

Transmission Cable Type As A Function Of Effective And Safe Power Utilization In An Electrical Circuit

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Abstract

In this research, experiments were carried out on the performance of certain common installation cables during which the temperature of each cable was recorded at intervals of 5 minutes (300 seconds) from 0 to 30 minutes of consecutive welding operation. A 5.0mm (2x2.5mm) iron China cable labelled as “Sunrise wire & cable” and a 5.0mm carbon-steel cable type were used as a group of cable with a high level of magnetism, while a 5.0mm (2x2.5mm) pure copper cable labelled as “Kable Smart Nigeria wire and cable fire resistance” and a 5.0mm pure aluminium cable (service cable) were used as another cable group that has a negligible or near zero level of magnetism to power a welding machine (ACARC WELDER, Model: BX1-300D, Produce Standard: GB15679.1-20004, frequency: 50Hz, power rate: (220-380V)(100-300A). Heavily covered (coated) electrodes (D/d = 1.45 – 1.80) were used in the experiment as the welding electrodes. The voltages across the arc during welding operations were measured and values obtained are in the range 3.90V to 5.37V with 2.74 to 3.77V and 22.8V to 31.4V with 13.62V to 18.77V respectively for the two cable groups as power lead cables to the welding machine while current was adjusted within 100A to 300A. The temperature of the cables was also recorded at the same intervals and range of time. The results show that power loss is enormous with the cable group A, and very low with cable group B when they were respectively used as power supply conducting leads connecting the power source and the welding machine. The effect of the results is manifested in the nature of the finished products from the practical welding operations as could be graded in the range zero-, worst-, worse-, bad- and fair-products; and fair-, good-, very good- and excellent/perfect-products respectively for cable group A and cable group B as voltage/current carrying conductors to the welder. The temperature gradients for the two groups of cable used is an upward slope that shows a set of corresponding and normal increments with the welder current settings for copper cable, and approximately normal increments for aluminium cable; while the increments appear abnormal for the group A cables consisting of iron cable and carbon-steel cable. The results indicate that much power was lost as heat energy in group A cables.

Keywords: Experiment, installation, magnetism, temperature, current and voltage.

Introduction

Naturally electricity and magnetism are fundamentally interlinked. Both magnetism lacking electricity, and electricity without magnetism, are inconsistent with special relativity, due to such effects as length contraction, time dilation, and the fact that the magnetic force is velocity-dependent. However, any magnetic material used to power any machine that requires high power consumption will impose an undue extra magnetism to the normal field effects in such

operation leading to an abnormal and unnecessary power dissipation as a wastage (Einstein's theory of special relativity).

Generally, a current is always accomplished by certain magnetic effect. A current carrying conductor placed near a magnetic needle will deflect the needle to a certain direction; and also when the direction of current in the conductor is reversed, the needle will deflect in opposite direction. It means there is a magnetic field due to the current carrying conductor (Danish Physicist, 1819).

The heat loss when current passes through a conductor is directly proportional to the resistance of the conductor, $H = I^2Rt$. That is, the heating of current in a conductor is strictly a function of its resistance. (Joule's law). An additional magnetism to flow of current via a conductor constitute an undue disturbance to the flow of current. This is the root of the frequent fire hazard in several cities of Nigeria where normal (nonmagnetic) conductor was not used for electrical wiring of structures.

The magnetic flux density of the induced magnetic field around the conductor increases if the current flowing through the conductor is increased and it decreases if the current is decreased (Biot Savart's law). The gravity of heat effect in a current carrying magnetic conductor enormous when the current is high, which is the characteristic of a high powered machine.

Temperature is certainly an important factor in evaluating equipment. However, if you follow guidelines that are based solely on absolute temperature measurement -or on a temperature rise (Delta T) —you run the risk of incorrectly diagnosing your problems. The consequences of such actions can lead to a false sense of security, equipment failure, fire, and even the possibility of personal injury. Understanding the additional factors involved in diagnosis is essential for obtaining productive results. One of these factors is the load or current flowing through conductors. The load can have a drastic effect on the temperature of a component. Changing loads can cause additional concerns because temperature changes lag behind load changes. The purpose of this paper is to illustrate the relationship between load and temperature of a faulty connection. The thermal response of a changing load is also investigated (Bernard R. et al, 2011)

This research looks into the effect of excess magnetism on the output power delivery of nonmagnetic and magnetic conductors when used to power a loaded machine. In the research experimental, magnetic and non-magnetic conductors were used to power a welding machine (ACARC WELDER, Model: BX1-300D, Produce Standard: GB15679.1-20004, frequency:

50Hz, power rate: (220-380V)(100-300A) with a heavily covered (coated) electrode ($D/d = 1.45 - 1.80$) used in the experimental welding during which the voltages across the arc g welding operations were measured. The temperature of the conducting cables were taken at several intervals.

The current rating or current-carrying capacity, ampacity of a high powered machine is always set very high to withstand cases of abnormal application to exceptionally high current. Ampacity is the RMS electric current which a device or conductor can continuously carry while remaining within its temperature rating That is, the maximum amount of electrical current a conductor or device can carry before sustaining immediate or progressive deterioration. The ampacity of a conductor depends on its insulation temperature rating, the electrical resistance of the conductor material, the frequency of current (in the case of alternating current) and the ability to dissipate heat (which depends on conductor geometry and its surroundings) and the ambient temperature (Wikimedia Project, 2014).

Materials and Methods

The materials used in the experiment include magnetic conductors - 5.0mm (2x2.5mm) iron China cable labelled as “Sunrise wire & cable” with another 5.0mm carbon-steel cable type; magnetic conductors - 5.0mm (2x2.5mm) pure copper cable labelled as “Kable Smart Nigeria wire and cable fire resistance” with another 5.0mm pure aluminium cable (service cable), a welding machine (ACARC WELDER, Model: BX1-300D, Produce Standard: GB15679.1-20004, frequency: 50Hz, power rate: (220-380V)(100-300A), heavily covered (coated) electrodes ($D/d = 1.45 - 1.80$), power source (mains), welding glasses and other protective materials like rubber hand-gloves. D/d is the ratio of electrode diameter (D) to the bare-rod diameter (d), which gives in fact the thickness of the coating. The normal manual welding method was used throughout the experiment, where the welding machine was perfectly fitted with the earth conductor had full and strong contact with load; and powered via the mains power supply (240V, a.c).The voltages across the arc during welding operations were measured and values obtained are the in range 3.90V to 5.37V with 2.74 to 3.77V and 22.8V to 31.4V with 13.62V to 18.77V respectively for the two magnetic conductors and the two non-magnetic conductors used as power lead cables to the welding machine while current was adjusted within 100A to 300A.The temperatures of the cables were recorded at intervals of 5minutes (300seconds) from 0 to 30minutes.

Results and Discussion

Table 1: The voltages across the arc in the experiment with each cable at different ACARC current ratings.

Machine Current(A)	Arc Voltage (V)			
	Cu cable	Al cable	Fe cable	C –S cable
100	23.20	13.62	3.90	2.74
140	25.42	14.92	4.27	3.01
180	26.91	15.80	4.52	3.18
220	29.73	17.45	5.10	3.51
280	31.60	18.55	5.30	3.73
300	31.98	18.77	5.37	3.77

Table 2 (a) Temperature of Non-magnetic Power Supply Cables (copper) under Welding Operating with Time at Different Machine Current Settings.

Time (mins)	T ⁰ C/100A	T ⁰ C/140A	T ⁰ C/180A	T ⁰ C/220A	T ⁰ C/280A	T ⁰ C/300A
5	36.80	37.00	37.20	37.80	38.50	38.80
10	39.70	37.60	39.90	39.40	41.20	42.20
15	40.30	38.90	40.60	41.20	43.10	44.70
20	40.50	40.10	41.60	42.60	44.20	45.30
25	40.90	45.60	42.10	43.80	45.10	46.80
30	41.10	41.80	42.70	44.60	46.00	47.10

Table 2 (b) Temperature of Non-magnetic Power Supply Cables (aluminium) under Welding Operating with Time at Different Machine Current Settings.

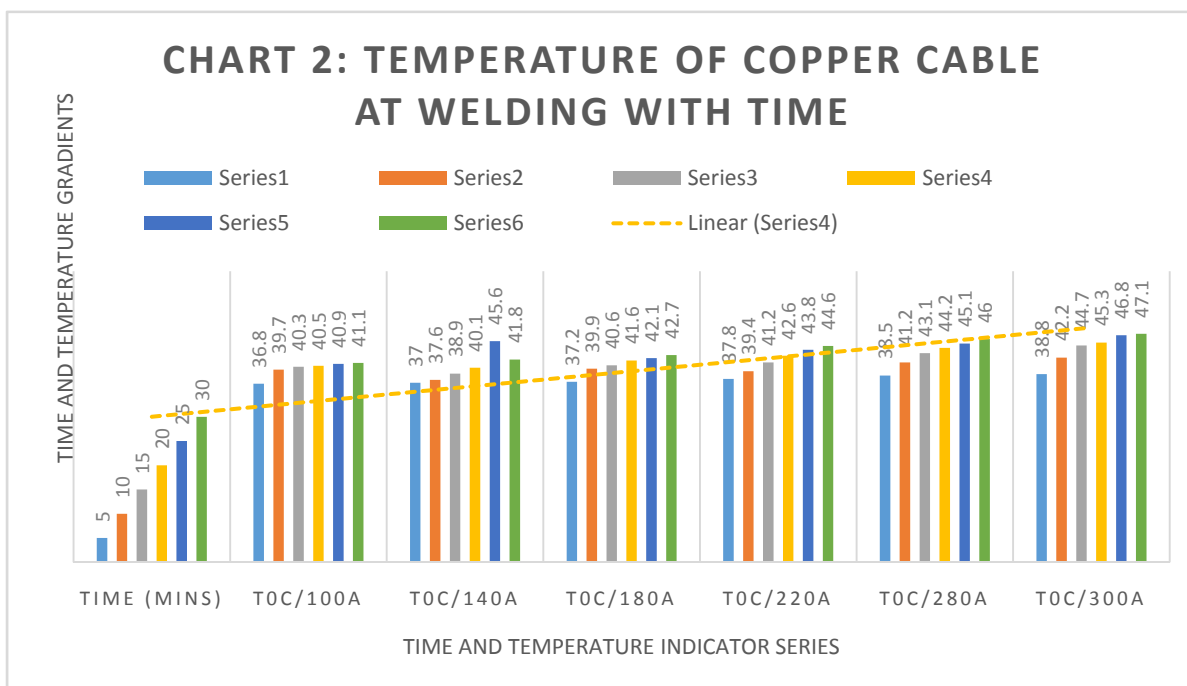
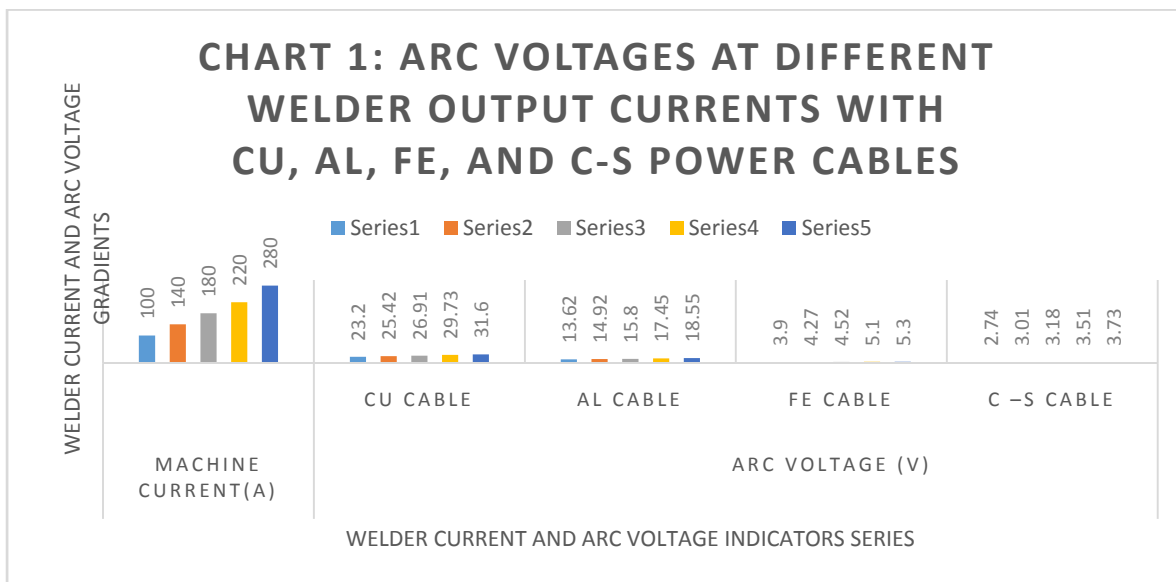
Time (mins)	T ⁰ C/100A	T ⁰ C/140A	T ⁰ C/180A	T ⁰ C/220A	T ⁰ C/280A	T ⁰ C/300A
5	62.56	62.90	63.24	64.26	65.45	65.96
10	67.49	63.92	67.83	66.40	70.04	71.74
15	68.51	66.13	69.36	70.04	73.27	75.99
20	68.85	68.17	70.72	72.42	75.14	77.01
25	69.53	70.72	71.57	74.46	76.67	79.56
30	69.87	71.06	72.59	75.82	78.20	80.07

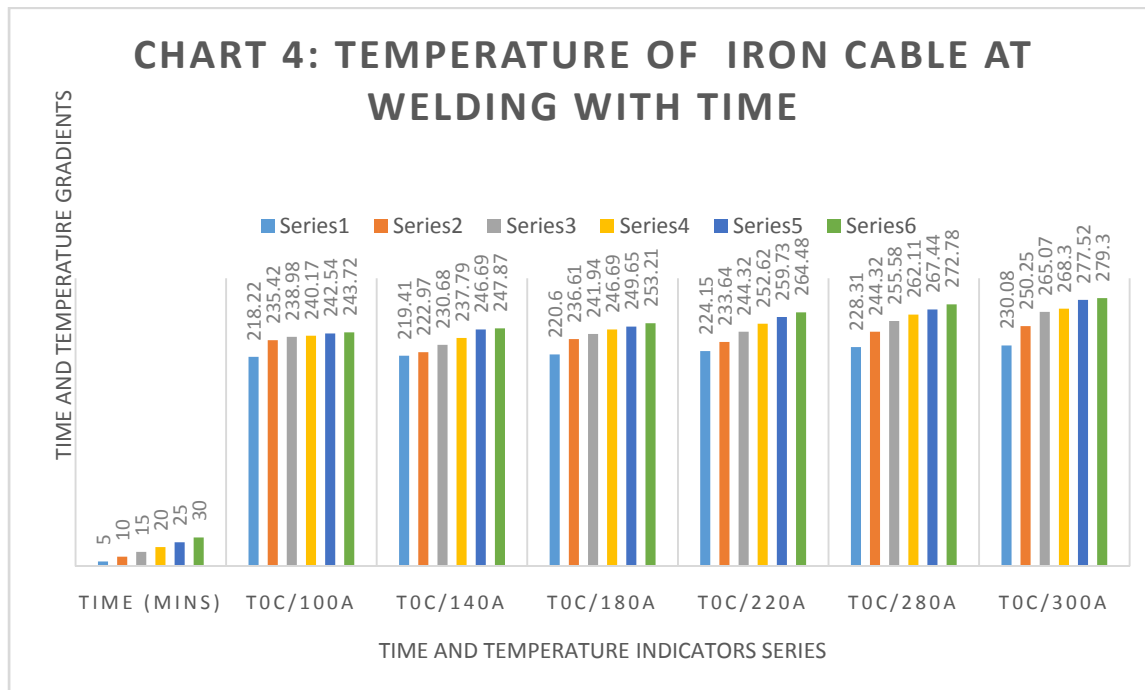
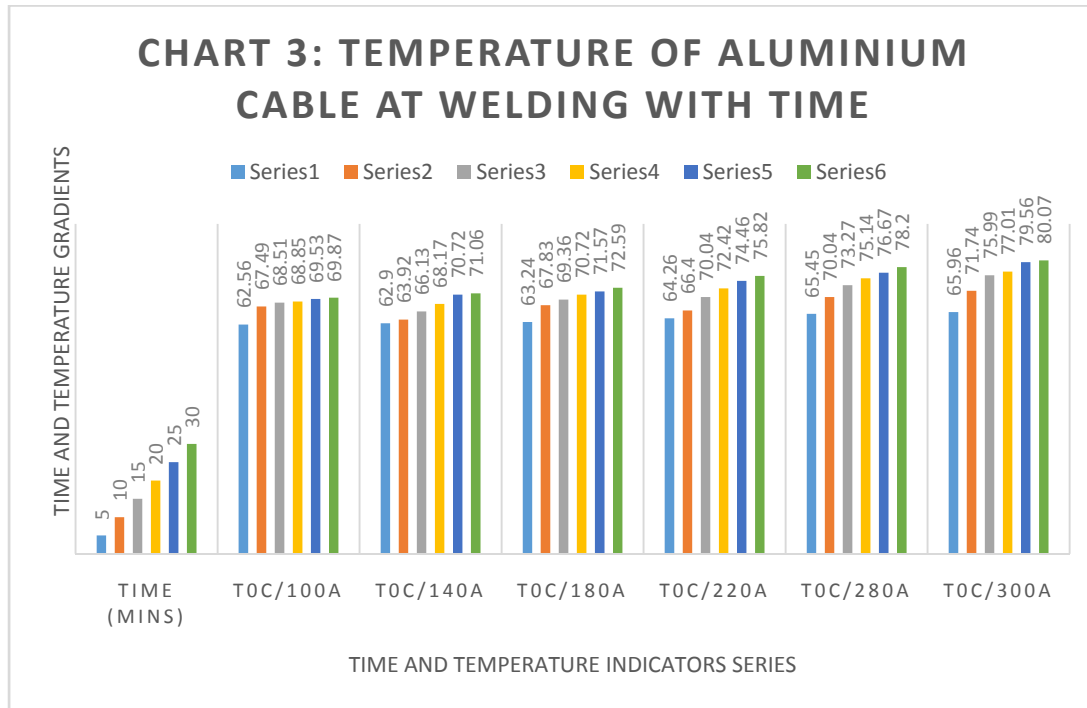
Table 2 (c) Temperature of Magnetic Power Supply Cables (iron) under Welding Operating with Time at Different Machine Current Settings.

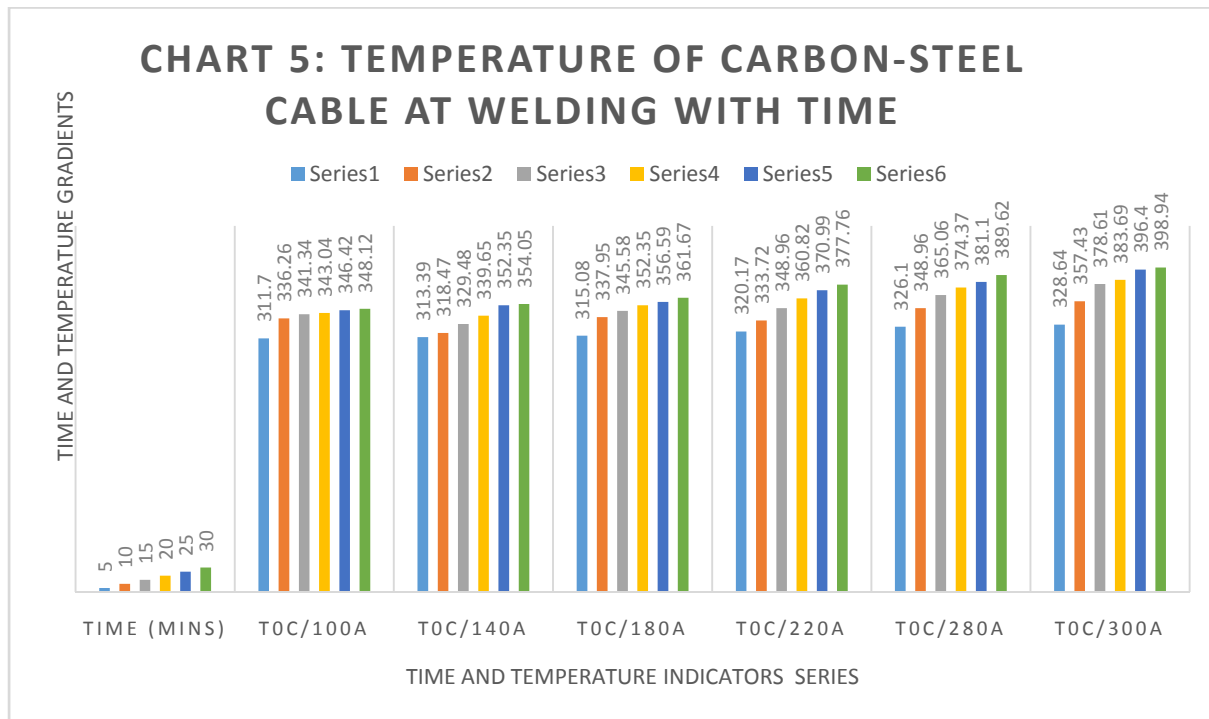
Time (mins)	T ⁰ C/100A	T ⁰ C/140A	T ⁰ C/180A	T ⁰ C/220A	T ⁰ C/280A	T ⁰ C/300A
5	218.22	219.41	220.60	224.15	228.31	230.08
10	235.42	222.97	236.61	233.64	244.32	250.25
15	238.98	230.68	241.94	244.32	255.58	265.07
20	240.17	237.79	246.69	252.62	262.11	268.30
25	242.54	246.69	249.65	259.73	267.44	277.52
30	243.72	247.87	253.21	264.48	272.78	279.30

Table 2 (d) Temperature of Magnetic Power Supply Cables (carbon-steel) under Welding Operating with Time at Different Machine Current Settings.

Time (mins)	T ⁰ C/100A	T ⁰ C/140A	T ⁰ C/180A	T ⁰ C/220A	T ⁰ C/280A	T ⁰ C/300A
5	311.70	313.39	315.08	320.17	326.10	328.64
10	336.26	318.47	337.95	333.72	348.96	357.43
15	341.34	329.48	345.58	348.96	365.06	378.61
20	343.04	339.65	352.35	360.82	374.37	383.69
25	346.42	352.35	356.59	370.99	381.10	396.40
30	348.12	354.05	361.67	377.76	389.62	398.94







Considering table 1, the arc voltages between electrode and the base material during the experimental welding activities were recorded for each power supply cable at various welder current settings. The table reflects that the magnitude of an arc voltage is directly proportional to the magnitude of welder current setting. At 100A, the welder arc voltage is 23.20V and at 300A, it is 31.98V for copper cable; and likewise in the case of the magnetic cable (carbon-steel), its arc voltage values, which appear the lowest set of values in the series, at 100A current setting, the arc voltage is 2.74V, while the value appreciated to 3.77V at 300A setting of the welder. The set of arc voltages in the cases of the nonmagnetic conductor (aluminium) and the magnetic conductor (iron) traced the same value path pictured by table 1.

Tables 2a -2d reflect the operating temperatures of the four different conductors used as the magnetic and nonmagnetic conductors in the research experiments. The tables indicate that temperature gradient of a conducting material is a function of the operating current, resistivity of the conductor and the length of time of the operation. Keeping the variable parameters of resistivity constant (parameters like lengths and cross-section areas of the conductors), heating of a conductor during the welding activities will then be a sole function of the welder current output setting, conductor's resistance and period of operation. Table 2a recorded the temperatures of the nonmagnetic (copper) cable at each welder current setting at several time intervals. The content of the table has it that at 300A welder current, the cable temperature is 38.80⁰C with the cable powered the welder steadily for 5minutes, while it increased to 47.10⁰C when the operation was extended to 30minutes with the cable. Also, at 100A welder current, the cable temperature is 36.80⁰C with the cable powered the welder steadily for 5minutes, while it increased to 41.10⁰C

when the operation was extended to 30minutes with the cable. Table 2b recorded the temperature values for another nonmagnetic conductor (aluminium) performance during the welding experiments. At 100A welder current, the temperature of the cable is 62.56°C while it was used to power the welder steadily for 5minutes, and the temperature rose to 63.24°C and 72.59°C at 300A welder current with aluminium cable used to power the welder for 5minutes and 30minutes respectively. Tables 2c and 2d discuss the temperature response of magnetic cables, iron and carbon-steel. The records show the temperature trends to trace the same path of the nonmagnetic cables. At 100A welder current, the temperatures of iron and carbon-steel cables are respectively 218.22°C and 311.70°C ; and both rose to 279.30°C and 398.94°C respectively at 300A welder current.

The graphical illustrations of data in tables 1 and 2(a-d) are shown in charts 1-5 where the periods of operation, the arc voltages and the temperatures of the respective conductors are indicated as series for a clear and better understanding of the experimental results.

The analysis of these results indicates that the power delivery efficiency of a cable is function of several variable parameters like the temperature response of the conductor, the operating current, resistivity of the conductor, the length of time of operation and some other factors, such as its magnetic make-up, that are inherent properties of the conductor.

Conclusion and Recommendation

It is evident from the results that the efficiency, reliability, quantity, quality and safety of power delivered by a conductor to loads is partly depended on the magnetic property of the conductor. It has been shown that magnetism places an additional burden to the flow of current in a current carrying conductor which has resulted in heating up the conductor while powering a high power demanding machine. This holds true in the cases of iron and carbon-steel conductors, which are both magnetic in nature. It is therefore what to recommend that while and where there is need to have an electrical circuit installed, the circuit and service cables should, as a matter of compulsion, be designed and effected with a cable type that is of negligible or zero magnetism content. This will in long way protect our structures from incidence of fire out break on the account of slight overloading in terms of input current and utilization load.

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