

Maintenance Practices Required by Electrical Installation and Maintenance Work Personnel for Repairing Industrial Motors in Enugu State

by

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Abstract

*The study determined to find out the maintenance practices required by electrical installation and maintenance work personnel towards the industrial motor. Three research questions guided the study while the null hypotheses formulated were tested at 0.05 significant level. The population of the study was 500, which comprised 120 EIMW teachers and 380 EIMW technicians. The sample for the study was 200, which comprised 80 EIMW teachers and 120 EIMW technicians. A structured questionnaire was used to collect data for the study. The internal consistency of the questionnaire was 0.68 for troubleshooting, 0.65 for precautionary measures and 0.76 for skills needed in the maintenance of the industrial motor which was determined using Cronbach Alpha reliability method. Mean was used to answer the research questions while *t* – test was used to test the null hypothesis at 0.05 level of significance. The findings of the study showed four significant ways of troubleshooting faults in an industrial motor, one significant precautionary measure that should be taken in industrial motor and two significant skills needed in the maintenance of industrial motors. It was recommended that workshops/seminar should be organised promptly for electrical technology teacher to acquaint them with maintenance practices required for the industrial motor. This will help them in teaching their students.*

Keywords: industrial motor, safety precautions, motor faults, maintenance skills

Introduction

The key to minimising industrial motor problems is scheduled routine inspection and maintenance. An electric motor is an electrical machine that converts electrical energy to mechanical energy. A motor may require additional or more frequent attention if a breakdown would cause health or safety problems, severe loss of production, damage to expensive equipment or other serious losses. Maintenance is the activities carried out in the workshop to prevent damage to tools and equipment, wastage of materials and death or injury of the personnel. Maintenance involves all the activities taken in order to prolong the service life of the item (Bakare, 2006). Adequate maintenance activities (which involves an electrical motor) in the electrical workshop usually involve the contributions of an expert or an electrical technician. An electrical technician is a person who has been trained formally on how to handle some fault in

electrical motors (Career-Builder, 2017). Electrical technicians help create, maintain and repair the electrical components and equipment or device that involves electricity (Career-Builder, 2017). They can sometimes work with electricians or electrical engineers, or work on site to keep machinery and speciality equipment running correctly. He acquires skill in the formal education system where he is taught several ways of handling electric motor such as troubleshooting, replacement of part, clean up services, etc.

One of the educational programmes where maintenance skills in electrical appliances can be obtained in Nigeria is Technical Education. Technical education is defined as that aspect of education that leads to the acquisition of practical and applied skills as well as basic scientific knowledge (Kotsikis, 2007). In this sense, it forms a practical segment of education that involves skill acquisition. Nwachukwu, Bakare & Jika (2009)

affirmed that technical college provides students through training with the relevant and adequate knowledge, skills and attitude for employment under the guidelines of a teacher in related occupations. In order to achieve these objectives, various trades or occupations are learnt at technical institutions including electrical technology.

Electrical technologies deal with all machines, tools, devices, and systems in which a current or a flow of electrons takes place through conductors and metals. It involves the design and development of high-voltage systems and components such as motors, generators, heaters, electrical power transmission and distribution systems, radio wave and optical systems, converters, and control systems for operating light and heavy machinery. Almost all low or high-tech gadgets today make use of electrical current to operate, making electrical energy the main and possibly the only factor to define what electrical technology is (Moon, Jeong, Lee & Pak, 2013). Electrical technology however, not only involves the design and production of all the electrical systems mentioned, but also the installation, testing and maintenance of these systems. An electrical technician installs, services, troubleshoots; and performs preventive and predictive maintenance functions on equipment. This includes plant lighting equipment and receptacle circuits, motors, starters, motor control centres, programmable controllers, control panels, electrical control systems and transformers. They may also service high voltage electrical systems, and ensure that work is in accordance with relevant codes. They repair, test, adjust, calibrate or install electronic equipment, such as industrial controls, transmitters, and antennas (Finley, 2010). Induction motors are mostly used as home appliances and in various industries. They are rugged and have moderately expensive (D'Aguanno, Marignetti & Faginoli, 2018).

Faults which occur mostly in induction motors are: motors fail to start, excessive vibration, excessive sparking when started, low speed, motor hums but will not start. If these are allowed to linger for a long time, it would cause a permanent damage to the motor. These faults can be traced and repaired by the electrical

technician by the process called troubleshooting (Siddique & Yadava, 2005). Troubleshooting therefore can be defined as the process of solving a problem or determining a problem to an issue. It often involves the process of elimination, where a technician will follow a set of steps to determine the problem or resolve the problem (Siddique & Yadava, 2005).

Each fault mentioned above has its unique solution which includes: if the motor fails to start, examine fuses, switches, and connections between motor terminals and points of broken connections service. Also look for broken wires. If the motor is having excessive vibration, have rotor balanced. If the motor is having excessive heating, reduce load, for excessive sparking when started, clean and sandpaper. If the motor suddenly begins to operate on a low speed, reduce load.

Statement of the Problem

In modern times, the advancement in electrical appliances has drastically taken new dimensions that demand correspondent change in the curriculum contents of related Electrical technology education programme. This is as a result of the changing demand in the skills needed for the repair and maintenance of industrial motor. Therefore, it is pertinent that electrical installation and maintenance personnel are acquainted with the possible faults that may arise in the constant use of industrial motors. The repair and maintenance skill can be learnt in technical colleges or informally in industrial workshops. In the event of faulty motor components, electrical technicians are expected to apply their expertise knowledge skilfully towards repair and maintenance services. These technicians are supposed to be trained formally in technical college and undergo internship training through SIWES. Therefore, there is still skill gap between EIMW students and industrial needs of their ability to carry out repair and maintenance practices as sole proprietors or as an employee.

There is also the problem of inadequate electrical motor components that electrical technicians can effectively use for servicing, troubleshooting and complete repair. Some technician also find it difficult to identify original motor parts to replace worn out ones, this can be attributed to the fact that many electrical technicians have not acquired

industrial motor maintenance skills. This may be due to the fact that industrial motormaster trainers in informal sector are yet to grasp all it takes to offer effective maintenance of industrial motor. Due to inadequate tools and parts, also, technical college administrators are yet to adequately execute the practical skill as slated in the electrical installation and maintenance work curriculum. Therefore, this study seeks to find out the maintenance practices required for industrial motors by electrical technicians in Enugu state.

Purpose of the study

The general purpose of the study was to investigate the maintenance practices required by electrical installation and maintenance work personnel for repairing industrial motors in Enugu State. Specifically, the study is determined to find out:

1. Ways of troubleshooting faults in an industrial motor
2. The precautionary measures that should be taken in industrial machine maintenance
3. The skills needed in the maintenance of industrial motor.

Research questions

In consideration of the purposes of the study, the following questions asked will guide the research study:

1. What are the ways of troubleshooting faults in an industrial motor?
2. What are the precautionary measures that should be taken in industrial motor maintenance?
3. What are the skills needed in the maintenance of industrial motor?

Hypothesis

H₀₁: There is no significant difference in the mean responses of electrical technicians and electrical installation and maintenance work teachers on the ways of troubleshooting faults in an industrial motor.

H₀₂: There is no significant difference in the mean responses of electrical

technicians and electrical installation and maintenance work teachers on the precautionary measures that should be taken in industrial machine maintenance.

H₀₃: There is no significant difference in the mean responses of electrical technicians and electrical installation and maintenance work teachers on the skills needed in the maintenance of industrial motor.

Methodology

The study adopted survey research design. Survey research design enables the researcher to selected few population to investigate, describe and explain what is in existence on the present phenomena being investigated (Ali, 2006). Three purposes, three research questions and three hypotheses guided the study. The population for the study was 500 comprised 120 electrical installations and maintenance work teachers and 380 electrical installation and maintenance work technicians. Sample for the study was 200 electrical experts comprising 80 electrical installation and maintenance work teachers from 10 government technical colleges and 120 electrical installation and maintenance work technicians.

The primary sources of data are from the electrical installation and maintenance work technicians and teachers in Enugu state, Nigeria through a structured questionnaire measured on a five point Likert scale of 5 (very important) – 1 (unimportant). The first part of the instrument measures the demographics and the second part measures the maintenance practices carried out on industrial motors which include troubleshooting and precautionary measures taken to maintain electrical industrial motors. The instrument for the study was self-constructed by the researcher. The industrial motor faults troubleshooting contained eighteen items, precautionary measures contained eight items and the skills needed in the maintenance of industrial motor contained seventeen items. The instrument for the study was subjected to face validation to ascertain the appropriateness of the questionnaire items. Three experts from the Faculty of Vocational Technical Education, University of Nigeria, Nsukka were required to validate the research instrument. These experts

were required to make suggestions to improve the instrument to meet the objectives of the study. Their suggestions were utilized to develop the instrument towards data collection.

Twenty (20) copies of the questionnaire was administered to electrical installation and maintenance work teachers and technicians that were not part of the population in order to measure the reliability coefficient of the study. The reliability for the study was done using Cronbach alpha method. The reliability coefficient for troubleshooting faults in industrial motor is 0.681, a precautionary measure in industrial motor maintenance is 0.654 and skills needed for maintenance of industrial machines are 0.781. Data was collected by hand through direct delivery which involved the use of research assistants in data

collection. The means of the responses of electrical installation and maintenance work teachers and technicians which determines the level of acceptance of the questionnaire items are shown in tables 1 – 3 using SPSS v.23. t-test was used to test the hypothesis at a significant level of 0.05. The mean response of the items is interpreted using the real limit of number as follows: very important (VI), important (I), moderately important (MI), slightly important (SI) and unimportant (UI) while the null hypothesis is significant if $t_{cal} > t_{tab}$.

Results

The data for responding to the research questions are presented in table 1 and 2. The remark on each of the items are NS – not significant or S – significant.

Table 1: Mean, Standard Deviation and P-value of Respondent's Responses on the Ways of Troubleshooting Faults in an Industrial Motor

S / N	Ways of troubleshooting faults in an industrial motor	Respondents				Grand total		R	t-cal	Sig 2-tailed	Remark
		$\bar{x}_{ET}$	SD_{ET}	$\bar{x}_T$	SD_T	$\bar{x}_{GT}$	SD_{GT}				
1	Check if the motor is mis-wound, damaged or rotor is striking the stator	4.35	0.752	4.38	0.584	4.36	0.668	I	-0.376	0.707	NS
2	Check if the stator is grounded, check for single phasing	4.32	0.623	4.30	0.624	4.31	0.623	I	0.278	0.782	NS
3	Motor runs but dies down, check voltage level and capacitor	4.49	0.635	4.45	0.593	4.47	0.614	I	0.467	0.641	NS
4	If motor takes too long to accelerate, check for defective capacitor and bad bearings	4.42	0.603	4.58	0.566	4.50	0.584	VI	-1.911	0.050	S
5	Motor runs in wrong direction, check for incorrect wiring of winding	4.62	0.486	4.46	0.501	4.54	0.493	VI	2.286	0.023	S
6	Motor overload protector continually trip, check for excess load on motor, check whether overload protector is in good condition	4.50	0.565	4.42	0.670	4.46	0.617	I	0.947	0.345	NS
7	Motor vibrates on running, check for defective bearing	4.57	0.496	4.56	0.499	4.56	0.497	VI	0.174	0.862	NS
8	Bearing continually fails, check bearing, check overload of motor and ensure that right bearings	4.58	0.495	4.55	0.500	4.56	0.497	VI	0.464	0.643	NS

Key: X_{ET} = Mean of electrical technician, X_T = Mean of EIMW teachers, SD_{ET} = Standard deviation electrician technician, SD_T = Standard deviation EIMW teachers, X_{GT} = Grand mean, SD_{GT} = Grand standard deviation, R = Remark	troubleshooting faults in an industrial motor. Also, the standard deviation of the responses of the respondents on the 18 items ranged from 0.49 to 0.72 which revealed that the respondents are close in their opinion.
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troubleshooting faults in an industrial motor. Also, the standard deviation of the responses of the respondents on the 18 items ranged from 0.49 to 0.72 which revealed that the respondents are close in their opinion.

The test of hypothesis presented in Table 1 showed that there is no significant difference in the mean opinion of the electrical technicians and electrical installation and maintenance work teachers in 14 items and there is a significant difference between the mean opinions of the electrical technicians and electrical installation and maintenance work teachers in 4 items.

Since there is no significant difference between the mean opinion of the electrical technicians and electrical installation and maintenance work

teachers, the null hypothesis (H_{01}) for the 14 items are accepted and rejected for 4 items, thereby accepting the alternative hypothesis.

Table 2: Mean, Standard Deviation and p - value of Respondent's Responses on the Precautionary Measures that should be taken in Industrial Motor Maintenance

S	Precautionary / measures that should be taken in industrial motor maintenance	Respondents				Grand total		R	t-cal	Sig 2 -tailed	Remark
N		$\bar{x}_{ET}$	SD_{ET}	$\bar{x}_T$	SD_T	$\bar{x}_{GT}$	SD_{GT}				
1	Disconnect power to the motor before performing services	4.49	0.565	4.37	0.512	4.43	0.538	IM	1.484	0.139	NS
2	Discharge all capacities before servicing motor	4.55	0.515	4.32	0.522	4.43	0.518	IM	3.120	0.002	S
3	Always keep hands and clothes away from moving part	4.53	0.578	4.52	0.527	4.52	0.552	VI	0.103	0.918	NS
4	Be sure required safety guards are in place before starting	4.26	0.730	4.23	0.697	4.24	0.713	IM	0.282	0.779	NS
5	Cleanliness is absolutely critical when replacing bearing	4.40	0.601	4.27	0.635	4.33	0.618	IM	1.502	0.135	NS
6	Badly worn out bearing needs replacement	4.10	0.678	4.37	0.682	4.23	0.680	IM	-2.802	0.006	NS
7	If installation of brushes needs to be done, feed them in spring end first	4.51	0.518	4.63	0.483	4.57	0.500	VI	-1.658	0.099	NS
8	Tighten the nuts or bolts evenly securely	4.76	0.424	4.76	0.456	4.76	0.440	VI	0.066	0.947	NS
	CLUSTER MEAN					4.44		IM			

Key: X_{ET} = Mean of electrical technician, X_T = Mean of EIMW teachers, SD_{ET} = Standard deviation electrician technician, SD_T = Standard deviation EIMW teachers, X_{GT} = Grand mean, SD_{GT} = Grand standard deviation, R = Remark

The data presented in Table 2 revealed the analysis on the precautionary measures that should be taken in industrial motor maintenance. The data showed that the items have a grand mean rating ranged from 4.23 to 4.76. This shows that all the items are above the mean rating of 3.00; therefore, precautionary measures are important in industrial motor maintenance. Also, the standard deviation of the respondents' responses ranges from 0.44 to

0.68, which revealed the closeness in the opinion of the respondents.

The test of hypothesis presented in Table 2 showed that there is no significant difference in the mean opinions of the electrical technician and electrical installation and maintenance work teachers in seven (7) items out of eight (8) items and there is a significant difference between the mean opinion of electrical technicians and electrical installation and maintenance work teachers in one item out of the eight items. Since there is no significant difference between the mean opinion of the electrical technician and electrical installation and maintenance work teachers, the null hypothesis (H_{02}) for the seven items are accepted and rejected for item 2, thereby accepting the alternative hypothesis.

Table 3: Mean, Standard Deviation and P-value of Respondent's Responses on the Skills Needed in the Maintenance of Industrial Motors

S/ N	Skills needed in the maintenance of industrial motor	Respondents				Grand total		R	t-cal	Sig 2 - tailed	Rem ark
		$\bar{x}_{ET}$	SD_{ET}	$\bar{x}_T$	SD_T	$\bar{x}_{GT}$	SD_{GT}				
1	Ability to identify motor fault	3.54	0.986	3.50	0.841	3.52	0.913	I	0.310	0.757	NS
2	Ability to disassemble motor	4.24	0.648	4.25	0.684	4.245	0.666	I	- 0.087	0.931	NS
3	Ability to assemble motor	4.04	0.726	4.21	0.723	4.125	0.724	I	- 1.632	0.104	NS
4	Competency in rewinding coil	3.91	0.805	3.91	0.766	3.91	0.785	I	0.037	0.971	NS
5	Competency in motor wire connection	3.96	0.798	4.08	0.715	4.02	0.756	I	- 1.093	0.276	NS
6	Ability to fit in insulation paper properly	3.92	0.851	3.93	0.735	3.925	0.793	I	- 0.107	0.915	NS
7	Ability to identify running coil	3.98	0.766	3.91	0.814	3.945	0.790	I	0.624	0.533	S
8	Competency in the use of meter	3.82	0.866	3.90	0.722	3.86	0.794	I	- 0.640	0.523	NS
9	Ability to fix bearing fault/change faulty bearing	3.99	0.761	4.07	0.670	4.03	0.715	I	- 0.795	0.428	NS
10	Ability to use the right tools for the right job	4.23	0.670	3.85	0.695	4.04	0.682	I	3.903	0.000	S
11	Ability to identify the starting coil	3.76	0.876	3.95	0.825	3.85	0.850	I	- 1.483	0.140	NS
12	Competency in the use of standard wire gauge	4.18	0.673	4.21	0.687	4.19	0.68	I	- 0.297	0.766	NS
13	Competency of turn ratio	3.17	0.967	3.55	0.870	3.36	0.918	MI	- 2.795	0.006	NS
14	Knowledge of slot arrangement	3.57	0.876	3.53	0.913	3.55	0.894	I	0.292	0.771	NS
15	Ability to identify top and bottom wire	4.02	0.804	4.10	0.756	4.06	0.780	I	- 0.662	0.509	NS
16	Ability to interpret circuit diagram	3.62	0.898	3.67	1.003	3.645	0.950	I	- 0.368	0.713	NS
17	Competency in inspecting rotor and stator	3.75	0.900	3.70	1.011	3.725	0.955	I	0.366	0.715	NS
	CLUSTERS					3.882		I			
	MEAN										

Key: X_{ET} = Mean of electrical technician, X_T = Mean of EIMW teachers, SD_{ET} = Standard deviation electrician technician, SD_T = Standard deviation EIMW teachers, X_{GT} = Grand mean, SD_{GT} = Grand standard deviation, R = Remark

The data presented in Table 3 revealed the analysis on the skills needed in the

maintenance of industrial motor. The data showed that the items have a grand mean rating between 3.35 and 4.24 which shows that all the items are above the mean rating of 3.00. This implies that the respondents agreed that the 17 items are important skills needed in the maintenance of industrial motor. Also, the standard deviation of the responses of the respondents on the 17 items ranged from 0.680

to 0.955 which revealed that the respondents are close in their opinion.

The test of hypothesis presented in Table 3 showed that there is no significant difference in the mean opinion of the electrical technicians and electrical installation and maintenance work teachers in 15 items and there is a significant difference between the mean opinions of the electrical technicians and electrical installation and maintenance work teachers in 2 items. Since there is no significant difference between the mean opinion of the electrical technicians and electrical installation and maintenance work teachers, the null hypothesis (H_{03}) for the 14 items are accepted and rejected for 2 items, thereby accepting the alternative hypothesis.

Discussion of the Findings

The findings of the study revealed the various ways of troubleshooting faults in industrial motors. The findings of the study is in congruent with the findings of Finley (2010) that troubleshooting begins with the consideration of the environment where the industrial motor is applied as some problems arise as a result of changing environments in which the motor operates as most of the problems arise from effect of external factors. Also, Maria (2013) affirmed that when troubleshooting industrial motor the multimeter should be adequately used, schematic reading, component testing and information on the name plate of the motor should be considered to avoid a total breakdown of the motor.

The findings of the study revealed the various precautionary measures and safety practices that should be adhered to for smooth and safe use of industrial motor. The findings of the study agreed with the findings of Bonaldi, Levy & Jonas (2012) who opined that since induction motors are the centre of the vast majority of the industrial processes with its rotating parts exposed to different adversities demands maximum attention as a result of its high cost. The industrial motor due to its vast use in industries without alternatives demand strategic precautionary procedures to reduce failures. The Health and Safety Executive (2019) who have divergent views of the

precautionary measures declared that maintenance personnel should be properly trained to recognize motor failing during inspection to avoid total breakdown which may be expensive to repair.

The findings of the study showed the several skills needed in the maintenance of industrial motor. The findings established the view of Oluka & Onyebuanyi (2017) who affirmed the importance of acquiring maintenance skills and its aftermath influence on the conservation of industrial motor to reduce the cost of repair and output efficiency. Also, Samson & Anthony (2015) laid much emphasis on the need for the inclusion of maintenance skills in the electrical engineering education/technology teacher education curriculum.

Conclusion

Safe motor operation and condition depends mostly on the area of application and this influence its performance. This study highlights the common faults in motor which grounds safety operations. The key to successful troubleshooting is to identify, analyse and eliminate all the possible causes either by testing or calculations until the problem is properly identified and resolved. This process helps the technician to avoid concluding and making modifications to faulty components which will later hamper motor performance. Adequate maintenance of industrial motor is needed considering the use of the right tools for the right job to prevent further damage to motor parts, providing conducive operational environment and condition for motor and daily routine check should be carried out on industrial motor to increase its efficiency and sudden breakdown.

Recommendations

Considering the findings of the study, the following recommendations were made:

1. Workshops/seminar should be organized promptly for electrical technology teacher to acquaint them with maintenance practices required for industrial motor. This will help them in teaching their students.
2. Teachers should encourage electrical technology student to make out time

- during their holidays to learn maintenance of industrial motors.
- School-industrial relationship should be strengthened to allow industries absorb electrical technology into their system for industrial training so as to be adequately equipped with maintenance practices as it applied to industrial motor.

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