

Investigation of the Heating Rate of Locally Fabricated Arc Welding Machine in Arochukwu Local Government Area Abia State Nigeria

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Abstract- *The study adapted experimental research design to investigate the heating rate of locally fabricated Arc welding machine involving three welding machines. One control Arc welding machine system W1 without treatment and casing and two experimental welding machines W2 and W3 with varying lamina treatments, cooling systems and casing. The experimental Arc Welding Machines W2 was fabricated using coated copper wire while the experimental welding machine W3 was fabricated with aluminum wire after treatment using adequate vanishing with good cooling system. The control welding machine W1 was used intact as fabricated without treatment. Two Research Questions and two hypotheses guided the study. The instrument for data collection used was a standard Celcius scale calibrated thermometer with a range of 1000C. The data collected were analyzed using mean and standard deviation to answer the Research Questions and t-test analysis at 0.05 level of significance used to test the Hypotheses. The findings showed that the experimental welding machine systems W2 and W3 had lower mean temperature intervals and the corresponding test of hypotheses showed there was no significant difference between the mean temperature intervals of the two experiment welding machines W2 and W3 indicating that treatment positively minimized their heating rate equivalently. Furthermore, the study revealed that the control Arc welding machine W1 had higher mean temperature interval than the experimental welding machines W2 and W3 respectively and there was significant difference between the mean temperature intervals of the control system W1 and mean temperatures intervals of systems W2 and W3 respectively. This indicated that the treatment with adequate vanishing of transformer core Lamina and cooling systems had*

positive effects in reducing eddy current loss and minimizing rate of heat generation of locally fabricated Arc welding machines with no possible danger of overheating when properly cased than locally fabricated welding machine without adequate treatment. This can enhance the efficiency of locally fabricated Arc welding machines and eliminate electric shock hazard. It was recommended that fabricators of artisan Arc welding machines should ensure adequate vanishing of transformer core laminas with good cooling systems to enhance efficiency of locally fabricated Arc welding machines with proper casing. Furthermore, Physics and other relevant technical students should be funded to acquire skills of welding machine fabrications.

Key words: *Eddy current, Transformer core lamina, Vanish, and Arc welding machine.*

I. INTRODUCTION

Similar to other Colleges of Education in Nigeria, Abia State College Of Education (Technical) Arochukwu (ASCETA) is an Educational Tertiary Institution established to impact knowledge and teaching pedagogy in education and technical skills to potential student teachers in training through its various schools of learning which include school of science and technical education. Inclusively, department of Physics is a department domiciled in the school of science education with technical inclination through its branch of applied Physics. The philosophy of Physics Education for Nigeria Certificate in education (N.C.E) is to make students intellectually informed in Physics and by the need to produce competent and effective teachers with good mastery of content and method and knowledge of the

development of the learner(NCCE minimum standard, 2020). The nature of the program of Physics in school of science education and that of electrical/electronic department in the school of vocation/technical education correlated with the Education for Employment (E for E) policy of ASCETA through its skill acquisition programs.

It is in accordance with this policy that the researcher aimed at embarking on the construction and testing of Artisan Arc welding machines and providing students of physics and technical education the opportunity to acquire the skills of fabricating locally made arc welding machines with the view to investigate more efficient method of reducing heat production caused by eddy current in the transformer core of a welding machine to ensure operational safety and enhancement of efficiency of locally fabricated welding machines. The investigation of eddy current heat lost reduction in Arc welding machine was motivated on the ground that most locally fabricated arc welding machines employed by artisan welders in the society were observed in use without casing. This development poses grave danger to both the welder and the clients waiting for their job execution. The reason for this practice is not unconnected with the fear of potential damage to their hard earned machine due to excessive heat produced by eddy current in the transformer core of a welding machine through Joule heating.

According to Youngs and Fredman (2008), Physics is a branch of science that deals with natural phenomenon at its fundamental level. Physics as a branch of science, plays a vital role in the technological development and advancement of any nation. Physics also helps in careers building which include: Teaching, Nursing, Medicine, Engineering, Information and Communication Technology ICT. In engineering technologies such as material and metallurgical engineering, civil engineering, and mechanical engineering, Physics plays important role in ensuring efficient and desired strength of materials are achieved through application of solid state Physics to ensure optimal performance of engineering systems. (Michael, 2006; Oerter, 2006).

Specifically in the fabrication of welding machines, Physics plays a pivotal role in its design specification to ensure materials used are of appropriate crystal

structure and low hysteresis loop with suitable treatment of transformer core laminar to ensure optimal performance of the welding machine. Observably, in Arochukwu Local Government Area and Abia state at large, most welding machines used by artisans to execute their engineering constructions are fabricated locally. It is also worthy to note that based on the small and medium enterprises (SMEs) program of the Present Government in Nigeria, most of the Nigerian youths especially the male gender engage in training to acquire necessary requisite welding skills to function efficiently in the welding profession. To an extent, these objectives has been achieved by those engaged in the training to acquire the requisite welding skills.

However, no profession is without its attended risks. The one observable hazardous practice by artisans on the streets nowadays and especially in Arochukwu Local Government Areas is the use of welding machine without casing to execute welding projects. One may not understand the rationale behind this practice by these welders on the street. This is not far from the fear of unanticipated damage to the welding machines at their detriment due to excessive heat production from the transformer core. Thus, a welder on the street leaves his welding machine without casing during project execution to avoid burning and damaging of their hard earned welding machine to possible over heating caused by Eddy current heating effect of the welding transformer core in accordance with Joule's heating rate (I^2R). This has a lot of implications. A customer may face electric shock if contact is made wrongly with the machine by accident. Secondly, the welder and his trainee may also be harmed by electrocution resulting in fatal accidents. This can cause serious emotional trauma on the families of the victims and permanent damage to the life of the welder.

Moreover, the use of unprotected welding machines can pose electric shock hazard to the welding job clients and the artisan welder using them on the street. More so, to any discerning mind, unprotected welding machines by artisans on the street makes the practice unprofessional and unhealthy to engage into. Remarkably, one of the roles of any engineering practice is safety first. On the other hand, the students of physics and technical education in ASCETA can

acquire skills in practical fabrication of welding machines in addition to their knowledge in theoretically and fundamental rules governing the operation and functions of a welding machine using Lenz's and Faraday's laws of electromagnetic induction. Hence, the problem of the study: What is the effect of varying treatments on laminas of welding machine transformer core on heat production rate of locally fabricated welding machine caused by Eddy current (I_{Edd}) loss. Hence, these call for urgent action not only to proffer possible solutions, best treatment method of welding transformer core laminar and fabrication of welding machine to ensure locally made welding machine with nationally accepted standard comparable with factory fabricated welding machines; but also to sensitize the welders on the dangers of using welding machine without casing in their trade for project execution. Expectantly, this research project could do justice to this ugly trend and provide students of Abia state College of Education (Technical) Arochuku (ASCETA) the opportunity to acquire needed skills in welding machine design and fabrication.

In line with the assertions of Catarina (2014), welding is a fabrication process that involves the joining of metallic materials by causing coalescence. Practically, most of the engineering materials like common steels are preferred to be joined by welding methods. According to Mengesha and Adefris (2014), the welding fabrications are mostly done by arc welding methods which include: Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW) and Gas Tungsten Arc Welding (GTAW). However, other welding methods are brazing, soldering, and oxyacetylene welding processes. Furthermore, Mengesha and Adefris (2014) stressed that in automobile industries, joining process using resistant spot welding is applied to achieve efficient material joining processes. According to Ibrahim and Adamu (2016), most arc welding machines operate at the utility mains frequency of 50Hz to 60Hz with optional variable current selector to eliminate power quality problem. However, in this research project, the operational input frequency will be 50Hz which is the national grid frequency of Nigeria.

In their research and construction of arc welding machine, Ibrahim and Adamu (2014), listed the

instruments for the fabrication of arc welding machines to include: Transformer core, Copper wire/Aluminum wires, and insulators for separations of transformer core laminas. The transformer core is made of laminations assembled to provide a continuous magnetic field path with a minimum air gap included. According to Qi, Xigong and Zhaofeng (2013), the laminations help to minimize Eddy current loss and hysteresis reduction in transformer core of Arc welding Machines. The lamination thickness varies from 0.35mm for frequency of 50Hz to 0.5mm for frequency of 25Hz. However, this study based on the frequency of Nigeria national grid will be focusing on lamina thickness of 0.35mm gauge. The lamina plates can be L-shaped or E-shaped plates. Copper wire is a wire that has Redish orange colour. It is the wire of choice for fabrication of transformer coils because it is malleable and has low resistance, high thermal and electrical conductivity, low heat emission rate comparatively when current passes through it. It has coated body which helps to prevent short circuiting of the wires when coiled better than Aluminum which produces high magnetization with higher heat emission rate. Insulators on the other hand, are materials that do not conduct electricity. They are used to separate two wires to avoid contact of any form between the coiled wires in a transformer core. According to online source (<http://www.lstransformer.com>), insulating varnish is a specialized insulating coating substance composed of material such as acrylic resin, polyimide, and epoxy resin which can be applied by spraying, dipping and brushing.

The purpose of transformer laminar insulation with varnish were to provide electrical insulation, enhance performance, provide moisture resistance and corrosion effect, prevents Arc flashover, resist contaminants, ensure safe operation and extended lifespan of the transformer, ensure thermal stability of the transformer core. From the construction and testing of arc welding machines, Ibrahim and Adamu (2016) stress from their findings that the number of turns given to a welding transformer was synergic to its output and concluded that the higher the turns the more efficient the transformer becomes and the efficiency could be enhanced immensely by painting transformer core laminar with varnish. This could enhance Arc welding processes which are that

processes through which an electric arc between an electrode and a work piece is utilized to weld base metals together.

The basic elements involved in arc welding processes protection; involves the use of shielding gas while others employ flux coatings to shed the weld pool from impurity of the surrounding atmosphere. The various arc welding processes according to Singh (2006) are Carbon Arc Welding (CAW), Shielded Metal Arc Welding (SMAW), Flux Cored Arc Welding (FCAW), Gas Tungsten Arc Welding (GTAW), Gas Metal Arc Welding (GMAW), Plasma Arc Welding (PAW), Atomic Hydrogen Welding (AHW), Electro-Slag Welding (ASW), Stud Arc Welding (SAW) and Electric-Gas Welding (EGW). Although, there are different types of arc welding machines. This research project review focused on transformer type of welding machine. A transformer type welding machine takes power directly from an input voltage power supply source through its primary coils and transforms it to the voltage required for welding through electromagnetic induction in its secondary coils.

A transformer type welding machine basically operates through the principles of electromagnetic induction within the transformer. The transformer consists of two coil windings which are primary and secondary coil windings coupled by mutual magnetic flux. If one of these windings perhaps the primary windings is connected to an alternating voltage source, an alternating flux will be induced resulting to an induced voltage on the secondary coil windings whose amplitude will depend on the magnitude of the primary voltage, the frequency of the applied voltage, and the number of turns between the primary coil and the secondary coils. By properly proportionating the number of primary and secondary turns, almost any desired voltage ratio of transformation can be obtained (Fitzgerald, Kingsley & Umans, 2003). Other areas of interest in welding are welding hazards, safety precaution, and maintenance roles in welding. Safety is one of the major issues considered very important in welding profession. Also, in welding, it is expected that the welder should adhere to stipulated welding rules and guide lines for the safety of the welding technician.

According to online source (Wikipedia online encyclopedia), the most common hazards which apply to all metal works are accidents resulting from being hit by machinery and exposure to hot metal. However, other hazards identified according to Health and Labour Department (2002); include: Electric shock, Arc radiation, fire and explosion, Air contamination, compressed gases explosions and Hazards from chippings of welds. Electric shock hazards are associated with all electric devices. Same is applicable to welding machine. Although, home appliances rating of voltage of about 220volts is higher than the operational voltage of a conventional welding machine, the shock hazards of welding machines could be fatal. Thus, to avoid electric shock hazard, it is strongly advisable to use welding machines that meets recognized national standards to avoid unnecessary accidents.

The welding machines that meet these standards are indicated in their name plates; as stipulated by the National Electric Manufacturers Association (NEMA). Such standards are also mentioned in the manufacturers' manual. However, to comply with standard specification of the Occupational Safety and Health Act, (OSHA) requirements, manufacturers have recently made changes to improve the safety of the machines by ensuring output terminals are covered with insulating output devices. They also made the ventilating holes smaller such that the welder would not come-in-contact with high voltage inside the case. Also, in a transformer type welding machine, the primary and secondary coils are separated by insulating materials. The metal cases and the frames to the transformer of the welding machines must be grounded.

Also, in the case of welding machines used by artisans on the streets of Arochuku Abia State, such safety rules are neither adhered to nor in existence. Welding machines are used without casing thereby exposing the welder to possible danger of electric shock hazard, and exposure to high voltage wave fields. Welding protection by engineering practice requires a welder must wear protective welding Helmet with special filter glasses; as bad Helmet could expose the welder to arc light which can create discomfort. As frequently observed, welders and others have had their eyes exposed to arc light for a short or long period of time,

resulting to a feeling of sensation of sand in the eyes which may last for about 24 hours or more. The effect of arc flash is not instantaneous rather takes some hours to manifest and mostly in the night, and can be temporarily relieved by using eye drops or eye washes. It is recommended the victims should consult a doctor for treatment if the Arc pain sensation persists for more than 24 hours.

Also, another safety measures is the Skin Protection. To ensure protection of the skin, the welder is advised to always wear workshop clothes without tear or openings to prevent arc rays from contacting the skin. Exposure of the skin to Arc rays can cause arc burns. Gloves should also be put on by welders. And both gloves and workshop clothes should be kept dry always as safety measures. Industrially, about 6% of the fire outbreaks in industrial plants have been attributed to welding primarily with portable equipment in areas not specifically designated for such work. Eliminating all combustibles from the welding fires, Welding arc and oxy-acetylene fuel gas can rarely cause fire outbreak when used in an area designed for welding and cutting processes.

II. RESEARCH QUESTIONS

1. What are the differences between the mean temperature intervals of the control Arc welding machine system (W1) and the Experimental Arc welding machine systems (W3 & W2)?
2. What is the difference between the mean temperature intervals of the experimental Arc welding machine systems (W3 & W3)?

III. HYPOTHESES

1. H_{01} : There is no significant difference between the mean temperature interval of the control Arc welding machine system (W1) and the experimental Arc welding machine systems (W2 & W3).
2. H_{02} : There is no significant difference between the mean temperature intervals of the experimental Arc Welding Machine systems W3 and W2.

IV. METHODOLOGY

The construction and testing of the arc welding machine with varying transformer core laminar treatment was achieved through the following: Design stage to ascertain the number of primary and secondary coils to achieve desired voltage for weld, Development stage which involves treatment of the core laminas, winding of the primary and secondary coils of the transformer. Validation stage which involves checking of the material to ascertain if they meet required design specifications, evaluation stage involved testing of the welding machine to estimate its performance, measurement of temperature interval and analyses of data collected.

V. DESIGN OF THE STUDY

The design of the study was experimental research design. This is because the study involved practical fabrication of arc welding machine with varying lamina treatment and cooling system and practically testing of the rate of heat production of the machines for efficiency. This study was carried out in Arochukwu local government Area, Abia state. Specifically, the study was carried out in-line with the philosophy of the department of Physics School of Science Education, and department of electronic electrical technology school of technical education in Abia State College Of Education (Technical) Arochukwu. The sample of the study will be three welding machine with coated copper wire and Aluminum wires purposively selected out of the Population of the locally fabricated arc welding machine used by welders in the area. This is because the data required were temperature intervals from specified arc welding machine. The copper wire selected has relatively low resistance and low heating rate than other choice metal like Aluminum used. Hence, Copper wire was more suiting for the welding machines fabrication. The instrument for data collection was standard Celcius Scale calibrated Thermometer for temperature measurement measuring up to 100°C.

VI. METHOD OF DATA ANALYSES

The data collected will be analyzed using mean and standard deviation to answer research questions and t-

test analysis to analyze the hypotheses to ascertain the effect of treatment on heat production of a welding machine.

VII. RESULTS

Research Question 1:

What are the differences between the mean temperature intervals of the control Arc welding

machine system (W1) and the Experimental Arc welding machine systems (W2 & W3)?

Hypothesis 1:

H₀₁: There is no significant difference between the mean temperature interval of the control Arc welding machine system (W1) and the experimental Arc welding machine systems (W2 and W3).

Table (1.1): Mean, Standard deviation and t-test Statistic of the control Welding Machine W1 and the Experimental Welding machine W2.

Welding Machine	N	Mean T (°C)	SD	Df	ΔT(°C)	α=value	t _{cal}	t _{tab}	Decision
W1	5	8.20	3.37	8	6.66	0.05	2.69	1.86	H ₀ : Rejected
W2	5	3.22	1.54						

Table 1.1 showed that the control welding machine system W1 had mean temperature interval of 8.20 and standard deviation 3.37 while the treatment welding machine system W2 had mean temperature interval of 3.22 and standard deviation of 1.54. Also Table 1.1 showed that the difference in mean temperature interval between system W1 and system W2 is 6.66. The higher mean temperature interval of 8.20 and standard deviation of 3.37 against the lower mean temperature interval 3.22 and standard deviation of 1.54 of the treatment system W2 in addition to the

mean temperature interval of 6.66 is an indication that system W1 generated more heating effect during Arc welding than system W2. Furthermore, Table 1.1 showed result of t-test analysis. It showed that the t-test statistic (t_{cal}=2.69) with (t_{cal}=1.86). Since the (t_{cal}=2.69) is greater than (t_{cal}=1.86), tested at 0.05 level of significance, the hypotheses H₀₁ was not accepted. Hence, there is significant difference between the mean temperature interval of the welding machines' system W1 and system W2.

Table (1.2): Mean, Standard deviation and t-test Statistic of the control Welding Machine W1 and the Experimental Welding machine W3.

Welding Machine	N	Mean T (°C)	SD	Df	ΔT(°C)	α=value	t _{cal}	t _{tab}	Decision
W1	5	8.20	3.37	8	4.80	0.05	2.58	1.86	H ₀₁ : Rejected
W3	5	3.40	1.63						

The result of Table (1.2) showed that Mean temperature interval of control welding machine system W1 is 8.20 with standard deviation of 3.37. The mean temperature interval of treatment welding machine system W3 is 3.40 with standard deviation of 1.63. The difference in mean temperature interval between welding machine system W1 and system W3 is 4.80. The higher mean temperature interval 8.20 and standard deviation 3.37 of system W1 against the lower mean temperature 3.40 with standard deviation of 1.63 of system W3 coupled with the difference in mean temperature interval 4.80 between system W1

and system W3 indicate that welding machine system W1 generated more heating effect than system W3. The table 1.2 also showed that from the t-test analysis, (t_{cal}=2.58) with (T_{tab}=1.86). Since t_{cal}=2.58 is greater than T_{tab}=1.86, when tested at 0.05 level of significance, the hypothesis H₀₂ was not accepted. Hence, there is significant difference between the mean temperature intervals of welding machine systems W1 and W3.

Research Questions 2:

What is the difference between the mean temperature intervals of the experimental Arc welding machine systems (W3 & W2)?

Hypotheses 2:

H₀₂: There is no significant difference between the mean temperature intervals of the experimental Arc Welding Machine systems W3 and W2.

Table (1.3): Mean, Standard deviation and t-test Statistic of the Experimental Welding Machine W3 and the Experimental Welding machine W2.

Welding Machine	N	Mean T (°C)	SD	Df	ΔT(°C)	α=value	t _{cal}	t _{tab}	Decision
W3	5	3.40	1.63	8	0.18	0.05	0.16	1.86	H ₀₂ : Rejected
W2	5	3.22	1.54						

Table 2.0 showed that welding machine system W3 has mean temperature interval of 3.40 and standard deviation 1.63. Similarly, welding machine system W2 had mean temperature interval of 3.22 with standard deviation of 1.54. The difference in mean temperature interval between system W3 and system W2 is 0.18. The mean temperature intervals of 3.40 and 3.22 of the system W3 and system W2 and their mean temperature difference of 0.18 indicated that the two welding machine systems W3 and W2 generated low heating equivalently during Arc welding. In addition, the t-test analysis showed (t_{cal} = 0.16) with (t_{tab}=1.86). since the t_{cal} = 0.16 is lower than the t_{tab}= 1.86, when tested at 0.05 level of significant and degree of freedom (df=8), the hypothesis H₀₂ was not rejected. Hence, there is no significant difference in mean temperature interval between the welding machine systems w3 and W2.

Table 2.0 showed that both experimental welding machines W3 and W2 generated equivalently low heating effect during Arc welding machine testing. Furthermore, Table 2.0 showed that there is no significant difference between mean temperature intervals of system W3 and system W2. The low heating effect showed indicated that treatments on both systems W2 and system W3 produced positive effects in lowering their rate of heat generation. It also showed that the treatment had positive effect on welding machine when fabricated with either coated copper wire or insulated aluminum wire. The findings corroborated with the findings of Ibrahim and Adamu (2016), who found that treatment of transformer lamina core with vanishing and good secondary and primary coils number of coils combination enhances welding machine efficiency and reduce effectively eddy current heat loss in welding machine transformer.

VIII. DISCUSSION

Table 1.1 and Table 1.2 revealed that the control welding machine system W1 generated more heating effect than the experimental welding machines W2 and W3. Furthermore, there was a significant difference in mean temperature intervals between system W1 and systems (W2 & W3) respectively against the system W1 that generated higher heating effect than the two welding machines W2 and W3 with lower heating effect. The significant difference in mean temperature interval between system W1 and Systems W2 and W3 in favour of systems W2 and W3 with lower generation of heating effect; was attributed to the varying treatments and design specifications of the experimental welding machines W2 and W3.

IX. CONCLUSION

From the findings of the study, it was concluded that treatment of transformer core laminas with adequate vanishing and installation of cooling system for good air current through a welding machine system has positive effect of reducing eddy current induction and lowering heating effect in a locally fabricated Arc welding machine than Arc welding machine with poor transformer lamina vanishing treatment without air cooling system.

From the findings of the study, it was also concluded that when laminas of transformer core is treated with adequate vanishing to enhance insulation with good cooling system, the treatment would show positive effect on heating rate of locally fabrication Arc

welding machine with either coated copper wire or Aluminum wire.

X. RECOMMENDATION

From the major findings of the study, the following recommendations were made:

1. Design and fabrication of locally made Arc welding machine should adapt best practices which include application of adequate varnish on transformer lamina before coupling with cooling system to ensure heat production is minimized during Arc welding operation.
2. Fabricators of locally made Arc welding machine should ensure the transformer is properly cased to avoid electric shock hazards at welding sites and workshops.
3. Naked wires should be properly taped to avoid electric shock hazards to both the welder and clients at the welding workshop.
4. Physics and other relevant technical students should be funded to acquire skills of welding machine fabrications.

REFERENCES

- [1] Safety And Health Labour Department (2002). Code Of Practice-Safety And health At Work for Manual Electric Welding. Online: [Http: Www, Ifogov, Hve/Labour](http://www.ifogov.hve/labour). Retrieved June, 2022.
- [2] Shanti N. (2002). Automation India Welding Technology Part II New Delhi-11004, Online [Info@. Automation india welding Occupational.Com](mailto:Info@Automationindia.com). Wiki [Edia Free Encyclopedia. The Arc Welding Machine. An Introduction to Safe Operations.
- [3] [Http://En.Wikipedia,Org/Wiki/Arc Welding](http://en.wikipedia.org/wiki/Arc_welding).
- [4] S. Catering (2014). Finite Element Analysis of A Welding Transformer, Vol.18, No.March. Pp 212 221.
- [5] Michael, P. (2006). The importance of Physics: Breakthroughs Drive Economy, Quality of Life, World Leaders, Public Increasingly Take Scientific Advances for Granted. Retrieved from <http://www.physics2005.org>.

- [6] M. Mengesha & M. Adefris (2014). Power Quality Assessment and Mitigation AtWalya Steel.
- [7] Industries And Ethio. *Plastic Share Company.Vol.31, No Pp 10-17.*
- [8] Q.I.U.Qi, L.I. Xigong, Z. Zhaufeng and S. Wei. The Devepment of A 20KHHZ High Power Inverter Spot Welding Power Supply, Vol.51. No. I.
- [9] Theraja, B. L & Theraja A, K. (2003). A text Book of Electrical Technology 23rdmedition. S-Chand and Company Ltd. India.
- [10] I.I Ibrahim& B.I Adamu (2016). Design And Construction of A Welding Machine with A Variable
- [11] Current Selector. *Independent Journal of Pure and Applied Sciences. Published By Exford Research and Publication, Vo;.6no.2.*