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Recycling of Scrapped Mating Rings of Mechanical Face Seals

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ABSTRACT : *Mechanical face seal is an auxiliary part of the equipment for process plant. They are expensive components, butthe mechanical face seals hardly functions for 1,000hours in operation before failure. As there is no use for the scrapped mating ring and absence of recycling companies especially in the less developed countries of the world, disposal of scrapped mechanical face seals is a serious problem. These seals are non-biodegradable. The success of this work will not only provide employment opportunities for people, production of cheaper machine (single point turning) tools for machine shops and a cleaner environment but, would also provide a relatively new area for researchers to work on.*

KEYWORDS : *auxiliary, disposal, environment, failure, scrapped*

I. INTRODUCTION

Mechanical face seals are mechanical components of equipment used for preventing leakages automatically in pipes and piping systems. Mechanical face seals are extensively used in centrifugal systems such as refineries, chemical and other industries where flow of fluids are required. The mechanical face seals, contains mating ring which is made of cemented carbides. Cemented carbides are classified into tungsten carbides and titanium-tungsten carbides [4].Manufacturing technology and machining processes mark a major distinction between Engineers and Scientists of developed countries and those of the less developed countries. In the case of the former, the manufacturing technology and machining processes have been fully explored and adequate attention given while in the latter there is little or no attention given to these processes. The technicians and technologists from less developed countries perform their duties adopting trial and error methods. This has led to backwardness because many materials, energy, time and money are expended on trials. The high rate of growth in manufacturing processes can only be achieved through improved manufacturing processes, methods and tooling not by trial and error [2]. It is worthy of note that technological advancement is aimed at lowering production cost, achieving higher quantity and better quality products. This goal can only be attained through optimal utilization of both human and material resources.

A lot of these non-leakage devices are used in the refinery and other piping systems. Large users agree in attributing a large proportion of process plant maintenance cost to mechanical seal failures [5]. The mechanical face seals are used for sealing products such as sour water, slop oil, liquefied petroleum gas, straight run kerosene, dehydrate gas oil, automotive gas oil, reformate gasoline, oil furfural mix and waste heat boiler [7].Mechanical face seal is a device that creates a non-leaking union between two machines or making a joint fluid-tight. The sealing occurs between surfaces, which moves relative to one another and involves the sealing of an annular relative motion. Mechanical face seals have extensive applications in places where centrifugal systems are required numerous power plant equipment applications, especially on pumps of different sizes and pressure ratings. Though, they are expected and are capable of rendering long-term service, mechanical face seals often times exhibit unsatisfactory performance by failing unexpectedly, resulting in a short life span. This reduces plant reliability and performance, which leads to expensive down-times and outages. The hardware are those components needed for installation on pumps and to ensure high process performance and reliability. The mechanical face seal is made up of: mating ring, rotating face, springs, secondary seal, tertiary seal, snap ring, disc plate and retainer.

II. MATERIALS AND METHODS

Tungsten carbide areexpensive. On the account of high cost, low strength and the difficulties of preparation of tungsten carbide, brazing a tip or block of the carbide to a carbon-steel shank produces carbide-

cutting tools. The most suitable metal for the shank is steel of about 0.5% carbon, in order to minimize the injurious effects of vibration and chatter on the brittle tip, the shank should be of generous cross-sectional proportion. To accommodate the tip a step or cavity is machined. Care being necessary to ensure that all surfaces are flat so that the tip is everywhere supported against pressure introduced when cutting. Failure to do this might result in bending stresses being introduced on the tip in service and its subsequent cracking. For securing the tip, brazing is usually employed [1]. Tungsten carbide is very hard, although by nature quite brittle, but nevertheless usable for some applications, such as dies and turning/cutting tools. Brazing is generally used when a tougher, stronger joint is required, provided that the work will be neither melted nor otherwise damaged by the higher temperatures involved in melting the brazing solder. Most ferrous and non-ferrous alloys of sufficiently high melting point can be brazed [3].The scrapped mating ring of mechanical face seal was obtained from the Kaduna Refinery and Petrochemical Company Limited, Kaduna. The mating ring was broken and the locally produced turning tools were produced at Jeo Best Welding Enterprise, Agbor. The machining of the various work pieces and the measurement of the tool vibrations were done at J & B Construction Company, Umunede. The chemical analysis of the mating ring and the measurement of the surface finish was performed at Delta Steel Company, Limited

III. MATERIALS FOR PHYSICAL TESTS

The materials used include hand lens, liquid dye penetrant, and magnets.

Materials for production of the turning tools

The following materials were used for the production of the turning tools;

a. mating ring;
b. vice (heavy metal plate);
c. maundy hammer;
d. used synthetic cement (baggco) bag;
e. metal plate;
f. shanks of 0.5% carbon steel;
g. brazing powder;
h. oxy-acetylene welding device;
i. grinding wheel/stone;
j. lapping stone, pliers; and
k. bevel and bevel protractor.

Both the locally produced and the standard tungsten carbide tools' were grinded to positive rake angle of 8^{o} The physical and chemical properties of the scrapped mating ring is compared with that of standard tungsten carbide tools.

IV. MATERIALS FOR CHEMICAL ANALYSIS

The material used for the chemical analysis of the mating ring is the digital spectrometer – GNR F20 metal analyzer.

Physical Tests

Visual Inspection : The first test performed on the scrapped mating ring was the visual inspection test. The naked eyes, hand lens and the liquid dye penetrant were employed. The defects could not be detected with the naked eyes, though it was observed that the mating ring had fine grain particles. The hand lens was used, this confirmed that the scrapped mating ring has a fine grain size, but revealed the presence of defects. The liquid dye penetrant used was bright red, while the developer was white. This made the defects easier for the naked eyes to view.

Magnetic Test : The scrapped mating ring was tested for magnetic properties using magnets of different types. Destructive Testing The destructive tests performed on samples of the mating ring, were hardness and impact test. This determined the resistance to shock loading and brittleness of the scrapped mating ring as described by Mohammed [6].

Production of turning tools : The scrapped mating ring is shown in plate 1. A synthetic used cement (baggco) bag was used to parcel the scrapped mating ring and placed on a heavy metal plate. It was then hit with the maundy hammer. This resulted in the shattering of the mating ring. Pieces of the mating ring were brazed onto shanks of 0.5% carbon of dimension 100mm by 20mm by 20mm, as a support for their cutting tips and edges.

The seating of the pieces of the mating ring are filled with the brazing powder/material, then the brazing was carried out using the oxy-acetylene gas welding
flame and aclamp. The grinding of the tools was performed on a tool cutter grinder to ensurecorrect cutting tool geometry. The tool was clamped on single point cutting tool attachment and asilicon carbide grinding stone fixed to the machine spindle. The tools produced were set andground, thereafter they were polished on a lapping stone to give a smooth surface finish. Plate 2shows the broken pieces of the scrapped mating ring. While plate 3 shows the samples ofproduced turning tools.

Plate 1: Scrapped Mating Ring

Plate 2 : Broken Pieces of Scrapped Mating Ring

Plate 3 : Samples of Produced Turning Tools

Chemical analysis : Chemical analysis was performed using a digital spectrometer - GNR F20 metal-analyzer. The digital spectrometer. A piece of the mating ring was placed on the spectrometer and sparked in an argon filled inlet, the rays were transmitted into a vacuum containing a spherical mirror which collimated the divergent light rays. The collimated light was diffracted by a plane grating and the resulting spectrum which was a measure of the different wavelengths of the constituent elements of the material, was analysed in an interfaced computer. The result produced:

a. chemical composition; and
b. percentage composition of the scrapped mating ring.

V. RESULTS

Physical Tests

Visual Inspection : This revealed that the mating ring possessed some defects and that it has fine grainsize.

Magnetic Test : The pieces of mating ring were observed to possess magnetic properties as they weremagnetized by various magnets.

Hardness Test : Hardness testing results as shown in Table 1.

Chemical Analysis

Qualitative Analysis : The result of the qualitative analysis, showed that the mating ring is made up of : tungsten, carbon and cobalt, as shown in Table 1.

Quantitative Analysis : Table 1, gives the percentage composition of the mating ring and compared with that ofa standard tungsten carbide tool.

Machining/Turning Test Results : The various single point turning tools were used to machine carbon steel on the lathe machine,produced at a positive rake angle of 8^{o} under the condition :At a speed of 180m/min , a feed of0.10mm/rev and varying the depth of cut from 0.1mm,0.2, …. 0.5mm.

TABLE 1 : CHEMO-PHYSICAL TEST ANALYSIS

Cutting Tool	Chemical Composition (%)	Grain size	Hardness HRA
Standard Tungsten Carbide	W = 87.7 Co = 10 C = 2.3	fine	91.1
Scrapped Mating Ring	W = 85 Co = 12 C = 3	fine	89.5

TABLE 2: RESULTS OF MACHINING CARBON STEEL WITH LOCALLY PRODUCED TOOLS.

Depth of Cut (mm)	Surface Finish (/Um)	vibration Freq (c/s)	Cutting Force (kgf)	Cutting Speed (m/min)
0.1	1.23	1.50	2.41	180
0.2	1.31	1.65	4.82	180
0.3	1.35	1.86	7.23	180
0.4	1.44	2.05	9.64	180
0.5	1.52	2.25	12.05	180

VI. CONCLUSION

The hardness and chemical composition of the scrapped mating ring is very close to that of the standard tungsten carbide turning tool, which accounts for their closeness in chemo-physical properties.The machining results, shows that the tool produced from scrapped mating ring of mechanical face seal is comparatively suitable for use as single point turning tools in machine tools' workshop.

The following are recommendations :

(i) recycling of mechanical face seals for the production of turning tools should be encouraged; and

(ii) further research in this area is desirable.

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