IMPROVISATION OF FURNACE FOR FORGING OPERATIONS IN TECHNICAL COLLEGES IN RIVERS STATE:IMPLICATION FOR VOCATIONAL COUNSELLING IN NIGERIA

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Abstract

The purpose of this research was to develop an improvised furnace to enhance students' performance in forging operations in technical colleges in Rivers State. The study adopted research and development design. Forging is the art of shaping metals by hammering. Man has known this art since ancient times. Today machines have largely replaced the sweat and muscle of the blacksmith, who nevertheless remains indispensable for carrying out the jobs done by hand, necessary in steel and engineering works. The furnace was found to be valid for forging at 4.00 and reliable using steel with molybdenum at hardness of 164 HRC. Any temperature and harder having melting points above 850^0c and 164 HRC respectively may be inserted directly into the flaming charcoal. The improvised furnace is a teaching material that is made up of a steel vessel hardened with carbon – molybdenum in the ratio of 0.20:0.68 percent respectively. It was lined with bricks and fired with charcoal, using an electric blower connected to a low voltage generator. This furnace was used to carry out various forging operations. Based on the findings of this study, the researchers recommended the government; technical college principals and relevant agencies should provide funds to procure the materials and components for designing and constructing these furnaces by the teacher for teaching forging in Technical Colleges in Rivers State. Also, constant power supply, generators, accumulators, anvils, steel vessels, pipes and electric blowers should be provided and distributed by the ministry of education to the Technical Colleges for construction of furnaces for effective teaching of forging in Rivers State. The industries, government, non-governmental agencies and private enterprises and communities should provide components and consumable materials necessary for teaching. These materials should be supplied directly to the individual Technical Colleges in Rivers State. Vocational counselors should guide students to take up occupation in forging.

Keywords: Improvisation, Furnaces, Performance, Forging, Vocational Counselor, Technology and College

Introduction

Forging as defined by Smith (1991) is the art of shaping metals by hammering. Man has known this art since ancient times. Today machines have largely replaced the sweat and muscle of the blacksmith, who nevertheless remains indispensable for carrying out the jobs done by hand, necessary in steel and engineering works. This is one of the reasons why steel is forged, since the stresses on the steel are very severe and the component if it were cut from rolled stock or in the form of a casting might be liable to break. This is because there is casting weakness during casting process which is caused by inadequate feeding and poor crystal structure resulting to varying section thickness and shrinkage cavities. This forms fibrous tissues in the direction of working and this makes casting unsuitable whereas rolled steel is generally stronger than cast steel because its strength is less across the fibre than along it for the particular job on hand. Another reason for forging is that large items such as ships' propeller shafts, large drums for boilers and naval guns could not be rolled owing to their size. Casting them might not produce the necessary strength and therefore forging must be employed. In addition, irregular shapes that could not be produced by rolling are made under the forging hammer. Warring (1982) added that both plain carbon and alloy steels are forged but the higher the carbon content the more difficult it is to forge the steel and some highly alloyed steels cannot be forged. It should be remembered that the temperature of the work-piece during forging must be maintained at a suitable level. In addition, the smaller the item, the quicker must be the forging operation, because heat is lost faster from them. Any attempt to forge steel when it is too cold may cause cracks. This means that if the steel cools below about 750^0C (dull red heat) the forging process must be interrupted and the piece returned to the furnace for reheating. After any forging operation the piece is heat treated to relieve stresses and to develop the best mechanical properties in the steel.

Forging process according to Stephen (2005) can be conveniently described under the following headings:

1) Heavy press forging
2) Light press and hammer forging (without using dies)
3) Drop forging or drop stamping (use of dies) and
4) Upset forging.

He further explained that heavy press forging is carried out in huge hydraulic presses capable of exerting a pressure of over 7000Nm^2 on the steel.The press is a robust machine in which the steel is squeezed between the ram and the anvil. The foundations of the press need not be as massive as those used in hammer installations. In pressing, the force is applied gradually and there is no heavy thump to be absorbed by the foundations. The ingot is the raw material for heavy pressing and may weigh as much as 200Nm^2. The ingot shape varies depending upon the required final shape, for example, octagonal (eight-sided) for round forgings and slab-ingot for flat forging.

Gray and Muller (2005) added that the products of the heavy press include: Propeller shaft and heavy crankshafts for ships; rotors for large electrical motors; rolls for rolling mills; boiler drums; naval and military guns and so on. Pressing is slow and as the metal cools, it requires to be reheated many of such reheating is necessary before forging is completed. The process begins when the ingot arrives in the heavy press shop being stripped from its mould, and in the case of an octagonal ingot the first operation is to fit a chuck and porter bar on to the feeder head so that it can be handled (Gray and Muller, 2005). The ingot is then reheated to a forging temperature of about 1200^{0}C in furnaces fitted with regenerators. Heating must be done carefully and slowly to reduce the risk of clinking. When the required temperature is reached the ingot with attached chuck and porter bar is removed from the furnace and lifted by means of a burden chain slung from an overhead crane. The ingot is balanced horizontally by a counter weight fitted on the porter bar. The assembly allows the ingot to be rotated, moved backwards and forwards, or from side to side during the pressing operation. The ingot is introduced between the ram and the anvil of the press and forging is commenced. The actual sequence of operations under the press depends upon the shape required in the finished forging. If a long tubular shape is required the ingot is first bloomed made into a square shape using flat faced tools on the ram and anvil. Curved tools may also be used for round forgings and are called swages. The ingot is worked, starting at the head end and finishing at the foot. Edging up further extends it; the ingot is rotated through 90^0 by the turning gear via the burden chain and a second series of squeezes is made at right angles to the first. As the ingot grows longer the counterweight on the porter bar is moved back to maintain the balance. If the final forging is to have collars or necks, V-shaped tools are used to shape these before forging is continued. Samuel (1985) explained how a ring or hollow object is forged. Such objects as boiler drums can be forged by first blooming the ingot down a little to a uniform diameter but it must be remembered that an ingot is tapered when removed from the mould. It is then removed from the press, annealed, cooled and parted or sliced into pieces of suitable length. The parted piece has the centre cut out using special drills called trepanning. Ingots weighing less than 5kg or lengths of rolled steel are forged by hammer. The steel is subjected to a series of sharp blows. Work is carried out faster than under the press but the effects of working do not penetrate as deeply as in pressing. Massive foundations are required since the shock of the hammer blows must be absorbed. The most widely used hammer is the double acting steam hammer in which the hammer blow can be varied from a light tap to a full-blooded blow with the full weight of the tap, that is top striking face and the steam pressure behind it. The stock for forging is heated in a variety of furnaces including the continuous type. It is then subjected to blows from the hammer. Wages and V-tools may be used to assist in bringing the forging to shape. It is interesting to note that one important product of the steam hammer is railway axles.

In the use of improvised furnace or furnace constructed by the teacher, the safety of the equipment, students and teacher must be taken seriously. Safety according to the Webster Encyclopedia Dictionary of English Language (1994) refers to the condition of being safe, freedom from exposure to danger, exemption from hurt, injury or loss. Here, the safety of the users of teacher constructed furnace is stressed. While we appreciate the importance of workshop facilities and equipment in our scientific and technological development, it is also important to note that workshops have not been safe for those using them.

Records according to Oranu (1996), shows that 17, 000 workers are killed every year, over 2,000,000 workers receive injuries while 300,000 workers are permanently impaired. Such records could not be true if workers have received proper and adequate safety training. Historically, there were examples of scientists who lost their lives due to lack of safety in the workshops. Abdullahi (2005) noted that the history of scientific development is replete with cases of fatal accidents, which occurred as a result of lack of knowledge of the nature and behaviour of certain tools, equipment or substances. He further stated that for science laboratories or workshops to achieve their aims and objectivities, they must be safe for those using them.

Guy (2003) suggested that the appointment of safety officers and provision for adequate notice boards where safety rules will be prominently displayed will provide safe working environment. In conformity with the suggestion of Guy above, Steere (2005) observed that a safe environment is the fundamental responsibility of the institution which the workshop is part of it. Thus, the provision of facilities, equipment in the school environment and its maintenance provides a safe working environment. Similarly, Giachino and Gallington (2003) pointed out that while the safety designed into a building is generally important in the final analysis, people would be the determining factors as to the overall safety of the building. The authors added that people have the potential within themselves to either prevent or cause accidents. There is the need therefore to teach people how to be safety conscious and this has to do with the safety training and program they attend. The task of the metallurgist in education is that of promoting and forming desirable attitudes towards safe practices on the part of the students. Oranu (1996) suggested that accident prevention should be taught as an integral part to the course.

Good workshop management should therefore ensure the safety of those working in the workshop and the safety of facilities and equipment provided in the workshop. This is necessary because Uzoagulu (1993) pointed out that a total of 207 and 211 tools and equipment are lost and are non-functional respectively in 12 departments within an interval of three years. This shows how on safe the equipments are. Therefore, Oranu (1996) recommended that safe practices and habits should be part of the student's training from the beginning of the shop career in the school environment. The author further advised that the acquisition and retention of safe habits of working should be encouraged as early as the student engages in this activity. The preservation of the student's life for adult employment demands that such safety training be basic in school shop instruction. He further observed that ninety-eight per cent of all workshop accidents are preventable and that only two per cent are unpreventable. Among the 98 per cent that can be prevented, two major causes of workshop accidents were identified, namely:

a) The workshop set-up on which the accident occurs and
b) The personality and practices of the students.

Every wise instructor will try as much as possible to eliminate all unsafe conditions in the shop when discovered before actual shop accident occur from these condition:

i) Fixed responsibility
ii) Elimination of physical hazards
iii) Safety instructions and
iv) Follwing up for results. Therefore, the instructor in all workshop accident has the responsibility for searching out and isolating the causes of the accident in order to prevent further accidents to other students.

It can be affirmed that good usage of improvised furnace by the teacher involves the safety of those working in the workshop and the safety of facilities and equipment available in the workshop. Thus, the development of a teacher improvised furnace was arrived at following these steps:

(1) The National Business and Technical Examination Board (NABTEB) syllabus in Metal Work was carefully analyzed to determine which aspects of the syllabus that required the use of furnace in teaching. After the content areas have been identified, the specific tasks requiring the furnace were identified such as heat treatment, soldering, forging and foundry.

(2) The next important task was a survey of various source materials and textbooks to determine the actual furnace that could be used. In arriving at suitable furnaces, the type of components that could be available to teachers in Rivers State and the functionality of the furnace were also considered.

(3) The teacher constructed furnace is an improvised teaching material that is made up of a steel vessel hardened with carbon – molybdenum of ratio 0.20 per cent : 0.68 per cent respectively. It may be lined with bricks and fired with charcoal, using an electric blower connected to a low voltage generator. The furnace was used for: Heat treatment, Soldering, Forging and Foundry and was found to be reliable. The picture of the furnace is as shown in figure 1 below.

Fig 1: Pictures of Teacher Improvised Furnace

Learning and using improvised furnace in teaching will empower the teacher during and after training. Ezeji (2005) maintained that it is hard to conceive any other education comparable with technology education that could totally empower the youths. Owing to its various appeals to the three domains of educational objectives, technology education possesses the rudiments to empower the youths' brains, hands, and mind.

Statement of Problem

Forging Technology ought to be taught using the same equipment the practitioners use in the industries. This is because teaching Forging

Technology involves the study of industrial technology. However, Ogundu (2005) observed the lack of functional furnaces in Rivers State Technical Colleges. Even where imported electric furnaces are available, the high voltage electricity needed to power it is not reliable. This lack of functional furnaces has possibly led to the poor performance of students in external examinations such as National Business and Technical Education Board. Candidates performed poorly according to the report from the Exam Ethics project (2006) because they were unable to attempt questions on blacksmith shop equipment and other equipment for Forging Technology. Furthermore, the lack of functional furnaces may have contributed to the students' poor exposure to practical classes the conventional teaching aids such as drawings, pictures and non functional furnaces used in the Technical Colleges for teaching Forging Technology are only descriptive and cannot be used to teach practicals. For this reason, the local construction of a furnace that can function with a low voltage generator and making counselors know about it is imperative.

Research Questions

The following research questions guided the study:

1) What is the validity of the improvised furnace when used for forging operations?

2) What is the reliability of the improvised furnace when used for forging operations?

Research Question 1: what is the validity of the improvised Furnace

The Rockwell Hardness Testing Machine, the Universal Testing Machine and the Impact Testing Machines were used in testing the furnace's hardness, tensile strength and impact strength respectively. Chapman (1994) stated that Rockwell and Brinell Hardness Testers are the most commonly used types of hardness testers for industrial and metallurgical purposes. Chapman (1994) further reported that inspectors in industries often use these machines to validate furnaces by way of construct validity which according to Akaninwor (2006) is a validity established mainly by relating a presumed measure of a construct or assumed quality with some behaviour or manifestation that it is assumed to underline. The validation is to ensure that the furnace does not melt before the metal it was supposed to forge. The Charpy testing machine was used in conducting an impact test for the furnace.

In order to further establish the suitability of the furnace for forging operations, four experts helped to validate the instrument. Two experts from the Rivers State University of Science and Technology, Port Harcourt, and two industrial-based experts from the Nigerian Engineering Works in Port

Harcourt, independently validated the instrument. The result of the ratings of the instrument is as shown in Table 1.

Table 1:*Mean Scores of Experts' Ratings of Teacher Constructed Furnace*

FURNACE	CONTENT	SPECIFIC TASK	MEAN	REMARKS
Furnace	Heat treatment	Treatment of mild steel	3.50	Suitable
Furnace	Soldering	Solder of copper	3.50	Suitable
Furnace	Forging	Forging of mild steel	4.00	Very Suitable
Furnace	Foundry	Casting pot using aluminum	4.00	Very suitable
Grand Mean			3.75	

Data presentation in Table 1 shows different topics validated and rated against the teacher constructed furnace by experts for teaching Metal Work Technology. The experts were asked to rate the furnace on a scale of very suitable (4 points), suitable (3 points), fairly suitable (2 points), and not suitable (1 point). For heat treatment, the furnace was rated 3.50; soldering 3.50; forging 4.00; foundry 4.00. The furnace was considered either suitable or very suitable for effective teaching of all the topics in Metal Work Technology.

Research Question 2: what is the reliability of the improvised teacher constructed furnace

The testing machine used to determine the reliability of the teacher constructed furnace was a rugged electromechanical high force materials testing machine fitted with strain gauge load cell force measuring system. It has a four-screw load frame and maximum frame capacity of 300KN. It was designed and manufactured by Tinius Olsen, the leading specialist manufacturer and supplier of static tension and/or compression materials testing machines. The machine was designed for use in research and quality control to measure material strength and performance.

The machine for the study was calibrated and used to test three untreated (control) sample steel vessels to determine the most suitable for use as furnace, taking into consideration each of hardness, impact and tensile strengths of the different materials. The readings obtained from the tests are presented in Table 2. The readings for each control specimen were compared with others in their respective test cases. Since the furnace was for instructional purpose, aluminum and steel were the raw materials used. The first specimen was considered reliable for temperature of about 850^0c. Any temperature and Harder metals above this temperature may be inserted directly into the flaming charcoal

Table 2: *Control Specimens Tests Results*

Test	**Control Specimens**		
	1 Steel with molybdenum	2 Plain carbon steel	3 High carbon steel
Hardness (HRC)	164	28.3	28.2
Impact Strength (Joules)	150	79.5	79
Tensile Strength (N/mm^2)	304.38	303.9	304.2

The readings as presented in Table 2 shows values that are within the range given in engineering handbooks for the respective properties and negligible variation within each test condition. The first specimen that is steel with molybdenum was therefore judged reliable.

Discussion of Findings

Forging as defined by Smith (1991) is the art of shaping metals by hammering. Man has known this art since ancient times. Today machines have largely replaced the sweat and muscle of the blacksmith, who nevertheless remains indispensable for carrying out the jobs done by hand, necessary in steel and engineering works. The furnace was found to be valid for forging at 4.00 and reliable using steel with molybdenum at hardness of 164 HRC. Any temperature and Harder metals above this temperature may be inserted directly into the flaming charcoal.

Momoh (2005) pointed out that the school workshops, laboratories and the total environment where vocational education is given must be adequately equipped to reflect the actual working environment. The theories of vocational education stated by Prosser's tells us that the actual working environment should be equipped to expose the students to the use of the Metal Work materials, tools and components for making furnace that will lead students to the acquisition of relevant knowledge and skills. The utilization results agrees with the result of a study on academic aptitude of vocational education carried out by Bishop (2001) where he stated that students have greater ability in visual reasoning and manipulative tendencies than other abilities measured. This rather, will make students to be very successful in skill acquisition. But conventional teaching aids, instead of building on these practical manipulative skills, end up in theorizing the subjects.

Implication For Counselling

One major hindrance to employment of the youth arises from lack of required information about job market. It is in this area that vocational guidance becomes imperative. Ogundu and Amakiri (2015) observed that through vocational guidance, students will be helped to know and appreciate the relationship existing between career choice and opportunities in the world of work. Vocational guidance programme will help the teacher develop necessary skills on how to collect, analyze, interpret and present relevant information, about available occupations to the youth in the area of forging operations using the improvised furnace. Through this process students can make the necessary adjustments from classroom to work, thus giving rise to reduction of unemployment; hence, reducing poverty levels in the country. Students make intelligent choice of saleable occupations when properly guided by a vocational counselor. Aluta (2007) pointed out that youths need to be helped to develop consumer skills and awareness so that they can make wise choice and consume intelligently, this can be possible through vocational guidance. Certain abilities are necessary to enable one start and progress in any occupation. A student may like a particular occupation such as forging, but may not be aware of the prerequisite qualification leading to such occupations. Through vocational guidance, students can be helped to acquire knowledge of the characteristics, functions, duties and rewards of the group of occupations within which he can make a choice. So the intelligent choice of an occupation based on the students' abilities is a very important consideration in offering vocational guidance. When students make intelligent choice of occupations they will acquire marketable skills that will subsequently make them self employable at graduation and this will reduce unemployment which will subsequently reduce poverty level of those individuals culminating in their sustainable economic empowerment.

Conclusion

The purpose of this research was to develop an improvised furnace to enhance students’ performance in forging technology in Technical Colleges in Rivers State. The study adopted research and development design. Forging is the art of shaping metals by hammering. Man has known this art since ancient times. Today machines have largely replaced the sweat and muscle of the blacksmith, who nevertheless remains indispensable for carrying out the jobs done by hand, necessary in steel and engineering works. The furnace was found to be valid for forging at 4.00 and reliable using steel with molybdenum at hardness of 164 HRC. Any temperature and harder metals above 850^0c and 164 HRC respectively may be inserted directly into the flaming charcoal. The improvised furnace is a teaching material that is made up of a steel vessel hardened with carbon – molybdenum of ratio 0.20 per cent: 0.68 percent respectively. It may be lined with bricks and fired with charcoal, using an electric blower connected to a low voltage generator. The furnace was used for forging operations.

Recommendations

Based on the findings of the study, the following recommendations were made:

(1) Government, Technical College principals and the different agencies should provide funds to procure the materials and components for designing and developing furnace for teaching foundry in the Technical Colleges in Rivers State.

(2) Constant power supply, generators, anvil, steel vessel, pipes and electric blower should be provided and distributed by the Ministry of Education to the Technical Colleges for construction of furnace for effective teaching of foundry in Rivers State.

(3) Government, Technical College principals and non-governmental agencies should provide funds to procure the materials and components for improvised furnace for teaching foundry to enable students acquire the necessary skills for the world of work.

(4) Vocational counselors should guide students to take up occupation in forging.

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