RECONDITIONING OF WORN-OUT METAL PARTS BY DIPPING METHOD.

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DEDICATION

Rest in the blossom of the Almighty Lord Mama Cecilia Abubakar, till we come to part no more.

To all those that lost a loved one, especially a mother to the hands of death.

CERTIFICATION

This is to certify that this project was carried out by Abubakar Nomso Nester in the department of Agricultural Engineering Federal University of technology, Minna.

....	14.02.001
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....	16/1/2001
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Dr. Eng. M.G. Yisa Head of Department	Date

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CHAPTER 1

INTRODUCTION

A modern machine may not be characterized only by high efficiency, but also by its complexity more economical operation necessitates good organisation of technical maintenance and repairs of available machine and equipment. Worn out parts of machines are seen every where especially in and around mechanic villages and workshops. Vehicles and machines have in recent times been abandoned by their owners due to failure by some parts in the engine system to perform their said function in the engine system, due to the fact that they are worn-out.

This cannot be able to carry the load or perform its constructed function of driving {transmitting power} Other components are being driven or converting power from one form to another. The worn out part has an un-wanted clearance, which is more than the designed tolerance. This causes the worn out part(s) to really touch the other bodies. For example when it is the turn of the worn out section of the part to either transmit or receive power to or from another part, as in the case of gears, the teeth will not be able to mesh well, thus power is lost.

The Nigerian economy has forced, and of course ignorance some operators to over load their machines, over the manufacturers specifically, and to gain more in less time this causes the engine components to get over worked and wear easily, due to the pressure and heat caused in the system. Some operators have been known to use cheat or low grade engine oils for the engine lubrication system. Spare parts are most at times not available and when available they are expensive beyond the reach of the common operator. Some spare parts are only available only on special request to the manufacturer, which apart from being expensive, it may take more time than could be tolerated to be imported and delivered to the operator. This is also on production set-book.

Engines are however, constructed from different parts and attachments (auxiliary materials). Some of these parts must be replaced after the first failure (non-restorable). Such parts include elements of automatic harnesses (diodes, triodes, and resistors), nuts, paper tubes, levels e.t.c. The engine is also made of parts, which may have more than one failure in the course of operations.

In such certain most of the machine parts such as shafts, bearings, fluted rollers, spindles, flyers, cams, and rods e.t.c. After every failure they could be repaired or reconditioned such parts are also known as reconditionable parts.

Reconditioning is a process by which an object (bad) is restored to a good and more useful condition. This could be done using different methods like the use of welding process to fill, that is using an electrode and a filler rod. The process of casting could also be used, Brazing is also an important method used in the reconditioning of metal parts. The other important and basis for this project is "The reconditioning of worn out parts.

1.1 WEAR:

Wear is the removal of surface material from a component by mechanical attack of solids. It is also the deterioration of a surface due to material removal caused by the relative motion between it and another body. The machine is composed of components that are in constant motion whenever the machine is on (working). This components which are either converting power from one point to another or one form of motion to another or transmitting this power from one point to another. For example, the conversion of chemical energy to mechanical energy as it occurs in the combustion chamber, and the subsequent convention of the reciprocating motion from the piston of the connecting rod, to rotary motion by the crank shaft and the further transmission of this rotary motion from the engine to the wheels through a system of gears by the propeller shaft. These components not withstanding the lubricating system installed (how efficient) the oil grade used and the accuracy of surface finishing by the manufacturer, the force of friction can not be completely eliminated. Thus, no matter how long it takes, the components that are in continuos mesh (rubbing components) in the engine, wear could be seen to affect implements used, especially for tillage operations carried out on the soil to be used for agricultural production. This is mainly due to the direct contact between the implement and the solid soil particles (silicon and its oxides and other solid inclusants) that make up the soil.

The soil in which tillage implements work is composed of the solid base material, whose type is determined by its parent (rock) material, organic matter (dead decaying tissues) and microfloral and fauna. Others include air and water found in between the soil voids. Though this and much more are found in the soil basically the solid material which is made up of silicon oxides that is responsible for wearing out implements. This oxides are hard and rough textured, these properties give the soil its wearing ability of this implements and is increased when the soil is moist, (abrasive wear as discussed in chapter 2). Wear is mostly experienced at the front-tip end of the implement, which goes first into the soil. Plows are the most easily worn as they are used to perform the first tillage operations which involves the breaking of hard soil into clods. A few example of such implements are the mould board plow, sub-soilers rotavators, harrows and ridges e.t.c.

Worn out components are thus, those components that have gone (or deteriorated) beyond the allowable clearance as specified by the manufacturer. This is such that it doesn't fit into or mesh with the other components. This could cause a significant loss of power (when the piston no longer fit into the cylinder) and/or noise been worn) while a poorly finished tillage operation is noticed in the case of a worn out tillage implement.

1.2 **Dipping**:

Dipping as defined by the McGraw hill dictionary of scientific and technical terms, is "applying an adherent layer of more noble-metal to the surface of a metal object by dipping into molten metal". Dipping involves either the fully or partial the molten metal (filler metal). The molten metal is suppose to stick on the base metal and the solid is then finished to specification using either the hand tool or machining.

Reconditioning of worn out parts is more or less than the process by which worn out parts (bad) are restored to a good and more useful condition by simply immersing the worn out section of the component into Molten filler Metal and then further finished to fit the original manufacturers specifications. To be able to recondition a worn out part using this process, first is the need to hence a worn out component filler metal and a furnace to melt, the right cleaning method, flux for cleaning and protection and a good safety arrangement.

Agriculture, which is different from many other industries, in that it must posses an area, most of its machines must be mobile and differing from the transportation industries. The agricultural machines mostly work on very difficult conditions and since most of the machines and their implements are imported, most of the parts are hard to come by as they are either expensive or only available on special request from the manufacturers which is very expensive. Because of this the farmer can hardly maintain a small machine e.g. a tractor, as the profit made is channeled to buying or ordering for spare parts.

This then facilitated the project topic. (The reconditioning of worn out parts by dipping) research and design of a simple, cheap but efficient method of reconditioning by dipping, the process is also designed in such a way that it could be carried in a simply organized farm workshop.

AIMS AND OBJECTIVES

1. The project is aimed at developing a simple method of reconditioning worn out parts by dipping
2. Using simple and readily available material for the process of dipping
3. Developing simple but efficient methods that could be used to achieve the process

CHAPTER 2

2.0 LITERATURE REVIEW

The engine is made up of different component parts used to transform power from one form to another (this could either be from chemical or electrical power mechanical (motion) power). In the process of doing this, the components must make contact with each other so that the converted power could also be transmitted directly (transmission of reciprocating motion from the piston to the crank shaft through the connecting rod)or convert the motion to another motion as in the conversion of the reciprocating motion to rotary motion by the crank shaft. The motion (needed to power the wheels must be transmitted to the wheels through gears and axles)

The performance of an engine is usually characterized by its operating performance or characteristics. And these include the speed-horse power (power output) dependence, specific fuel and oil consumption's, absence of knocks, and abnormal noise. Any departure of performance characteristics from normal ones points to some faults. Such faults could be as a result of wrong faults, such faults could be as a result of wrong adjustments or some changes in the engine that cannot be remedied through a suitable adjustment. These are mechanical faults or wear.

2.1 Wear

This is removal of material from a component by mechanic attack of solids. I t could also be defined as the deterioration of a surface due is material removal caused by the relative motion between it and t another body .The machine consist of individual component parts forming certain joint. The performance of a joint is characterized by it operational factors which in this case is the fit of the parts forming the joint, this is determined by the design of the leather. Thus, for a joint a fault manifest itself by a disturbance of the fit of joined parts, i.e. a disturbance in the specified clearance of interference between the parts. An engine may loose power as a result of increased clearance between the piston and the connecting rod assembly. Any disturbance is associated with changes in the dimensions, shape, surface roughness, chemical composition, structure and mechanical properties of the mating parts.

2.2. **Classification of wear types**

There are different types of wears as they occur in machine component parts, assemblies and units, V.I.Kazantser of the former soviet union [USSR], as quoted by Borovskikh(1988)classified the different types of wear into two groups – Natural and the accidental groups of wear

2.2.1 **Natural wear**

This was as a result of friction and high temperature and loads occurring under normal service conditions. This type of wear is characterized by a slow progress i.e. the manufacturers proposal for servicing is followed. The method and servicing hours are adhered to strictly, the right type of servicing materials such as the oil grade and grease type are used. Wear cannot be eliminated but only reduced. This type of wear are those wear action that are only reduced and not eliminated.

2.2.2. **Accidental wear**

This is as a result of bad servicing. Though manufacturing defects, poor materials and design error could cause it. This type of wear is characterized by rapid progress and is accompanied by residual deformation of the machines unlike in the case of natural wear, where all the maintenance principles and guides as provided by the manufacturers are precisely followed, the accidental wear is caused by shear negligence on the part of the operator. Here, to avoid the occurrence of accidental wear which is more faster in the deterioration of surface than the natural wears the operator should try and maintain his sheet so as to allow only for Natural wear.

2.3 Causes of wear

The Natural wear of a movable joint is dependent on many factors such as relative velocity of mating parts, their initial condition (surface roughness, work hardening, e.t.c.), lubrication method, amount and quality of the lubricant and the presence of abrasives.

The great diversity in mechanical and chemical properties of the rubbing materials themselves extremely complicates the picture of natural wear. This makes it very difficult to reveal the general laws governing the amount and character of wear of a certain joint under various operating conditions. What is common to all movable joints is that the degree of their wear increases with operating time.

There are various theories of soviet scientist explaining the process of wear as quoted by Borovskikh, Y. (1988). This includes the molecular friction theory advanced by B.V. Deryagin and the theory of mechanical and molecular mechanical wear by I.V. Kragelsky, B.I. Kragelsky and B.I. Kostetsky. They studied the chemical and structural change occurring in thin surface layers in the process of wear. According to Kostetsky, occurs as a result of seizure of metallic surfaces, Oxidation, The action of high temperatures and abrasives, and flaking

2.3.1 Adhesive (seizure) wear

This is also known as galling or scoring and is characterized by an intensive destruction of the surfaces of the machine components rubbing without lubrication. As they slide over one another under pressure, surface projections, or asperity one plastically deformed and eventually welded together by high local pressure.

As sliding continues, these bonds are broken, producing cavities on one surface, projections on the second surface and frequently tiny abrasive particles, all of which contribute to further wear of the surface. This type of wear also occurs on component parts restored by various methods.

2.3.2 Oxidation wear

This is a process of gradual destruction of surfaces of rubbing parts under the action of oxygen (from the atmosphere) on the metallic surfaces subject to deformation. Oxidative wear is typical of crankshaft Journals and pins, Piston rings, and other components operating under similar conditions.

2.3.3 Pitting

This type of wear is characterized by flaking spalling and other similar Phenomenon on rolling friction surfaces. This type of wear manifest itself most vividly on the surfaces of ball bearings and gear teeth.

2.3.4 Thermal wear

This is as a result of high action of specific pressure and sliding velocity on the rubbing surfaces. The heat generated in the process of overcoming friction softens the metal on the surfaces and causes their intensive destruction due to fusion, smearing and transfer of small volumes of the metal between them. Thermal wears are the major types of wear that occurs on cams, valve push rod, end plates, cylinders faces, e.t.c.

2.3.5 Abrasive wear

This occurs as a result of materials removed from the surface by contact with hard particles, which may either be present at the surface of a second material or may be present as loose particles between two surfaces. As the surface slide over each other, these particles cut the microscopic volumes of metal, off them. Unlike in the case of adhesion ear no bonding occurs.

This type of wear inevitably accompanies all the other types of except for pitting. It is common to machine components that operate in abrasive media such as ploughs, scraper blades, crushers and grinders used to handle abrasive materials. It may also occur when hard particles such as sand ploughs, scraper blades, crushers and grinders used to handle abrasive materials. It may also occur when hard particles such as sand, are introduced (un-intensionally) into moving parts of machinery. This principle is used for grinding operations to intentionally remove materials.

2.3.6 Friction

The force of friction could be said to the force that acts between two bodies in motion, the force of friction tends to retard or oppose motion. Forces of friction appear when contacting bodies or their parts move relative to one another. The friction that occurs in the relative movement of two contacting bodies is called external; and the when contacting bodies or their parts move relative to one another. The friction that occurs in the relative movement of two contacting bodies is called external; and the friction between parts of the same continuous body {for example, a fluid} is called internal.

Though we have been the different types wears and their characteristics the effect of friction in the achievements of these types of wear can not be over looked. According by Godwin A.M. of the Soviet Union, who was quoted by Askeland D.R (1987) said that the major source of wear is basically the force friction". This implies that to handle wear friction should be the main force to be focused on to be reduced to the barest minimum .Not withstanding that frictional force opposes motion, no two bodies will move over each other without the force of friction between them. We going to consider the two main types of friction and how they affect wear.

2.3.6. **Dry friction**

This is the type of friction that appears between two solid surfaces in the absence of any intermediate layer, for instance, a lubricant between them. It is also when attempts are made to set up such sliding motion. In that case we have to do with the "force of static motion.

To reduce dry friction, the surface of the sliding bodies must be finished to the highest degree of smoothness. The laws of dry friction consist of the following; the maximum force of static friction, and also of the force of sliding friction do not depend on the area of contact between the two bodies and are approximately proportional to the magnitude of the normal force pressing the contacting surfaces together (load)

$F_{fr} = fF_n$

Where f = dimensional proportionality constant (the coefficient of friction for sliding or static friction as the case may be)

F_n = normal force pressing the contacting bodies.

F_{fn} = maximum force of static friction.

Dry friction is experienced in walking, between the soles of the feet and the ground and between tyres and the roads. Without which motion will not be easy, like trying to walk or drive on iced pavements.

In reducing dry friction which also aids wear in contacting bodies especially in accidental wear, as classified by V.I. Kazantser, quoted by Askeland D.R, the most radical way is to replace sliding friction with rolling friction. Rolling friction appears between cylindrical or spherical body rolling over a flat or curved surface. Rolling friction normally obeys the same low of friction except that the coefficient of friction is much lower.

2.3.6.2 Viscous friction is a type of internal friction as the lubricant serves as the continuous body. Unlike dry friction, viscous friction is characterized by the force of viscous friction vanishing together with the velocity. In a continuos medium there are two basic forces that act, that is apart from the frictional force there is also the forces of resistance of the medium. At times the resistance of the medium is much greater than the friction force. Though there are no possibility of considering the causes of these forces in detail we shall treat both forces and the laws they obey jointly. At low velocity the force grows linearly with the velocity:

$F_{fr} = -K_1 V$ (negative sign signifies that the force is directly opposite to the velocity)

At higher velocity, the linear law transforms for a quadratic one, that is the force begins to grow in proportion to the square of the velocity

$$F_{fr2} = - K_2V^2ev$$

Where ev = Unit vector of the velocity.

K_2 = depends on the velocity at which F_{fr1} is transformed into F_{fr2} depends on the shape and dimensions of a body, and also on the viscosity and density of the fluid.

2.4 Reconditioning

It could be recalled that we tried to define reconditioning as "the process by which an object (bad i.e. worn out) is restored to a good and more useful condition", from the introduction chapter. A worn component could be restored to have either the repair or nominal size. It is imparted the true geometrical shape, and necessary surface properties.

For the purpose of reconditioning worn our parts, there are the following general methods of reconditioning used.

2.4.1 **The restoration of the original fit of components by using their repair size counter parts**: here the most costly and critical of two mating parts is machined to a repair size the other one is replaced by a totally new one of suitable size. This method is used in the reconditioning crankshafts. Their Journals and pins are machined to the nearest repair size and the bearings (of repair size) are then selected to fit the machined Journals and pins with the necessary clearance therefore, a repair size is one nearest to the normal size of a given part, which ensures the necessary shape and surface roughness of the part machined to size.

Some machine components that come in standard repair sizes include; the piston, piston rings and pins, values, pash rods, and thin walled bearing insects. They could easily be gotten from the market. Their mating parts which are expensive to get hence they are the ones that are machined to sizes are the cylinder blocks, crankshafts e.t.c.

2.4.2 **The reconditioning of the original fit of components by using additional repair parts:** This is specifically used where the reconditioned components are to have a standard repair size. The technique consist essentially in that the worn surface of the part under repair is machined to its true shape and a specially made additional part which is also known as the make-up piece is fitted to it. The make-up pieces are already manufactured in the form of various sleeves liners, rings, threaded inserts and gears e.t.c.

The make-up pieces are usually fitted on or in the parts under reconditioning by means of press. This causes the outside or inside sizes of the make up piece change. This should be put into consideration when the sleeve is pressed into a hole its inner diameter is reduced, so this should be taken into considerations when specifying for the allowance for finish. To make the pressing easier the female part (outside) is heated on the male part (The inside) is cooled, all to a certain temperature. Steel sleeves one heated to about 600°C. The cooling could be achieved in various liquid media: oxygen (vaporization temperature-183°C) Solid carbon dioxide (Vaporization temperature -79°C) liquid Nitrogen (196°C) and a mixture of solid Carbondioxide and alcohol (-100°C)

TABLE 1 AWS FLUX CLASSIFICATION

Ranging flux type No	Base metals	Recommended Filler metals	Recommended Temperature Range		Flux ingredient
1	All breazable alluminium alloys	$Bals_2$	°F 700-1190	°C 371- 643	Chlorides, flourides
2	All breazable magnesium alloys	BMg	900 – 1200	482-649	Same as in 1
3A	All except those listed under 1,2 and 4	Bc_up, Bag	1050-1600	566-871	Boric acid, Borates flourides ,fluoborants
3B	As in 3A	Bcu,Bcup,BAG, Bau,BN, RBCuZn	1350-2100	732-1779	Same as in 3A
4	Aluminium-bronze,Aluminium-brass, and iron or Nickel based Alloys with AL or Te or both		1050-1600	566-877	CL,fl,Borates and wetting agent
5	As in 3A	Same as 3B (excluding Bag-1 through-7)	1400-2200	760-1204	Borax, Boric acid Borates, wetting agent

SOURCE; WILLIAMS B.A and KEVIN B.E. (Welding technology foundamentals)

2.4.3 **The reaction of the original fit of components by making them have their nominal size:** This method of reconditioning of worn out parts is worth considering as it forms out parts is worth considering as it forms the basis of this project. It is advantageous. To the third world countries because no matter the extent of wear, The reconditioning could be done using a good number of techniques. This is also achieved provided that the strength of the components is high enough and the method selected is cost effective. Unlike in the preciously discussed methods, only the worn out part is worked upon i.e. there will be no need to change (by buying) only standard repair sizes or the use of additional repair parts (make-up pieces) as in the cases above. The electrolytic plating, plastic working and coating with polymer materials, the following are the methods which are now still at the stage of experimental testing and these are: Friction welding, Plasma-jet hard surfacing liquid metal surfacing and electro- physical welding techniques.

2.5 **Fluxes**

The first rules in the process of dipping are cleanliness. Not only must the working environment be clean, for safety and efficiency, but the work piece must be made clean, that is devoid of solid or liquid waste. As any inclusant in the form of air bubble, dust particles, oil or wax and e.t.c. Can reduce the adhesion (wetting) of dip.

Virtually all metals have been their oxides, that is they react easily with oxygen from their pure state to give these oxides except for noble metal is attached by atmospheric air and water vapor increases with temperatures. Iron, which forms one of the basic metals used in the fabrication of engine parts, is known to revert completely to its oxides. The intensity of oxidation is greatest when metal is molten.

Fluxes are non-metallic substances that are used to remove and /or clean the surface of the base metal and filler (molten metal) metal. Fluxes could also be defined as non-metallic substances used to remove the oxygen absorbed on or the oxide and preclude the oxide formation during the process of dipping in open air, to change the surface tension of the molten filler metal. Thus the flux protects the filler and base metals against oxidation, removes the oxide films, changes the surface tension of the liquid phase and is therefore capable of influencing spreadability.

2.5.1 Types of flux.

Fluxes could be grouped into two types depending on the manner at which they operate in the cleaning and protection process.

2.5.1.1 **Reactive fluxes**

These types of fluxes are known as reactive because they work by producing chemical changes. Most relative fluxes are hygroscopic, i.e. they absorb water (atmospheric moisture) thus they must be kept in airtight containers. Because of their acidic nature, such flux residues must be removed immediately after dipping (before work is assembled). These fluxes come in either powder form, or suspensions (Liquids such as propyl alcohol, or a gaseous mixture) or paste (This is also achieved by mixing the flux into oil).

2.5.1.2.1 Organic fluxes

Into this category fall the resin-based fluxes, stearic acid and chloride-free types of fluxes. They are usually non-hygroscopic

And are fairly inert compared to the reactive fluxes. They are designed to function at lower temperature life. Their residues must be removed as well before coupling because of the chemical changes that occur after the fluxes are heated to produce corrosive effects, that is corrosive by product.

2.6 **Filler metal**

Rybakov, The Russian Scientist who did a lot of work in the field of developing filler metals for gas welding said that the wire (filler metal) needed or intended for use as a filler material in gas welding should match the base metal in chemical composition as closely as practicable. Filler metal, also obey the Rybakov statement. This is so because some metals in their pure state do not alloy or bond together as they act much like oil and water, an example of such metal is lead and iron in their pure state. This with any of the two metals used as a filler metal and the others. The base metal will end up not achieving the said goals.

The American welding society (AWS) defines filler metal as "A form of filler metal used for welding or brazing or dipping process which does not conduct electricity (electric current)"

Some common filler metals used include"

1 – Mild steel

2 – Cast iron

3 – Stainless steel

4 – Braze welding alloys

5 - Aluminium

- a – drawn
- b – Extruded
- c – Cast

Filler metals come in different sizes and shape depending on the use and manufacturer. For example mild steel, bronze welding alloys, stainless steel and some Aluminum rods are made in 0.91m length and are available in the following diameter ranging from 6mm-9.53mm. They are packaged in 22.7kg bundles (pack). Mild steel rods are copper coated to prevent them from rusting. Aluminum rods or coils come in 0.91mlenght. Some Aluminum rods are flux coated.

2.6.1 Choosing filler metal

In selecting filler metal, apart from considering the chemical composition, that is if there is going to be wettability or not. There are other factors to be considered. And these are selection based on strength, melting temperature of the filler metal with respect to the melting temperature of the base metal Another secondary consideration is for color match with the base metal, for corrosion resistance, for electric properties if need be, and finally by cost. Cost considerations have to come last, because if any filler metal can't met one or more of the other requirement, its cost doesn't matter, because the alloy simply can't be used. Let's look closer at some of these filler metal selection factors.

2.6.1.1.1 Melting temperature

Filler metals are frequently selected on the basis of melting temperature those with high temperature also tend to have high strengths. Through, that is not a hard and fast rule, but it's a good general guide. If all that is needed is arrange of alloys with different melting temperatures, then the list will start and end with lead-tin solders. They are least expensive and easy to work with.

2.6.1.1 Wettability

No matter what else is looked for in a filler metal alloy, it must be able to adhere to the base metal. Not all filler metal will be able to wet all range of base metal. The most important factor for any filler metal alloy is that it must be able to wet the base metal. Lead and iron will not alloy or bond together, because pure lead acts like water and oil when poured into molten steel. It simply separates like cream does from milk. But tin wets iron and tin wets lead. This tin can form alloys with both lead and iron separately. Therefore lead-tin filler metal will wet iron base metal and similarly, iron-tin alloy will wet lead base metals.

2.7 Surface cleaning and preparation

Cleaning of the surface of the base metal so as to achieve the formation the desired wetting without inclusants, which could reduce the strength of the final product. Cleaning is necessary to achieve successful repeatable final product. The cleaning operations could be done in two major ways, that is the chemical cleaning method and the mechanical cleaning method. In most cases both methods are used on the same surface depending on the same surface depending on the position of the component as it is placed in the engine.

2.7.1 Chemical cleaning method

These are most widely used. As part of any chemical cleaning procedure for processing dip method of reconditioning, solvent degreasing it removes all oils and grease should be the first operation. This is necessary to ensure wettability of the chemicals used for cleaning.

2.7.2 Mechanical cleaning method

This is usually continued to those metals with heavy tenacious oxide films or to repair components reconditioned by the process of dipping, exposed to service. Mechanical cleaning methods include standard machining processes – abrasive grinding, grit blasting, filling or wire brushing (Stainless steel bristles must be used). These are used not only to remove surface contaminants, but also to slightly roughen or fray the surface to be dipped.

CHAPTER 3

3.0 METHODOLOGY

The act of reconditioning worn-out parts by the process of dipping, could be done with ease provided the input needed are available, the operator semi-skilled and the right material selection is done. The skills of the operator is very much limited to the availability of the cleaning materials and technique involved forms a good determinant of the level of wet achieved.

In the process of carrying out the dipping of worn out metals into molten metals there are two basic considerations that are taken before the process proper; work place (workshop) and safety measures that are taken for the protection of the operator.

3.1 **Work place**: The work place, which could be part of the workshop, should be kept very tidy. The workbench and other equipment needed should be kept at the corner of the workshop, this is to prevent any careless accident due to spillage as the process involves molten metal. The work place should take the look of a foundry.

3.2 **Safety measures**: this forms the backbone of any process in engineering. All the safety measures that are put in place by the operator are not only for a selfish interest but also in consideration of others using the workshop and for the protection of the workshop building entirely.

3.2.1 **Personal safety**: This involves all the safety measures put in place to protect the operator himself. The use of gloves (thick insulated industrial gloves) must be used to protect the operators hands against pillage. The glove should be at least of arm length. The use of industrial safety boots cannot be over emphasized as it protects the feet from spillage, hot metal and sharp object on the floor. In the absence of insulated suit then at least a well fitting overall should be used. Gurgles also should be used.

3.2.2 **General safety:** this includes the totality o f safety considered in the workshop considering others and the workshop. The use of colored sign codes (red color with danger boldly written on it) should be displayed some meters before reaching work place, especially when work is in progress. Tools not in use should be kept away in the tools box. The floor and work table also devoid of all sharp objects. There should be kept at a place accessible a functional fire extinguisher and since many at times accidentals are inevitable a well-equipped first aid box should be provided for at a place that could be seen and accessed by all.

3.3 **Wear Testing**: This has not been adequately standardized (Metal Handbook). There are a hundred of different testing devices and procedures described in technical literatures. Many of these are based on simple configurations e.g. Pin-on-disc, block- on-ring, ring-on-ring, or cylinder on cylinder. There are however, three questions to ask despite the great variety of wear test: -

- Is the system lubricated?
- Is most of the wear debris removed?
- Is the wearing surface in contact with another?

3.4 **Reporting wear data**: - The most simply and easy way to summarize wear data is to note changes in length, volume or mass. (or these same measures per unit time) for specific condition. Wear is sometimes given as the inverse of these quantities.

These quantities when expressed in these manner no longer material constant, because they are based on experimental constants.

Several models of sliding wear lead to the prediction of volume change.

ΔV = KLS/ 3H (Metal Hand book)

Where L = load

s = sliding distance

k = constant

$\Delta V/L$ =wear rate

Wear is sometimes reported as "specific wear", d/ps

Where d = depth of wear

P = bearing pressure

3.5 **Wear debris**: These are the pieces of material, varied in size and shapes that become loose during wear. The structure and properties of debris can provide clues to the type of wear involved and prevailing conditions that exist during their formation.

3.6 Process design : To be able to achieve good quality product and a simple but efficient method, a flow diagram could be used to show from the start of the process to the final finish and testing of the component reconditioned.

3.7 **Flow chart**: The flow chart is a simplified process diagram used to depict pictorially the stages involved and how they follow each other from the start to the end.

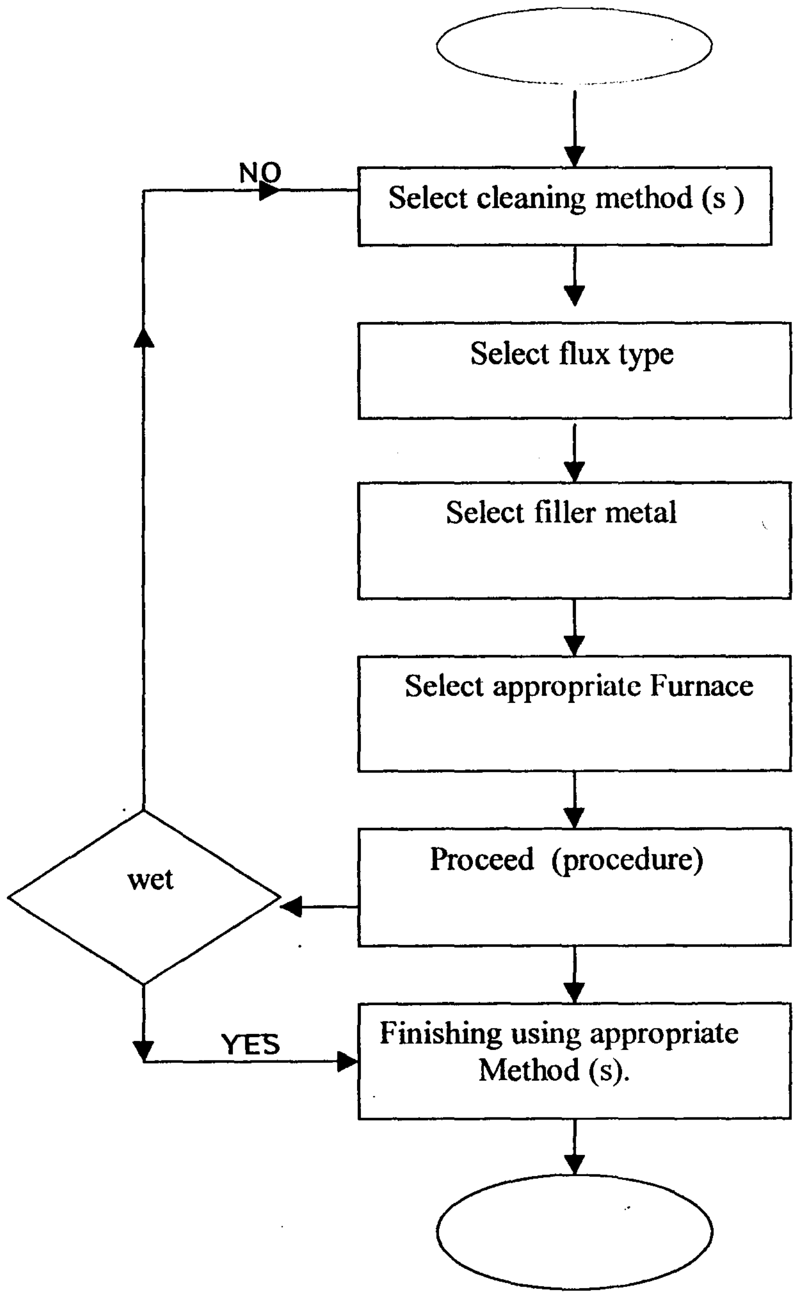

Fig.3.1: Process of Dipping Flow Chart

3.8 Selecting cleaning methods: The first and most important rule in the process of dipping is cleanliness. Not only must the working environment must be made clean for safety reasons the work piece must be clean too to aid wetting. As any inclusant in the form of air bubbles, dust particles, oil or grease or wax e.t.c. can reduce wetting (strength) of the product. Thus, it is essential that all dirt and grease, and as much oxides as possible are removed from the surface prior to when the base metal is dipped into the molten metal. Dry clean cloth could be used to remove all the solid dirt e.g. sand or dust particles while special cleaning fluids (detergent then rinse properly and dry) are used to clean off the oily dirt on the base metal.

3.9 **Select flux type**: Virtually all the metals have their oxides, that is they can easily react with oxygen from their pure state to give these oxides except for noble metals and alloy steels. The rate at which a metal is attacked by atmospheric air and water vapour increases with temperature . Iron which is used as a major metal used in the fabrication of engine parts is known to revert completely to its oxides. Fluxes generally are non-metallic substances used to remove and/or clean the surface of the base metal and filler (molten) metal. They could also be defined as non-metallic substances used to remove the oxygen absorbed on or the oxide film from the surface of base metal and preclude the oxide formation during the process of dipping in open air, to change the surface tension of the molten filler metal. The two main groups of fluxes that could be selected from one reactive fluxes which are hygroscopic and work by producing chemical changes, and organic fluxes which are non-hygroscopic and are designed to function at lower temperatures.

3.10 **Select filler metal**: The process of selecting filler metals is very important as it to a very great degree affects the strength of the final product. There are a wide range of filler metals that cold be used depending on the following:

- Is the component in constant contact (mesh) with other components?
- The temperature at which the component is made to work in.
- The load to be carried and / or to be transmitted by the component.
- The above considerations must be known as most of the filler metals have temperatures ranging from less than 100°C to more than 200°C with varying strength.

3.11 **Selection of furnace** : There are variable furnaces with varying capacity, size and shape. However the furnace selected should be able to melt the filler metal and raise the temperature of melt to not more than approximately between 110°C to 150°C maximum above the melting point of the filler metal. The filler metals are available in grades.

3.1.2 **Procedure**: The process is dipping (immersion) however, the procedure could be done using the furnace method which is just to leave the melt in the furnace and dp the worn out part or the open method which is done by pouring the melt into a bowl after raising it to about 100°C-150°C and then dipping the component. The procedure that is selected must be simple enough to allow for easy access to the melt.

3.2 Material selection

The materials to be selected must have to conform with the properties of the base metal. The flux should be able to withstand high heat without breaking, the furnace heat capacity enough to melt the filler metal and the filler metals ability to wet the base metal and develop enough strength when cold (solid). Bases on these the following materials were selected to as to achieve a good end product.

3.2.1 Cleaning materials : the materials selected are based on the mechanical cleaning materials (that is steel wire brush, sand paper (coarse)and rags and the chemical cleaning materials (that is petrol, detergent and water)

3.2.2 **Flux material**: This is in relation to the base metal to be reconditioned and also based on the recommendations of the American welding society (AWS) as seen on table 1. The "Easy flow flux powder" was selected, because it has a high temperature of 800°C and its recommended in Table 1

3.2.3 **Filler metal:** the filler metal that is selected is also in relation to the base metal, that is that which can wet the base metal. This led to the choice of similar scraps, which apart from its wettability it will also save cost.

3.2.4 **Furnace**: the furnace that is selected is the electric arc furnace (EAF). This is because it uses mainly scraps as it raw materials. There is also need for a hot bowl, which is used to contain the molten metal from the furnace, in which the dipping process is to take place. A tong of good length was also selected since the process involves hot molten metal, which could no be handled with the bare hands.

3.2.5 **Safety materials**: Because of the nature of work, thick, heat insulated gloves were used and since the arm length gloves were not available the wrist length type was selected, a safety boot, and a fitting over all.

3.2.6 **Others**: these include a chalk used to write "Hot" on the dipped metal, Danger sign to warn other users of the work shop of the activities going on around that area, an exactinguisher was also provided for and a first aid box.

3.2.7 Procedure: the procedure has been written in a step manner so as to aid the understanding and easy application of the process.

3.2.8 Cleaning: here the cleaning was done in two forms, Mechanically, the component (worn-out part) was brushed using the steel brush to remove all the solid dirt's, then the coarse sand paper was used to further clean smaller solid particles and roughen the surface a bit, this increase the wetting area and adhesion is also increased. Then petrol was used to wash off any form of oil on the component using a clean rag (immersed in the petrol), The detergent was dissolved in water to form a detergent solution in which the component was further solution in which the component was further solution in which the component was further washed to clean off any trace of oil and finally the component was rinsed in clean water and then dried using a clean dry rag.

3.2.9 **Fluxing**: The flux selected was bought from the market in powder form. It was then found to be difficult to apply dry flux on the dry surface. This then led to the adding of a little water on the flux so as to get a paste. A soft, rubber toothed brush was then used to apply the paste fluxes on the surface.

CHAPTER 4

4.0 DISCUSION

4.1 Limitations

The limitation here are those activities that were carried or were exempted during the cause of performing the project and could cause a significant reduction on the operational efficiency of the final product and they are as listed below;

1. The reliability of the measuring apparatus .
2. The volume of melt that is used to dip fill the worn out part .
3. The inavalability of dimensional specifications from the manufacturers of the components.
4. The un-avoidable presence of inclusants in the melt.
5. The lack of a temperature measuring apparatus
6. The proper roughness of the worn out part of the worn out component.This might have been in excess or too little.
7. The volume of flux that was used might be in excess or too small. This could cause a reaction with the finished product or not properly clean the surface as the case may be respectively.
8. In preparing the surface (cleaning) the solids might not have been completely removed.

However, these limitation could be improved upon, that is to say that they are not beyond being improved on.

4.1 Further discussions

The process of dipping as used for the reconditioning of worn out parts is not very common compared to welding and casting methods e .t.c. the process is however, better than the above mentioned processes in terms of its cost, simplicity and most importantly the case with which the process could be achieved without the use of an experienced (skilled) operator (that is to say that almost every careful farmer could be able to set up a mini work shop and recondition some worn out parts).

There are so much scrap to use and on using most of the these scraps it was found out that a little force was able to scale them off, this then made us use similar components (scraps) as feed for the furnace (This are the component that have worn out beyond repairs or have been broken), this then formed a better bond with the worn out part. The roughness of the worn out parts also played a significant role on the bonding between the melt and the components, on dipping the worn out parts into the melt, it was found to have bonded but it scaled easily so this formed the use of very rough files to roughen the surface to not more than 0.25mm deep as from literature anything beyond that will affect the performances of the final product.

The worn out component also had to be preheated before dipping. There was this problem of a temperature measuring device which was not needed to know the dipping temperature of the melt which is suppose to be between 100°C to 150°C above the melting temperature of the melt. It proved a little difficult in identifying the fluxes to use as the commercial fluxes in the market came with their trade name and no chemical composition as on the AWS table

CHAPTER 5

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

From the flow chart as shown in page, is more of a straight flow chart with no branches, thus signifying that every point in the process is very important for the success of the project. In the selection of all the inputs, the table recommended by American welder's society (AWS) should be strictly adhered to. The flow chart also showed that the rightful selection of these inputs is very significant.

1. In establishing this method it could be seen that it is a relatively cheaper method of reconditioning worn out parts in comparison to other to other methods like using casting methods, welding methods e.t.c., because of the machinery involved in setting up such workshops and on the skills of the operators that is needed.

2. With the success of this project the average farmer could be able to afford maintaining his farm implements as the process is not only limited to the recommending of worn out parts but could be used to surface project some implements by dipping them into melts of metal with a better property, depending on the function to be performed by the implements. For example the process could be used to surface harden the shear of the mould board. This could be done using very cheap materials that lie around, cheap labor with no need for prior skills and cheap establishment of workshops.

5.2 Recomendation

Most of the components used in the engine and other part of the machine have gone through various methods of surface treatments such as space hardening, annealing e.t.c., thus it recommend that before installing any component that has undergone this process of dipping should be at least surface treated using any of the methods that is appropriate and is recommended by the manufacturers. This is so that the reconditioned component could stand the test of time. In the process of selecting the input materials needed to achieve a good finished product, there should be no compromise, as in the using the wrong materials, that is why from the flow chart it could be seen that before the finishing method was selected, a decisions was taken to see that if the bond is not satisfactory, then they need to start all over again which will to make the process expensive. But with the use of the right material which will not only save time and cost, will also bring about a more efficient final product the dipping temperature which from literature should be at least 100°C and at most 150°C above the melting temperature of the melt should strictly adhered to the recommended thickness of melt allowed for efficient final product must be maintained at 0.25mm.

I will recommend that the process should be extended to other components of different shapes, as this project was limited to those worn out components with sharp and outer worn out surfaces, for example push rod and both the intake and exhaust valves. Also, I recommend that there would be need to improve on the project by carrying out some test analysis, performance evaluation and testing of the final product.

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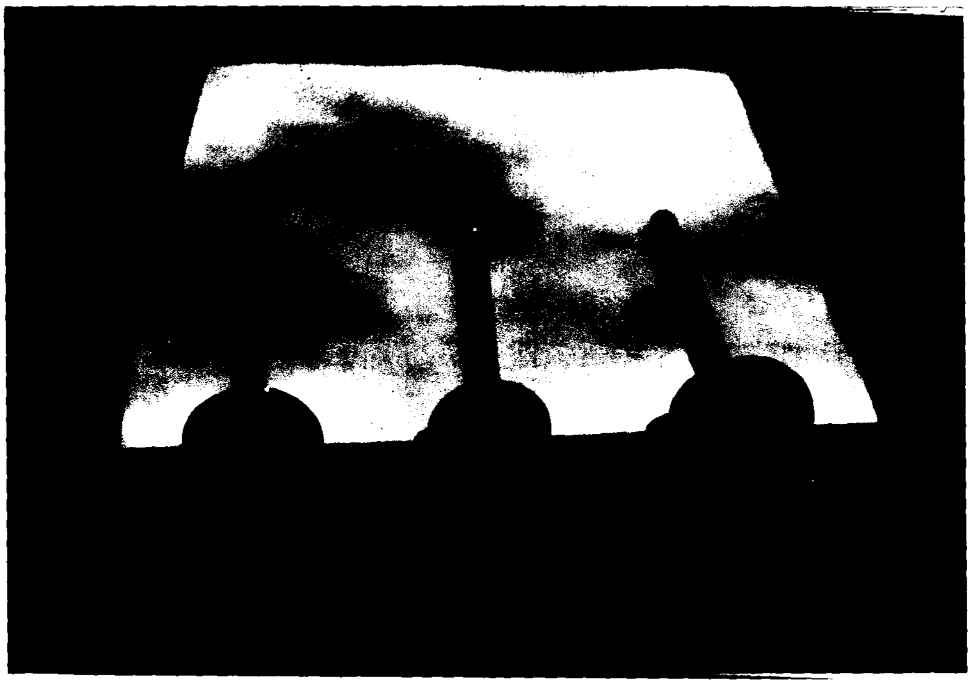

PLATE 1: Reconditioned Valves

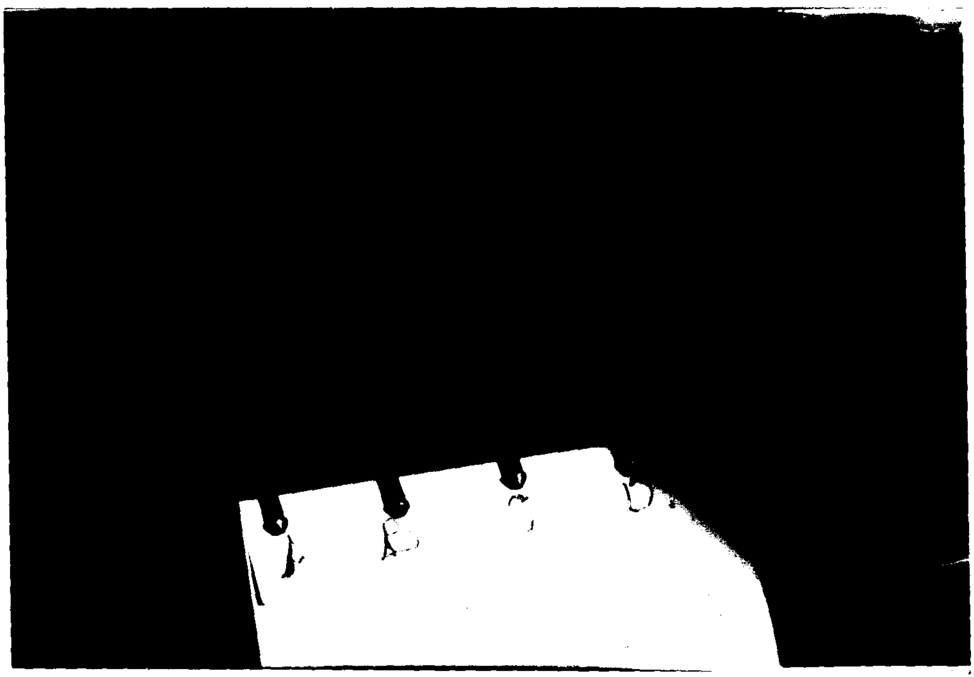

PLATE 2: Reconditioned Push Rods