STRATEGIES FOR STANDARDIZING SAFETY PRCAUTIONS AMONG LOCAL METAL CASTING ARTISANS IN KANO STATE, NIGERIA

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Abstract

This study investigated strategies for standardizing safety precautions among local metal casting artisans in Kano State, Nigeria. Two research questions guided this study and two hypotheses were tested at 0.05 level of significance. The study adopted descriptive survey research design. Population for the study was 1551 respondents, comprising of 1500 Foundry artisans, 35 Metalwork Technology Industrial Personnel and 16 Metalwork Technology Lecturers/Instructors respectively in Kano State, Nigeria. Out of the 1500 artisans, 300 was sampled using Taro Yamane formula. A total of 367 respondents were used for the study. The instrument for data collection was a questionnaire which contained 29 items for the construct. Cronbach's Alpha reliability coefficient was employed for checking reliability and the index was found to be 0.98 for the instrument. Three lecturers from Federal University of Technology, Minna were involved in both face and content validity of developed questionnaire. The data collected were analyzed using the Statistical Package for Social Sciences (SPSS) version 23. Mean and Standard deviations were used to answer the two research questions while one-way Analysis of Variance (ANOVA) was used to test the two hypotheses at 0.05 level of significance. It was found out among others that: Strategies for standardizing safety precautions in mould preparations in local metal casting operations include; and adhering strictly to safe operating procedures during mould preparation activity, among others. Strategies for standardizing safety precautions in metal handling practices in casting operation include: frequently reinforcing training on safe work practices around furnace during metal melting operation, among others.

Keywords: Strategies; Metal handling; Practices; Metal Casting; Safety Precaution.

1.0 Introduction

The production of metal castings is a complex process that has long been associated with worker injuries and illnesses that are related to exposure to chemical and physical agents generated or used in the casting process (Senthil Kumar and Navean, 2016). Foundry workers may be exposed to numerous health hazards, including fumes, dust, gases, heat, noise, vibration and nonionizing radiation. The continuous exposure to some of these hazards may result in irreversible respiratory diseases such as silicosis and it increases the risk of lung cancer and other diseases among the foundry workers.

The foundry workers may also be exposed to safety hazards that can result in injuries including strain, burns, eye damage, loss of limb, and death. The major categories of adverse health effects include: Respiratory diseases; ergonomic injuries due to falling or moving objects, lifting and carrying, etc; heat induced illnesses and injuries; vibration induced disorders; noise induced hearing loss; and eye injuries. The occurrence of these problems in a foundry should be considered as **s**afety health **e**vents. The means for eliminating or significantly reducing each

hazard are well known and readily available. The occupational injuries and illnesses in foundry workers, their working conditions, engineering controls and their work practice used in sand casting foundries are recognized. Based on the recommendations have been developed for reducing the safety and health risk related to working in sand casting foundries. The foundry operations that have been studied include handling of raw material such as scrap metal and sand; preparing sand ; making mold and cores; reclaiming sand and other material used in core and mold production rough cleaning of castings; melting and alloying metals; pouring; removing cores and shaking out castings; maintaining and cleaning all the equipment's regularly and periodically durin and after casting.

According to Senthil Kumar and Navean (2016), casting, as it is commonly involving in pouring of molten metal into a mold that made in to an external shape of the article to be cast. The mold may contain a core which determines the dimensions of any internal cavity or hollow. Molten metal is introduced into the mold. After cooling occurs, the mold is subjected to a 'shakeout' procedure which releases the casting and removes the core. The casting is then cleaned and any extraneous metal is removed from it.

1.2 Statement of the Problem

Foundry next to construction (Prasad, 2019) belongs to industries with increased occupational risk. During the entire casting production process, employees are exposed to dangerous, harmful and arduous factors that can cause occupational diseases and accidents at work. Foundry technological processes use various techniques and materials to make the model, mold and casting characterized by the diversity of their chemical composition and properties. The technological processes of making the casting used in foundries can pose a threat to the employee as well as to the environment. Most of the technological processes used in practice create problems at the workplace and for the environment. Some the problems are associated with the occurrence of pollution, contamination, noise and other factors harmful to health and the environment. The consequences of the above mentioned problems, as reported by Epidemiological studies, resulted in increased risk of lung and gastrointestinal, prostate, kidney and hematological cancers among foundry workers. In addition, The International Agency for Research on Cancer (IARC) concluded that there is sufficient evidence of a carcinogenic effect on people employed in the foundry industry and labelled this industry as a carcinogen for humans (IARC 1987). Similarly, The European Union (EU) includes technological processes in which there is exposure to polycyclic aromatic hydrocarbons present in carbon black, coal tar and coal tar pitch in processes that release carcinogens or mutagens. Hence the need to investigate strategies for standardizing safety precautions among local metal casting artisans in Kano State Nigeria.

1.3 Purpose of the Study

The aim of this study was to investigate strategies for standardizing safety precautions among local metal casting artisans in Kano State of Nigeria. Specifically, the study sought to achieve the following objectives.

1. Identify techniques for standardizing safety precautions to be observed in mould preparation among local metal casting artisans in Kano state, Nigeria.
2. Suggest techniques for standardizing safety precautions to be observed in Metal handling practices in local casting operations in Kano state, Nigeria.

1.4 Research Questions

The following research questions we answered in this study:

1. What are the techniques for standardizing safety precautions to be observed in mould preparation practices among local metal casting artisans in Kano State, Nigeria?
2. What are the techniques for standardizing safety precautions to be observed in Metal Handling Practices among local metal casting artisans in Kano State, Nigeria?

1.5 Research Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

H_{O1}: There is no significant difference in the mean responses of metal casting artisans, metalwork industrial personnel and metalwork lecturers on the techniques for standardizing safety precautions to be observed in mould preparation among local metal casting artisans in Kano State, Nigeria.

H_{O2}: There is no significant difference in the mean responses of metal casting artisans, metalwork industrial personnel and metalwork lecturers on the techniques for standardizing safety precautions to be observed in metal handing practices among local metal casting artisans in Kano State, Nigeria.

1.6 Significance of the Study

The findings of this study would of immense benefit to metal casting artisans, the National Board for Technical Education (NBTE), National Directorate of Employment (NDE), Kano state government, the society and future researchers in the area of metal casting.

The study adopted descriptive survey design. The population for the study was 1551 respondents, comprising of 1500 Foundry artisans, 35 Metalwork Technology Industrial Personnel and 16 Metalwork Technology Lecturers/Instructors respectively in Kano State, Nigeria. Out of the 1500 artisans, 300 was sampled using Taro Yamane formula, Therefore, a total of 367 respondents were used for the study. Out of the 367 questionnaire administered, only 351 was returned making a percentage instrument return rate of 95 percent. The instrument for data collection was 29 items questionnaire. Content and construct validation were conducted on the research instrument (questionnaire) by three lecturers from Federal University of Technology, Minna. Cronbach's Alpha reliability was employed for checking reliability and the index was found to be 0.98. Mean and Standard deviations were used to answer the research questions while one way Analysis of Variance (ANOVA) was used to test the null hypotheses at 0.05 level of significance. The ***decision point*** for accepting the mean score is 2.50 and above, else the mean score is rejected. While standard deviations should be less than 1.00 (< 1.00).

3.1 Research Question One

What are the strategies for standardizing safety precautions to be observed in mould preparation among local metal casting artisans in Kano state of Nigeria?

Data that was used to answer research question one is shown in table 1.1.

Table 1.0: Mean and Standard Deviation of Metal Casting Artisans, Metalwork Industrial Personnel and Metalwork Lecturers on techniques for standardizing safety precautions in mould preparation practices in casting operation.

S/N	ITEM	$\bar{x}_1$ n=300	$\bar{x}_2$ n=35	$\bar{x}_3$ n=16	$\bar{x}_A$	SD_A	D
1	Providing adequate ventilation to reduce hazards from mixture of moulding sand, water and binding materials	3.33	3.17	3.31	3.27	0.66	A
2	Using noise pads to dampen noise or reduce the impact of noise arising from moulding operation	3.32	3.29	3.31	3.31	0.59	A
3	Applying proper sanitary practices (good personal hygiene) during moulding operation to prevent slips and falls	3.34	3.31	3.25	3.30	0.64	A
4	Use of protective clothing and equipment during mould preparation	3.35	3.31	3.31	3.32	0.55	A
5	Making provision for dealing with emergency that may arise during mould preparation activity	3.15	3.14	3.25	3.18	0.66	A
6	Properly labelling of all hazardous substances use for moulding	3.50	3.51	3.44	3.48	0.51	A
7	Training foundry workers to inform them of possible foundry hazards associated with mould preparation operation	3.25	3.23	3.19	3.22	0.90	A
8	Training foundry artisans on how to control hazards during mould preparation	3.50	3.51	3.44	3.48	0.51	A
9	Providing regular inspection of workers at each stage of mould preparation	3.34	3.23	3.19	3.25	0.66	A
10	Adhering strictly to safe operating procedures during mould creation operation	3.34	3.23	3.25	3.27	0.65	A
11	Regularly checking moulding equipment to ensure they are in safe operating condition	3.34	3.17	3.38	3.30	0.63	A
12	Keeping records of moulding maintenance practices	3.32	3.34	3.19	3.28	0.62	A

13	Using simple mechanized machines to do strenuous tasks during moulding operation	3.15	3.14	3.25	3.18	0.66	A
14	Using air purifying respirators to reduce risk of inhalation of hazardous dust from mould sand	3.50	3.51	3.44	3.48	0.51	A
15	Regularly reporting status about damaged equipment in hazardous condition	3.25	3.23	3.19	3.22	0.90	A
16	Maintaining regular practices of house keeping	3.50	3.51	3.44	3.48	0.51	A
17	Keep regular use of safety devices	3.34	3.23	3.19	3.25	0.66	A
	GRAND MEAN	**3.34**	**3.30**	**3.30**	**3.31**	**0.64**	**A**

Key:

i. $\bar{x}_1$ = Mean Scores for metal casting artisans.
ii. $\bar{x}_2$ = Mean Scores for metalwork industrial personnel.
iii. $\bar{x}_3$ = Mean Scores for metalwork lecturers.
iv. $\bar{x}_A$ = Average Mean.
v. SD_A = Average Standard Deviations.
vi. D = Decision, and
vii. A = Agree.

Data in Table 1.0 showed the opinions of the metal casting artisans, metalwork industrial personnel and metalwork lecturers on the techniques for standardizing safety precautions to be observed in mould preparation practices in casting operation in Kano state, Nigeria. The three categories of respondents unanimously agreed to all the items with mean value ranging from 3.18 to 3.48. This implies that the items presented are techniques for standardizing safety precautions to be observed in mould preparation practices in casting operation in Kano state, Nigeria. The grand mean of metal casting artisans, metalwork industrial personnel and metalwork lecturers are respectively 3.34, 3.30 and 3.30 indicating that the respondents unanimously agreed to the techniques presented for standardizing safety precautions to be observed in mould preparation practices in casting operation in Kano state, Nigeria. Also the average grand mean ($\bar{x}_A$) for total respondents which is 3.31 signified that the three groups of respondents agreed to the items as techniques for standardized safety precautions to be observed in mould preparation practices in casting operation in Kano State. Similarly, table 1.1 also showed the average standard deviations (SD_A) of the items ranging from 0.51 to 0.90. The 17 items had their standard deviations less than 0.96 showing that the respondents were not too far from the mean and were close to one another in their responses.

3.2 Research Question Two

What are the techniques for standardizing safety precautions to be observed in metal handling practices among local metal casting artisans in Kano state, Nigeria?

Data that was used to answer research question two is shown on table 1.2.

Table 1.2: Mean and Standard Deviation of Metal Casting Artisans, Metalwork Industrial Personnel and Metalwork Lecturers on techniques for standardizing safety precautions in Metal Handling practices in casting operations

S/N	ITEM	$\bar{x}_1$ n=300	$\bar{x}_2$ n=35	$\bar{x}_3$ n=16	$\bar{x}_A$	SD_A	D
1	Provision of adequate personal protective equipment to reduce risk of burns from handling of hot molten metal	3.36	3.31	3.56	3.41	0.56	**A**
2	Maintenance of personal protective equipment associated with metal melting operation by workers	3.35	3.46	3.25	3.35	0.68	**A**
3	Periodically running shifts or reducing work time to reduce workers exposure heat arising from metal melting operation	3.35	3.17	3.56	3.36	0.61	**A**
4	Training foundry artisans on possible hazards that may arise from handling of hot molten metals	3.37	3.49	3.63	3.50	0.53	**SA**
5	Placing or posting conspicuous safety warning signs in areas concerning hot molten ,metals	3.16	3.20	3.50	3.29	0.70	**A**
6	Placing labels describing content on containers of hazardous hot molten metals	3.50	3.49	3.56	3.52	0.51	**SA**
7	Provision of warning signs in English and where appropriate in the predominant language of non –English reading workers (e.g Hausa language)	3.23	3.29	3.25	3.26	0.80	**A**
8	Frequently reinforcing training on safe work practices around furnace during metal melting operation	3.50	3.40	3.56	3.49	0.52	**A**
9	Eliminating sources of radiant heat in the metal heating zone	3.32	3.29	3.63	3.41	0.56	**A**

10	Eliminating sources of water vapour in the molten metal area	3.36	3.40	3.50	3.42	0.56	**A**
11	Reducing heat exposure heat exposure duration	3.36	3.31	3.56	3.41	0.56	**A**
12	Provision of proper exhaust ventilation to reduce exposure to hazardous fumes and dust	3.36	3.46	3.25	3.36	0.60	**A**
	GRAND MEAN	**3.35**	**3.36**	**3.48**	**3.40**	**0.60**	**A**

Key:

i. $\bar{x}_1$ = Mean Scores for metal casting artisans.
ii. $\bar{x}_2$ = Mean Scores for metalwork industrial personnel.
iii. $\bar{x}_3$ = Mean Scores for metalwork lecturers.
iv. $\bar{x}_A$ = Average Mean.
v. SD_A = Average Standard Deviations.
vi. D = Decision,
vii. SA = Strongly Agree, and
viii. A = Agree.

The data presented in Table 1.2 shows the views of metal casting artisans, metalwork industrial personnel and metalwork lecturers on the techniques for standardizing safety precautions to be observed in metal handling practices in casting in Kano State. The respondents strongly agreed to items 4 and 6 with mean values of 3.50 – 3.52. In their responses, the respondents agreed to items 1,2,3,5,7, 8,9 10,11 and 12 with mean scores ranging from 3.26 – 3.49. The grand mean of metal casting artisans, metalwork industrial personnel and metalwork lecturers are respectively 3.35, 3,36 and 3.48 indicating that the respondents agreed to the techniques presented for standardizing safety precautions to be observed in metal handling practices in casting in Kano State. Also, the average grand mean for total respondents which is 3.40 signified that the three groups of respondents agreed to the items as techniques for standardizing safety precautions to be observed in metal handling practices in casting in Kano State, Nigeria. The standard deviations of the items ranges from 0.51 - 0.80. The 12 items had their standard deviations less than 0.81 showing that the respondents were not too far from the mean and were close to one another in their responses.

3.3 Hypotheses Testing

3.3.1 Hypothesis One

There is no significant difference in the mean ratings of metal casting artisans, metalwork industrial personnel and metalwork lecturers on the techniques for standardizing safety precautions to be observed in mould preparation practices among local metal casting artisans in Kano state, Nigeria.

Data that was used to answer Hypothesis one is shown in table 1.3.

Table 1.3: One-way ANOVA of mean scores of respondents on the techniques for standardizing safety precautions to be observed in mould preparation practices in casting operation

Source	Sum of Square	Df	Mean Square	F	Sig. (p-value)
Between Groups	0.084	2	0.042	1.937	0.146
Within Groups	7.537	349	0.022		
Total	7.621	351			

The result of analysis as presented in Table 1.3 showed that there was no significant difference ($p < 0.05$) in the mean scores of the respondents. The hypothesis one was therefore upheld (accepted). The data supported the hypothesis one, $F(2, 349) = 1.927$, p (sig.) $= 0.146$. This result implies that the items presented are suitable techniques for standardizing safety precautions to be observed in mould preparation practices in casting operation in Kano State.

3.3.2 Hypothesis Two

There is no significant difference in the mean ratings of metal casting artisans, metalwork industrial personnel and metalwork lecturers on the techniques for standardizing safety precautions to be observed in metal handling practices among local metal casting artisans in Kano State, Nigeria.

Data that was used to answer Hypothesis Two is shown in table 1.4.

Table 1.4: One-way ANOVA of mean scores of respondents on the techniques for standardizing safety precautions to be observed in metal handling practices in casting operation.

Source	Sum of Square	df	Mean Square	F	Sig. (p-value)
Between Groups	0.270	2	0.135	5.168	0.080
Within Groups	9.094	349	0.026		
Total	9.364	351			

The result of analysis as presented in Table 1.4 showed that there was no significant difference ($p > 0.05$) in the mean scores of the respondents. The hypothesis two was therefore upheld (accepted). The data supported the hypothesis two, $F(2, 349) = 5.168$, p (sig.) $= 0.080$. This result implies that the items presented are suitable techniques for standardizing safety precautions to be observed in metal handling practices in casting operation in Kano State.

4.0 Findings of the Study

With respect to the research questions and hypotheses of this study the summary of the findings of this study among others are given below:

1. Techniques for standardizing safety precautions in mould preparation practices among local metal casting artisans are: adhering strictly to safe operating procedures during mould preparation activity, regularly inspecting foundry workers at each stage of mould preparation, using the appropriate mould preparation tool for specific task, regularly checking to ensure moulding equipment are in safe working condition, keeping records of moulding equipment maintenance as well providing adequate ventilation to reduce hazards resulting from mixture of mould sand and binding materials, among others.
2. Techniques for standardizing safety precautions in metal handling practices among local metal casting artisans are: frequently reinforcing training on safe work practices around furnace during metal melting operation, provision of proper exhaust ventilation to reduce exposure to hazardous fumes and dust, placing labels describing content of containers of hazardous hot molten metals, provision of adequate personal protective equipment to reduce the incident of burns resulting from handling hot molten metals, among others.
3. There is no significant difference in the mean responses of metal casting artisans, metalwork industrial personnel and metalwork lecturers on the techniques for standardizing safety precautions to be observed in mould preparation practices in casting operation in Kano State, Nigeria.
4. There is no significant difference in the mean responses of metal casting artisans, metalwork industrial personnel and metalwork lecturers on the techniques for standardizing safety precautions to be observed in metal handling practices in casting operation in Kano State, Nigeria.

5.0 Discussion of Results

Findings on the techniques for standardizing safety precautions to be observed in mould preparation practices in casting operation in Kano State revealed among others that, techniques for standardizing safety precautions in mould preparation practices in casting operation are : adhering strictly to safe operating procedures during mould preparation activity, regularly inspecting foundry workers at each stage of mould preparation, using the appropriate mould preparation tool for specific task, regularly checking to ensure moulding equipment are in safe working condition, keeping records of moulding equipment maintenance as well providing adequate ventilation to reduce hazards resulting from mixture of mould sand and binding materials, among others.

The findings on adhering strictly to safe operating procedures during mould preparation activity is in line with the findings of Anshika (2017) who studied top ten foundry safety practices and discovered that a key parameter for high yield and safe operation is to strictly

adhere to existing standard work procedure established to ensure safety precaution is improved in foundries.

The findings on regularly inspecting foundry workers at each stage of mould preparation, using the appropriate mould preparation tool for specific task, regularly checking to ensure moulding equipment are in safe working condition is in agreement with the research discoveries of National Institute for Occupational Safety and Health (NIOSH, 2015) who in a study on the control of occupational safety and health hazards in foundries found that to enhance safety precaution in mould preparation, engineering controls such as local exhaust ventilation, noise damping materials, machine guarding, molten metal splash barriers, and radiant heat shielding can be employed to provide a healthful and safe working environment for mould preparation in foundries.

The findings on hypothesis two revealed that, there is no significant difference in the mean responses of metal casting artisans, metalwork industrial personnel and metalwork lecturers on the techniques for standardizing safety precautions to be observed in mould preparation practices in casting operation in Kano State, Nigeria. The hypothesis two was therefore upheld (accepted). This result implies that the items presented are suitable techniques for standardizing safety precautions to be observed in mould preparation practices in casting operation in Kano State.

The findings on the techniques for standardizing safety precautions to be observed in metal handling practices in casting in Kano State revealed among others that, Techniques for standardizing safety precautions in metal handling practices in casting operation are : frequently reinforcing training on safe work practices around furnace during metal melting operation, provision of proper exhaust ventilation to reduce exposure to hazardous fumes and dust, placing labels describing content of containers of hazardous hot molten metals, provision of adequate personal protective equipment to reduce the incident of burns resulting from handling hot molten metals, among others.

These findings was collaborated by Edwin (2017) who studied values of foundry products for modern industries in the state and local government and found out that, an effective work practices program encompasses many elements, including safe standard operating procedures, proper housekeeping and sanitation, use of protective clothing and equipment, good personal hygiene practices, provisions for dealing with emergencies, workplace monitoring, and medical monitoring.

The findings on placing labels describing content of containers of hazardous hot molten metals was buttressed by Rajkolhe, and Khan (2014) who studied defects, causes and their remedies in casting process and found out in ideal situation, standardized work practices are supported by proper labeling and posting and training all of which will serve to inform personnel of foundry hazards and of the procedures to be used to guard against such hazards. Edosa (2015) in a study on developing the foundry industry for sustainable development found out that good supervision provides further support by ensuring that the work practices are followed and that they effectively protect workers from the hazards.

The findings on hypothesis four revealed that, there is no significant difference in the mean responses of metal casting artisans, metalwork industrial personnel and metalwork lecturers on the techniques for standardizing safety precautions to be observed in metal handling practices in casting operation in Kano State, Nigeria. The hypothesis four was therefore upheld (accepted). From the results it can be deduced that the items presented are suitable techniques for standardizing safety precautions to be observed in metal handing practices in casting operation in Kano State Nigeria.

6.0 Recommendations

Based on the findings from this study, the following recommendations are made:

1. Foundry artisans should endeavour to adhere strictly to the techniques that are used for standardization and enhancing safety in mould preparation and metal handling operations in metal casting practices.

2. Kano State Government should create awareness of the various techniques that are used for standardization and encourage the stakeholders to adhere strictly to these techniques to enhance quality and safe work practice in mould preparation and metal handling operations to improve metal casting practices in Kano State, Nigeria.
3. Kano State Government should make effort to purchase the modern computer and electronic equipment that can be used to enhance standard operational practices in mould preparation and metal handling practices in metal casting. Constant power supply to enable the stakeholders reduces their cost on using generators for their operations is also needed.
4. Quality training and periodic retraining programmes should be organized by government, association and other relevant agencies for foundry artisans to expose them on how to use modern electronic foundry equipment to enhance standardization in mould preparation and metal handling practices.
5. Industries, government, non-governmental agencies, private enterprises and communities should provide consumable materials necessary for practical activities and teaching techniques for standardizing safety precautions to be observed in mould preparation and metal handling practices in metal casting practices in Kano State, Nigeria.

From the findings of this study, it can be concluded that techniques for standardizing local metal casting practices were established. The techniques are in the area of mould preparation, safety precautions in mould preparation, metal handling and safety precautions in metal handling practices. The study has provided an additional literature to the existing body of knowledge in the techniques for standardizing mould preparation and metal handling practices in metal casting operations in Kano State Nigeria. This provides an empirical evidence for the use of the different techniques for standardization in mould preparation and metal handling practices as well as in enhancing safety precaution in mould preparation and metal handling practices.

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