenance.

2) *Prioritization of Primary Factors of Breakdown:* The frequency of occurrence (Table 2) was quantified to come out with the most influential primary causes of breakdown.

Table 2: Categorization of primary factors of tractor breakdown in order of importance

Factor symbol	Factors	Frequency of occurrence	Percentage (%)	Cumulative frequency
A	Man (users)	40	33.33	33.33
B	Machine make up	35	29.17	62.5
C	Environmental conditions	25	20.83	83.33
D	Methods used	15	12.5	95.83
E	Material (product)	5	4.17	100
Total		120	100	

The result presented on table 1 indicates that if the factor ‘A’ is solved, the problem of tractor breakdown will be reduced by 33.3 %. If factors ‘A and B’ are tackled efficiently, the problem of breakdown will be solved at 62.5 %. Finally, if factors ‘A, B and C’ are solved, the problem of breakdown would be avoided at 83.33 %.

The “law of the vital few,” or more often, the “80:20 rule” was used to better appreciate the variables as illustrated on fig 2. This study is interested in isolating the few important causes that would lead to a high effect of breakdown (prioritization). Thus, solving the problem of the vital few causes (Machine make up, Manpower and Environment), will permit that more than 90 % of the effects of breakdown will be efficiently touched.

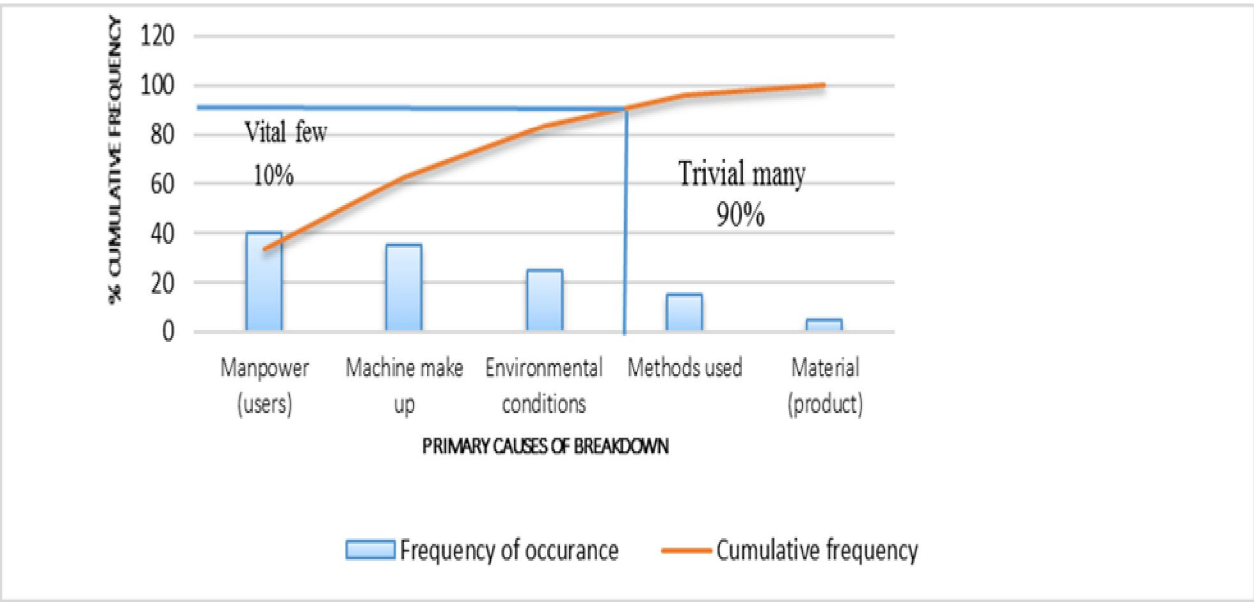

Fig. 2: Pareto diagram prioritizing the primary factors of breakdown

In order to better tackle these vital few causes of breakdown, they were categorized into internal (Machine make up) and external (Manpower and Environment) causes of tractor breakdown.

B. Analysis of the External Factors of Tractor Breakdown;

These are causes responsible for the operational weaknesses of SONALIKA tractors but which are not due to the “hard ware” component (tractor make up) but the rather due to the software.

1) *Educational Background of tractor Operators and Mechanics in the five AEZ of Cameroon:* Education is the knowledge of putting one's potentials to maximum use [15]. From fig 3, 44 % of operators were found to have limited their education only to the primary school level, against 13 % who have no formal education. These results can be more or less attributed to the frequent breakdown of tractors as tractor operators can hardly read and understand the manual. It ties with the results of [16], who says, the literacy status of tractor operators and mechanics may influence understanding about the use of tractors and its associated implements because he can study the operation manual and understand all the instructions. Also, though 20 % and 23 % respectively had access to secondary and tertiary level of education. This categories of operators on the other hand do not have the knowledge of how to better manage the tractors.

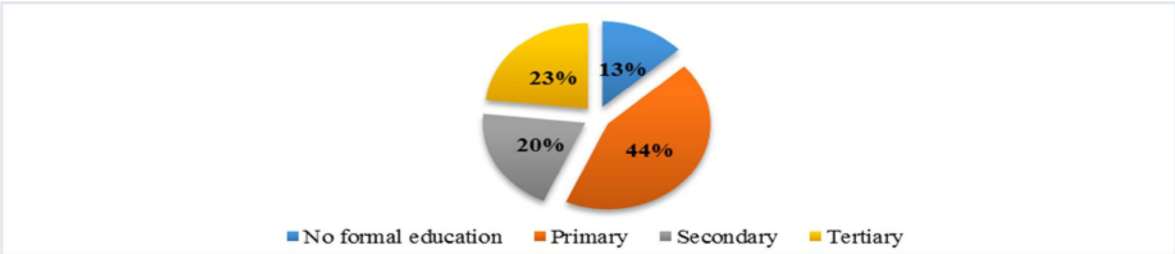

Fig 3: Educational background of tractor operators and mechanics

2) *Training Background of tractor Operators:* Fig 4 shows that majority of operators (46 %) learnt how to operate tractors from other tractor operators rather than through a formal tractor operating training center such as the National Centre for Studies and Experimentations in Agricultural Mechanization (CENEEMA). This means that different tractor operators would train their subordinates based on their own limited experience producing gaps or lapses in their subordinates training which is in accordance to the findings of [16] and [17]. Also, it was found out that 23 % of operators got their training or experience from other vehicles such as heavy-duty trucks. All these high informal training of operators influence greatly on the breakdown of tractors as they do not have a good mastery and understanding of the DO and DON'T of tractor operation principles which lead to most failures.

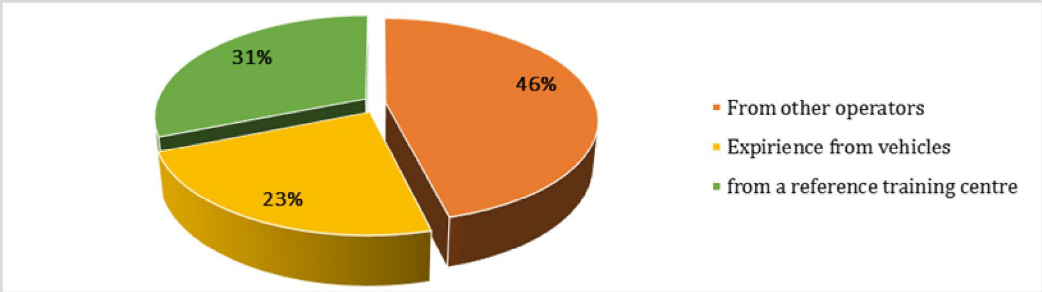

Fig 4: Training background of tractor operators

3) *Experience background of tractor operators:* Fig 5, shows that 48 % of operators have experience of less than 5 years, 22 % have experience of 5 to 10 years and 30 % have experience of more than 10 years. This shows that a good number of operators are not familiar with the tractors as such they hardly detect a fault when it pops up. This is in line with the general saying that experience is the best teacher. When the machines have strange sounds or is indicating a fault, they cannot easily be identified which later generates into a bigger cause of tractor failure. That is why [18] and [19] recommend to define our objectives according to where we are up to before moving to mechanization.

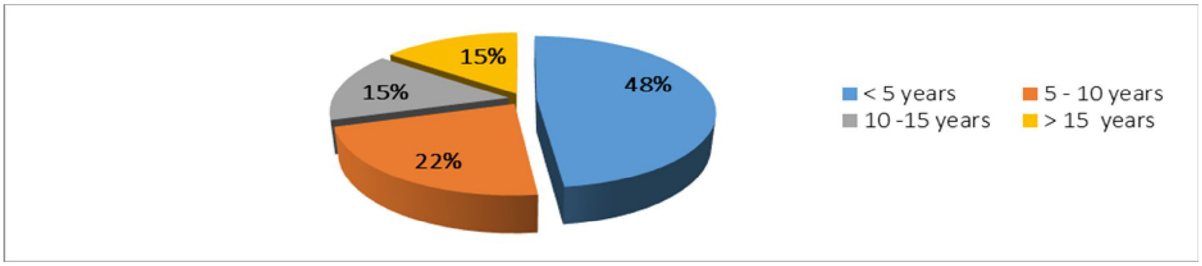

Fig 5: Experience of tractor operators

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4) *Issuance of Tractor Operation Guide:* Tractors operator's manuals are the 'oracle' on proper tractor operation and maintenance. Reading the operator's manual is important because it tells the owner or operator how to set the machine and what part to check before one takes it to the field and what type of maintenance to carry out and when to do it [17]. From survey (Fig 6), 54 % of operators (chart 'A') had access to operator's guide but it was realized that only 18 % (chart 'B') actually make use of the guide. Indeed, when asked for instance on the rate of changing engine oil and filter oil, 52% clearly indicated that it depends on the availability of work. This shows the impact of illiteracy level of operators.

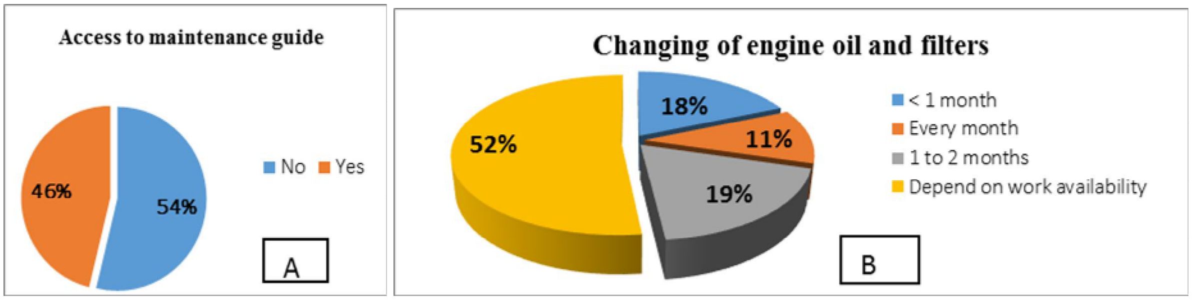

Fig 6: Issuance of tractor operation guide

5) *Availability and Proficiency of Tractor Mechanics:* Fig 7 shows that 73 % of operators do not readily have access to tractor mechanics. Also, those that are readily available are financially inaccessible to tractor operator and this as such reduces the rate of use of tractors as most of them are unusable. It's worth mentioning that, out of the few available tractor mechanics, some (27%) are less proficient as they are recycled truck mechanics having possibility to handle to some extent tractors. This makes them to be limited in their expertise as some breakdowns are usually beyond their know-how leading to abandonment of tractors.

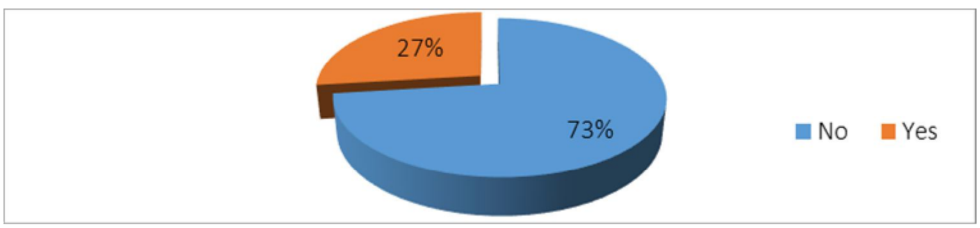

Fig 7: Availability and proficiency of tractor mechanics

IV. IDENTIFICATION AND ANALYSIS OF THE INTERNAL CAUSES OF TRACTOR BREAKDOWN;

Out of the three vital few causes of operational weaknesses of tractors obtained from figure 2, Machine make up (hardware) is categorized as an internal cause responsible for the operational weakness of these tractors.

A. Identification of various tractor systems that breakdown frequently in all the five zones

From results obtained in the different zones it was seen that all the zones have almost the same reasons for breakdown with slight differences due to the pedological nature of soils and the types of crops cultivated. Fig 8 shows the percentages of breakdown of the different systems of tractors in all the zones of Cameroon.

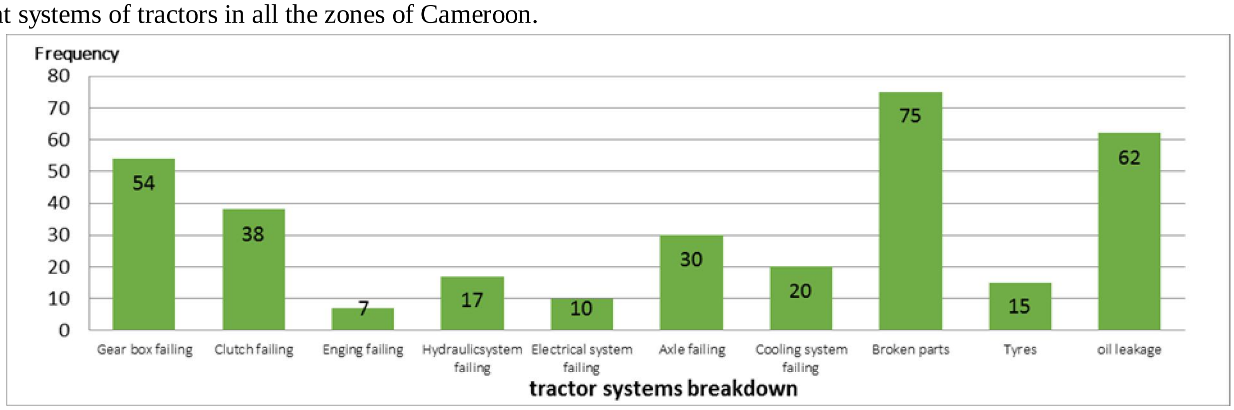

Fig 8: Showing breakdown frequency of various tractor systems

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Fig 8 shows that most causes of breakdown for this tractor observed within the 05 agro-ecological zones of Cameroon are broken parts that account for 75 %, followed by oil leakages 62 %, gear box failure 54 %, clutch failure 38 %, axle failure 30%, hydraulic failure 17 % and other minor causes. A genuine observation was made from the analysis of result that the cooling system failure (overheating) happened only for the category of tractors DI 90 due to unsuitable and unprotected radiator.

1) *Broken Parts:* this is the major cause of breakdown in tractors which might be due to poor quality materials used in the fabrication of parts. These parts mostly do not possess adequate properties that are attributed to materials used in the manufacturing of machine elements. This can be easily observed as the bolts, nuts, chassis, implements, three-point linkage get regularly broken (fig 9) when high force is applied which is an indication that the compressive strength and ultimate tensile strength of the material is relatively lower than normal. The hardware is found to be made out of cast iron which has a high amount of graphite 2 to 4 % and as such, it makes it less ductile and very brittle. Its compressive strength ranges from 6.3 to 7.1 tons/cm^2 and ultimate tensile strength between 1.26 to 1.57 tons/cm^2 which is far less than that of mild steel which is 4.75 to 25.2 tons/cm^2 and ultimate tensile strength is 5.51 to 11.02 tons/cm^2 ([14]; [20]; [21]; [22]). This clearly shows that machine elements made of cast iron has a very low ultimate tensile strength thus cannot resist for a long time without breaking which is the reason for frequent broken parts of tractors especially the implements that are in contact with a soil that has not been prepared (presence of trees, roots, obstacles in the subsoil) and requires much strength for farm operations.

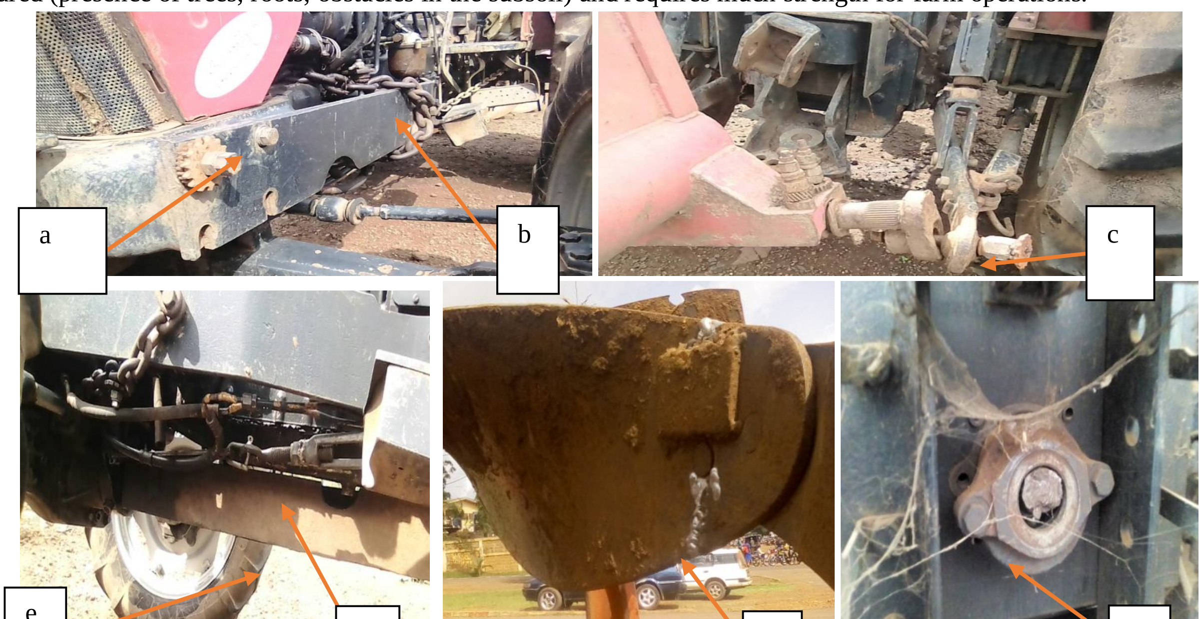

Fig 9: Showing broken parts of tractors ... poor quality of material: a) Ad... washer, b) Engine support, c...pted bolt, d) Engine block support, e) Transmission bar guard, f) Welded mold board plow, g) Broken PTO

2) *Oil Leakages:* It is also another issue that causes SONALIKA tractor breakdown. As oils leak, there is shortage of required amount in the various systems that lead to wears and broken parts due to insufficient lubrication. This is realized from survey that the hoses and clips used in transporting oil to a destination and holding the hoses to prevent leakages respectively are of low quality and have a high tendency of failing frequently thus excessive leaks are seen on the tractors (fig 10).

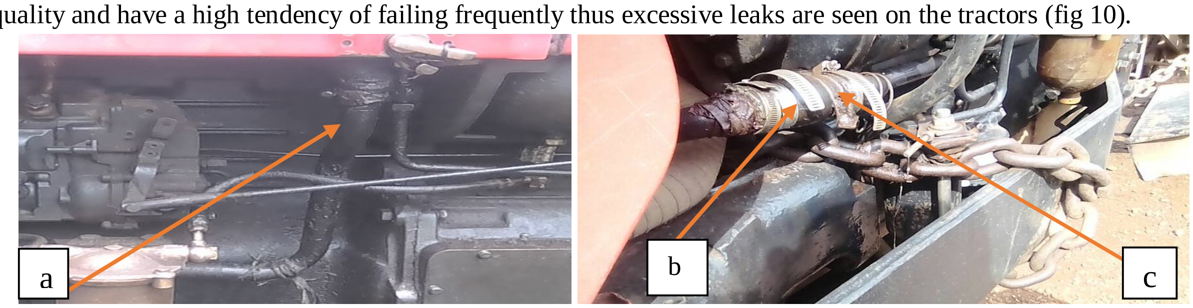

Fig 10: Oil leakages on tractor and clips holding hoses to prevent oil leaks: a) Hose covered with leaked oil, b) Oil leakage, c) Weakened clips

3) *Gearbox and Clutch:* from survey it was seen that the gears most often skip and this is because the spring that blocks the various gears weakens easily and also because of misalignment of the transmission shaft. It was also realized that breakdown of gear box might be due to the usage of unsuitable gears where not necessary thus leading to premature failures. There is also frequent breaking of clutch disc and plates that calls the attention of mechanic most often and since they are not readily available and spare parts are scares it forces most tractor owners to abandon tractors after a short time of usage.

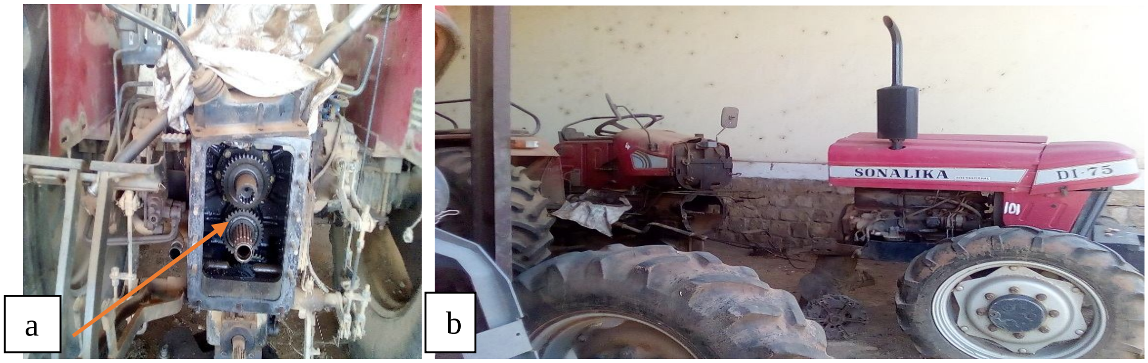

Fig 11: Illustration of gear box breakdown: a) Broken gears, b) Separation of engine from gearbox to change disc clutch and plates

B. Analysis of the root Causes of Breakdown of Various Tractor Systems

1) *Cause-effect (ISHIKAWA) Diagram for Tractor Breakdown:* Ideas collected after interviews and group works were gathered based on the different tractor systems as main causes and root causes of breakdown using the ISHIKAWA diagram (fig 12).

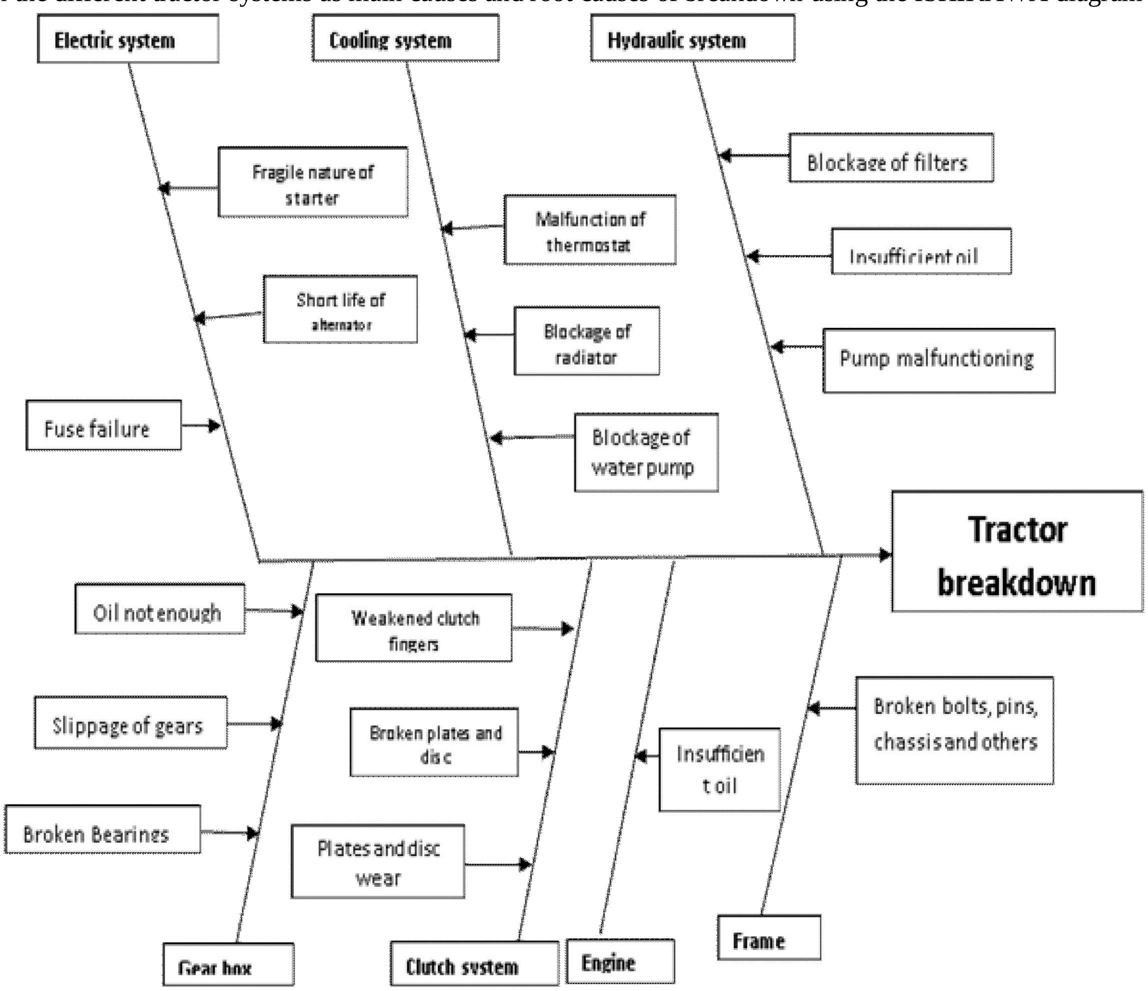

Fig 12: ISHIKAWA (cause-effect) diagram tractor breakdown.

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2) *Pareto Chart and Graph:* Root causes gotten from the cause-effect diagram were categorized using Pareto chart starting from the most frequent.

Table 3: Ranking of the internal causes of tractor breakdown

Root causes	Frequency of occurrence	Percentage frequency (%)	Percentage cumulative frequency (%)
Broken bolds and other parts	30	13.39	13.39
Gears failing	29	12.95	26.95
Clutch disc, plates and clutch fingers fail	28	12.50	38.84
Oil leakages	25	11.18	50.02
Axle	22	9.82	59.84
Oil pump failing	20	8.93	68.93
Filters failing	18	8.04	76.81
Primary and secondary shaft failing	15	6.70	83.51
Cardiant joint	11	4.91	88.42
Water pump failing	10	4.46	92.88
Blockage of radiator	8	3.57	96.45
Others	8	3.57	100
Total	224	100	

The Pareto chart (fig 13) was equally used to prioritize the internal causes of the breakdown. According to [23], this principle highlight that some causes are more important than others. From the obtained results, solving causes found in zone A will permit to solve 80% of the problems of tractor breakdown which are the vital few causes of breakdown.

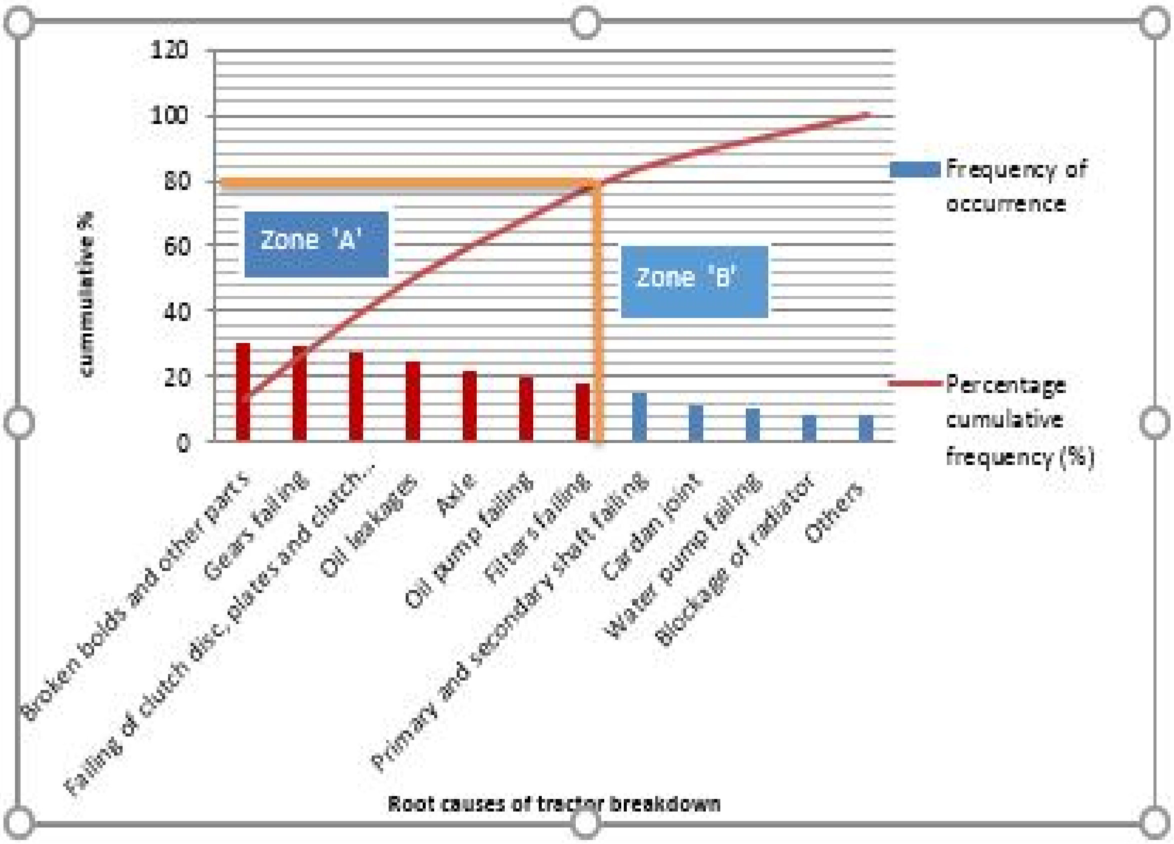

Fig 13: Pareto chart prioritizing the root causes of tractor breakdown

It's worth mentioning that the cause-effect (ISHIKAWA) diagram and Pareto (ABC) analysis are maintenance tools that are used to identify root causes of breakdown and their prioritization which permits to identify on which aspect to remedy in order of importance. However, it does not bring out a way to remedy these causes as such management tool is necessary to solve the problems.

C. Solutions to SONALIKA tractor breakdown

It's important to highlight that prior to the distribution of these SONALIKA tractors and equipment by the government, considerable time had been wasted in Douala port where the containers spent more than six months waiting for administrative documents. Later on, they spent another one year in open air before the tractor mounting unit could be put in place and roofed. Thus, these materials exposed under harsh climatic conditions (sun, rains, grasses) might have contributed more or less to their damage.
It is with regard to this that among the solutions proposed, some are specific to the faults caused by the exposure of the tractors to nature and others specific to the hardware design and software environment.
Table 4 presents the remedies to the root causes of SONALIKA tractor breakdown identified by the researchers. This solution if implemented will improve on the self-life of this category of tractors.

Table 4: Remedies of tractor breakdown root causes

Root causes	Remedies
Broken bolds and other parts	Replace with high quality material
Gears failing	Reinforce the gear box
Clutch disc, plates and clutch fingers fail	Replace the disc with high quality
Oil leakages	Replace the bellows pump bearing with high quality
Axle	Reinforce the axle
Oil pump failing	Replace the bellows pump bearing with high quality
Filters failing	Adapt a protective steel sheet
Primary and secondary shaft failing	Better bolts threading
Cardiant joint	Replace the cardiant joint
Water pump failing	Tighten the pump
Blockage of radiator	Clean the radiator

Table 5 presents the solutions proposed for the various faults or breakdown in general. Implementing these solutions will on one hand permit to render the existing SONALIKA tractors on the field more durable and on the other hand permit to improve on the existing technology, that is the hardware components.

Table 5: Proposed solutions to existing problems of SONALIKA tractors on the field and to the design of the hardware

Faults or breakdown		Observations	Proposed Solutions
1	Oil filter	Bad disposition, which easily breaks in areas of stumps or uneven ground.	Mount a solid protective sheet
2	Hydraulic filter	Suffers the same damage as engine oil filters	The same solution as in the previous case
3	Water separator	Expands under the effect of heat. The material used to design that does not support the tropical climates of Sub Sahara Africa	Replace the material used for its design
4	Screw for fixing the weighting masses	Loosens regularly	1-Check and tighten regularly. 2-The designers should use deeper threads
5	Fragile diesel fuel supply valve	Breaks easily when disassembled rendering its maintenance troublesome	1-During disassembly less experimented mechanics should use two keys 2-Replace with a stronger brass faucet
6	Transfer case	Oil seal very quickly looses	Replace the oil seal
7	Transmission shaft	Protective sheet	Check and tighten bolts, weld broken legs and reattach protective sheets, avoid stumps and rough areas.
8	Assembly screw at the front of the motor	Poorly design threads, poor material quality	When draining, i. e. at 100 h, tighten all tractor bolts and nuts.
9	Screw to attach the gearbox to the engine	Loosens quiet often	Tighten all tractor bolts and nuts again at the 100-hour drain.
10	Steering oil tank cover	Often loosens and lets oil pour out	Make sure each time you check that the cap is securely reattached
11	Overheating during ploughing	Radiator not suitable (as indicated above, not all tractors have this problem, only the DI 90).	Observe the rooting period and especially replace (not tighten) the alternator belt before it starts to slip.
12	Exposed radiator	Leaves, stems of plants easily have access to the radiator	clean as often as possible if working in the bushes.
13	Steering cylinder	Removed by pieces of wood during ploughing	Avoid working in non-grubbed areas
14	Multifunction control button	Rusty, because of the presence of scale, a poor quality manufacturing material	Clean the machine regularly and monitor it closely.
15	Electrical wiring	Incorrect arrangement of electrical cables (circuit malfunctioning), burnt bundles, cut off during ploughing because they are not protected.	Rectified during its design
16	Deteriorated batteries	Heating during transport in containers, exposure to weather conditions	To be replaced before use
17	Lift arms	The fixations on the rear axle breaks	Correct the driver's training gap

V. CONCLUSIONS

In the 1960s the advent of mechanization was taken for granted by most development practitioners. It was assumed then that it was only a matter of time before agriculture would be transformed and developed to the extent that use of tractors by farmers who either owned them or hired them through services provided operators would become ubiquitous. Cameroon is no exception to this migration. Indeed, throughout the past decades, it has been carrying out efforts to modernize the agricultural production tools. A concrete example is the importation of 1000 tractors via the Cameroon-Indian partnership. These tractors were dedicated for Cameroonian farm operators who will help to improve the mechanization levels of farms thus increasing the farm land sizes and consequently farm productivity making them more competitive.

The desire to adopt more sophisticated technology has induced a positive effect on the agrarian population as more farm operators are having access (physical) to tractors especially 4-wheel tractors (4WT) of different brands. However, the number of tractors present within a geographical area does not necessarily reflect the quality of mechanization. Most of tractor operators are found to use tractors beneath their design shelf life. This research focus on understanding the reasons on why there is an important density of premature tractor breakdown. Based on the methodology used in this research and the results obtained, it can be concluded that the premature failure of tractors can be attributed to both the hardware (material) and the software (know-how) components. It was found out that:

A. There are five primary factors responsible for the operational weaknesses of SONALIKA tractors in Cameroon which are categorized in 4M and E (Machine make up, Method of handling, Manpower, Materials (product) and Environment).
B. Out of these five factors of tractor breakdown, there are three vital few factors which are prioritized and if they are avoided, the problem of operational weaknesses of SONALIKA tractors will be solved by 90 %.
C. A high proportion of tractor operators (73 %) don't have access to tractor mechanics. Those that are readily available are financially inaccessible to tractor operator and this as such reduces the rate of use of tractors as most of them stay unrepair.
D. In the entire five zones most of the internal cause (hardware) of tractor breakdown are mostly broken parts of tractors as a result of poor material used for its design, oil leakages and gear box failure.
E. 46 % of tractor operators learnt how to operate tractors from other tractor operators rather than through a formal tractor operating training center such as CENEEMA. Different tractor operators rather train their subordinates based on their own limited experience and as such producing more gaps or lapses in their subordinates training.

The cause-effect (ISHIKAWA) diagram and Pareto (ABC) analysis are maintenance tools that were used to identify root causes of breakdown and their prioritization which permitted to identify the elements to remedy in order of importance.

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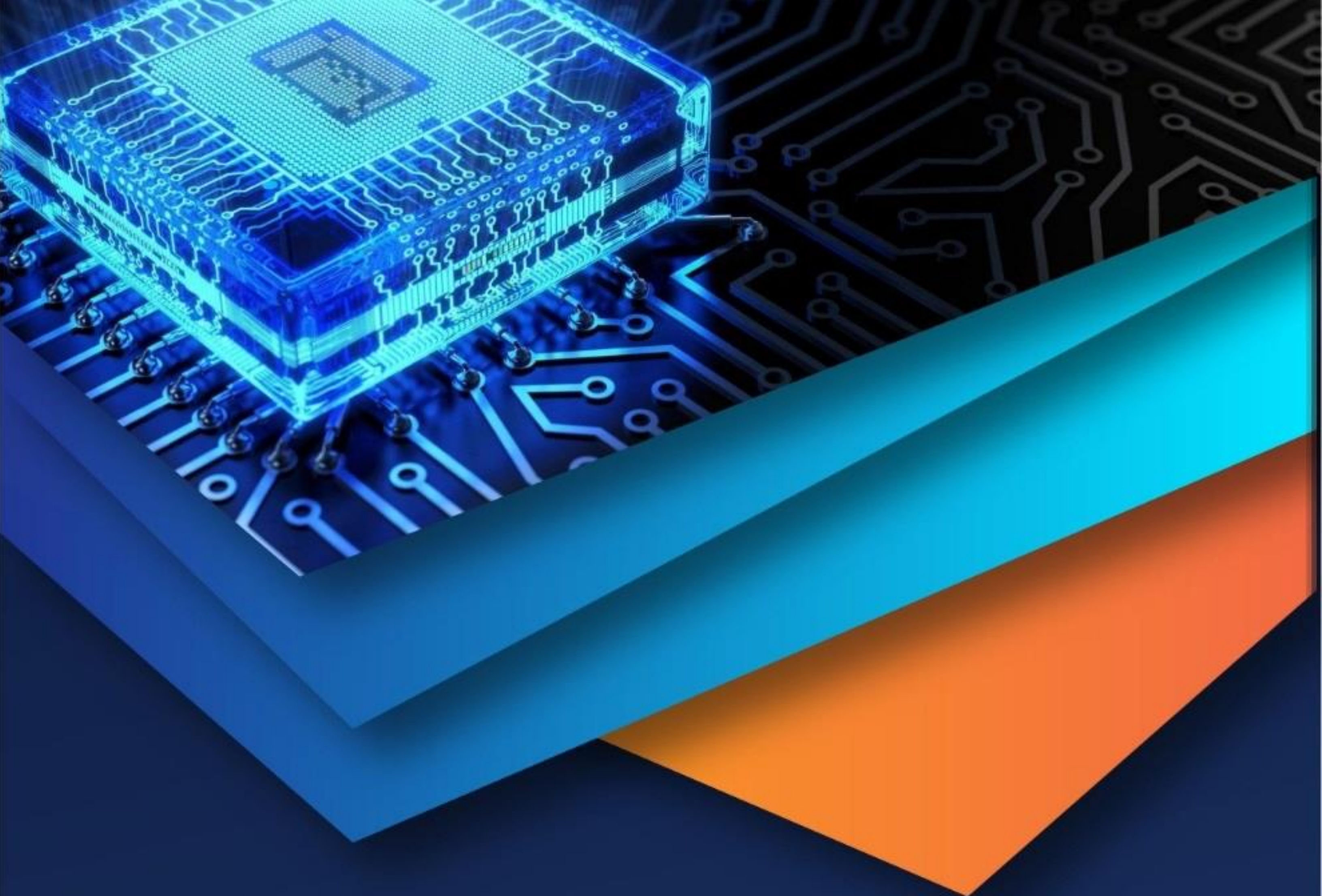

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