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The Test Method for Wear Testing Inconel 625 with a Pin-on-Disk Apparatus

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ABSTRACT

This study was carried out to design and fabricate a cost effective and efficient wear tester (pin on disc) used in the metallurgy research field. Design and calculations were established and the machine was fabricated with well selected materials and components all sourced locally. The performance of the fabricated machine was finally evaluated against a standard wear machine in the Standards Organization using statistical methods and the result showed that the locally fabricated machine is 97% effective.

Keywords: ceramic wear, friction; metal wear, non-abrasive, pin- on- disk; wear, inconel 625

I. INTRODUCTION

Scope

This test method describes a laboratory procedure for determining the wear of materials during sliding using a pin-on-disk apparatus. Materials are tested in pairs under nominally non-abrasive conditions. The principal areas of experimental attention in using this type of apparatus to measure wear are described. The coefficient of friction may also be determined.

The values stated in SI units are to be regarded as standard. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

II. Summary of Test Method

For the pin-on-disk wear test, two specimens are re quired. One, a pin with a radius tip, is positioned perpendicular to the other, usually a flat circular disk. A ball, rigidly held, is often used as the pin specimen. The test machine causes either the disk specimen or the pin specimen to revolve about the disk center. In either case, the sliding path is a circle on the disk surface.

III. Significance and Use

The amount of wear in any system will, in general, depend upon the number of system factors such as the applied load, machine characteristics, sliding speed, sliding distance, the environment, and the material properties. The value of any wear test method lies in predicting the relative ranking of material combinations. Since the pin-on-disk test method does not attempt to duplicate all the conditions that may be experienced in service (for example; lubrication, load, presssure, contact geometry, removal of wear debris, and presence of corrosive environment), there is no endurance that the test will predict the wear rate of a given material under conditions differing from those in the test.

Note 1—Wear results may differ for different orientations[18].

The pin specimen is pressed against the disk at a specified load usually by means of an arm or lever and attached weights. Other loading methods have been used, such as, hydraulic or pneumatic.

Note 2—Wear results may differ for different loading methods[18].

Wear results are reported as volume loss in cubic millimeters for the pin and the disk separately. When two different materials are tested, it is recommended that each material be tested in both the pin and disk positions.

The amount of wear is determined by measuring appropriate linear dimensions of both specimens before and after the test, or by weighing both specimens before and after the test. If linear measures of wear are used, the length change or shape change of the pin, and the depth or shape change of the disk wear track (in millimeters) are determined by any suitable metrological technique, such as electronic distance gauging or stylus profiling. Linear measures of wear are converted to wear volume (in cubic millimeters) by using appropriate geometric relations. Linear measures of wear are used frequently in practice since mass loss is often too small to measure precisely. If loss of mass is measured, the mass loss value is converted to volume loss (in cubic millimeters) using an appropriate value for the specimen density.

Wear results are usually obtained by conducting a test for a selected sliding distance and for selected values of load and speed. One set of test conditions that was used in an inter laboratory measurement series is given in Table guide. Other test conditions may be selected depending on the purpose of the test.

By considering all class of materials we can make cameras from each materials Wear results may in some cases be reported as plots of wear volume versus sliding distance using different specimens for different distances. Such plots may display non-linear relationships between wear volume and distance over certain portions of the total sliding distance, and linear relationships over other portions. Causes for such differing relationships include initial “break-in” processes, transitions between regions of different dominant wear mechanisms, etc. The extent of such non-linear periods depends on the details of the test system, materials, and test conditions.

IV. Apparatus

General Description—Fig. shows a schematic drawing of a typical pin-on-disk wear test system, and photographs of two differently designed apparatuses.5 One type of typical system consists of a driven spindle and chuck for holding the revolving disk, a lever-arm device to hold the pin, and attachments to allow the pin specimen to be forced against the revolving disk specimen with a controlled load. Another type of system loads a pin revolving about the disk center against a stationary disk. In any case the wear track on the disk is a circle, involving multiple wear passes on the same track. The system may have a friction force measuring system, for example, a load cell, that allows the coefficient of friction to be determined.

Wear Measuring Systems—Instruments to obtain linear measures of wear should have a sensitivity of 2.5 µm or better. Any balance used to measure the mass loss of the test specimen shall have a sensitivity of 0.1 mg or better; in low wear situations greater sensitivity may be needed.

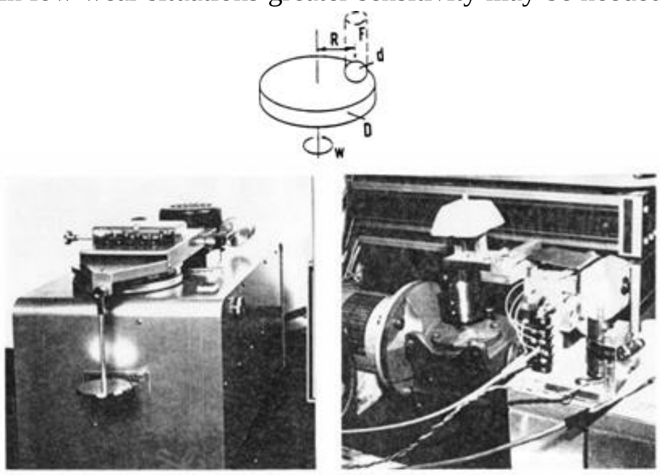

Fig 1. (a) Schematic of pin-on-disk wear test system. (b) Photographs of two different designs

Motor Drive—A variable speed motor, capable of main-taining constant speed (61 % of rated full load motor speed) under load is required. The motor should be mounted in such a manner that its vibration does not affect the test. Rotating speeds are typically in the range 0.3 to 3 rad/s (60 to 600 r/min).

Revolution Counter—The machine shall be equipped with a revolution counter or its equivalent that will record the number of disk revolutions, and preferably have the ability to shut off the machine after a pre-selected number of revolutions.

Pin Specimen Holder and Lever Arm— In one typical system, the stationary specimen holder is attached to a lever arm that has a pivot. Adding weights, as one option of loading, produces a test force proportional to the mass of the weights applied. Ideally, the pivot of the arm should be located in the plane of the wearing contact to avoid extraneous loading forces due to the sliding friction. The pin holder and arm must be of substantial construction to reduce vibrational motion during the test.

V. Procedure

Immediately prior to testing, and prior to measuring or weighing, clean and dry the specimens. Take care to remove all dirt and foreign matter from the specimens. Use non- chlorinated, non-film forming cleaning agents and solvents. Dry materials with open grains to remove all traces of the cleaning fluids that may be entrapped in the material. Steel (ferromagnetic) specimens having residual magnetism should be demagnetized. Report the methods used for cleaning. Measure appropriate specimen dimensions to the nearest 2.5 µm or weigh the specimens to the nearest 0.0001 g.

Insert the disk securely in the holding device so that the disk is fixed perpendicular (61°) to the axis of the resolution.

Insert the pin specimen securely in its holder and, if necessary, adjust so that the specimen is perpendicular (61°) to the disk surface when in contact, in order to maintain the necessary contact conditions.

Add the proper mass to the system lever or bale to develop the selected force pressing the pin against the disk.

Start the motor and adjust the speed to the desired value while holding the pin specimen out of contact with the disk. Stop the motor.

Set the revolution counter (or equivalent) to the desired number of revolutions.

Begin the test with the specimens in contact under load. The test is stopped when the desired number of revolutions is achieved. Tests should not be interrupted or restarted.

Remove the specimens and clean off any loose wear debris. Note the existence of features on or near the wear scar such as: protrusions, displaced metal, discoloration, microcracking, or spotting.

Re measure the specimen dimensions to the nearest 2.5µm or reweigh the specimens to the nearest 0.0001 g, as Repeat the test with additional specimens to obtain sufficient data for statistically significant results

5. Test Specimens and Sample Preparation

Initial trials were carried out on several grades of Nickel based super alloys (Inconel 600, 625, and 718) as substrates and Nickel Chromium Carbide, Aluminium Oxide as coating[19] materials in order to produce a corrosion resistant coating for automobile components. In a tube furnace, the coated test coupons were heated to 1000-11000°.In addition, morphological analyses (SEM/EDS/XRD) demonstrated that Inconel 625 specimens had a homogeneous covering. Due to their outstanding hardness and corrosion resistance, Inconel 625 coated specimens can also be utilised in the vehicle industry to make exhaust couplers, spark plugs, and other components

Materials—This test method may be applied to a variety of materials[8]. The only requirement is that specimens having the specified dimensions can be prepared and that they will withstand the stresses imposed during the test without failure or excessive flexure. The materials being tested shall be described by dimensions, surface finish, material type, form, composition, microstructure, processing treatments, and indentation hardness (if appropriate).

Test Specimens—The typical pin specimen is cylindrical or spherical in shape. Typical cylindrical or spherical pin specimen diameters range from 2 to 10 mm. The typical disk specimen diameters range from 30 to 100 mm and have a thickness in the range of 2 to 10 mm. Specimen dimensions used in an inter laboratory test with pin-on-disk systems are given.

Surface Finish—A ground surface roughness of 0.8 µm (32 µin.) arithmetic average or less is usually recommended.

NOTE 3—Rough surfaces make wear scar measurement difficult.

Care must be taken in surface preparation to avoid subsurface damage that alters the material significantly. Special surface preparation may be appropriate for some test programs. State the type of surface and surface preparation in the report.

VI. Calculation and Reporting

The wear measurements should be reported as the volume loss in cubic millimeters for the pin and disk, seperately.

Use the following equations for calculating volume losses when the pin has initially a spherical end shape of radius R and the disk is initially flat, under the conditions that only one of the two members wears significantly:

pin ~spherical end! volume loss, mm3

(1) p ~wear scar diameter, mm!4

= 64 ~sphere radius, mm!

assuming that there is no significant disk wear. This is an approximate geometric relation that is correct to 1 % for (wear scar diameter/sphere radius) < 0.3, and is correct to 5 % for (wear scar diameter/sphere radius) < 0.7. The exact equation is given in Appendix X1.

disk volume loss, mm3

(2) p ~wear track radius, mm!~ track width, mm!3

= 6 ~sphere radius, mm!

assuming that there is no significant pin wear. This is an approximate geometric relation that is correct to 1 % for (wear track width/sphere radius) < 0.3, and is correct to 5 % for (wear track width/sphere radius) < 0.8.

Calculation of wear volumes for pin shapes of other geometries use the appropriate geometric relations, recogniz- ing that assumptions regarding wear of each member may be required to justify the assumed final geometry.

Wear scar measurements should be done at least at two representative locations on the pin surfaces and disk surfaces, and the final results averaged.

In situations where both the pin and the disk wear significantly, it will be necessary to measure the wear depth profile on both members. A suitable method uses stylus profiling. Profiling is the only approach to determine the exact final shape of the wear surfaces and thereby to calculate the volume of material lost due to wear. In the case of disk wear, the average wear track profile can be integrated to obtain the track cross-section area, and multiplied by the average track length to obtain disk wear volume. In the case of pin wear, the wear scar profile can be measured in two orthogonal directions, the profile results averaged, and used in a figure-of-revolution calculated for pin wear volume.

While mass loss results may be used internally in laboratories to compare materials of equivalent densities, this test method reports wear as volume loss so that there is no confusion caused by variations in density. Take care to use and report the best available density value for the materials tested when calculating volume loss from measured mass loss.

Use the following equation for conversion of mass loss to volume loss.

If the materials being tested exhibit considerable transfer between specimens without loss from the system, volume loss may not adequately reflect the actual amount or severity of wear. In these cases, this test method for reporting wear should not be used.

Friction coefficient (defined in Terminology G 40) should be reported when available. Describe the conditions associated with the friction measurements, for example, initial, steady-state, etc.

Adequate specification of the materials tested is important. As a minimum, the report should specify material type, form, processing treatments, surface finish, and specimen preparation procedures. If appropriate, indentation hardness should be reported

Fig 2. Support Bearing Pullers

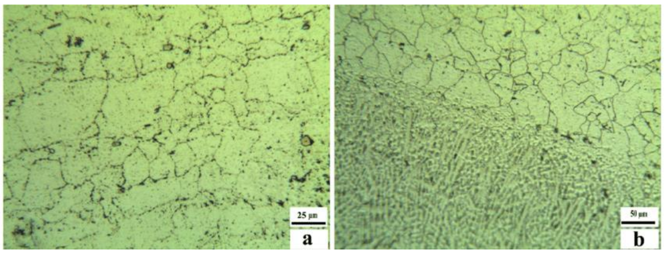

Fig 3. A view of Inconel 625 material

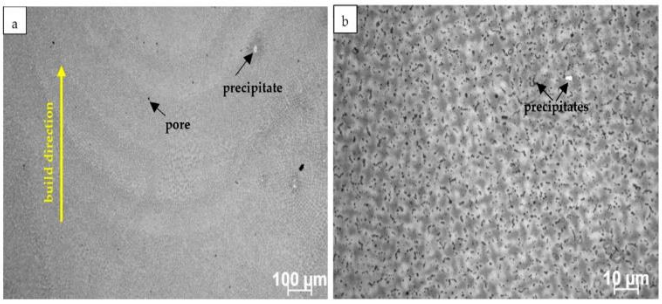

Fig 4. Hardness test view of Inconel 625 material

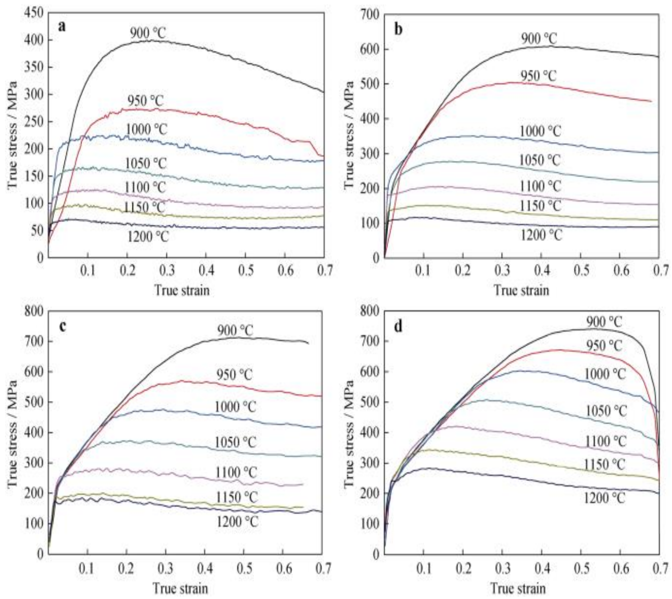

Fig 5. True stress strain of Inconel 625

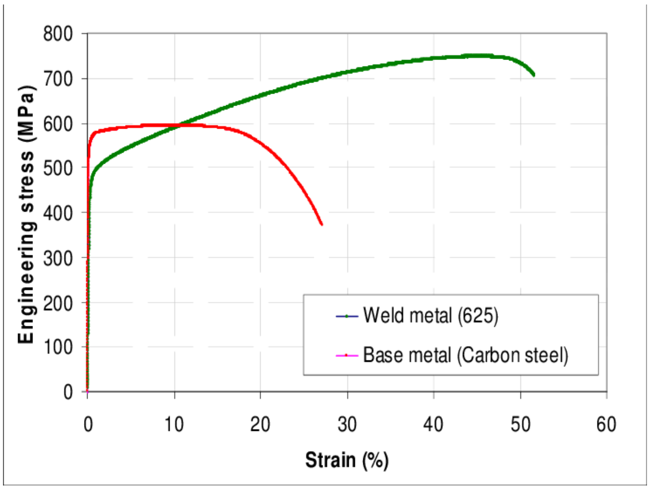

Fig 6. Stress strain curve for Inconel 625

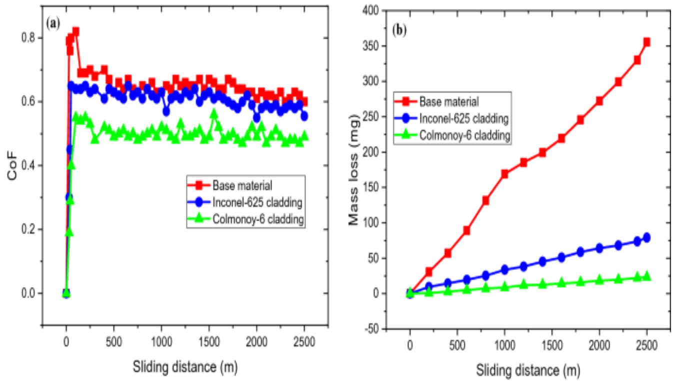

Fig 7. wear test sample data

Fig 8. Plasma Electric Arc Ceramic Coating

Fig 9. Chrome Oxide Coated Wear Surface

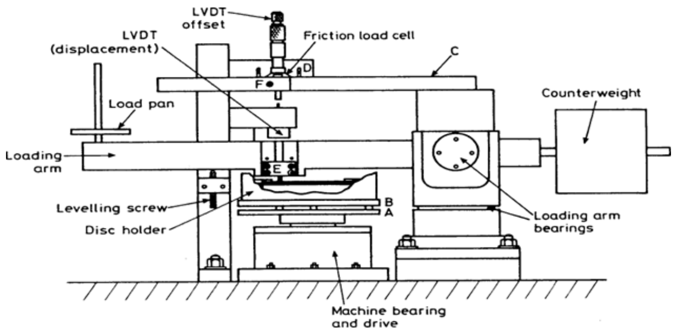

Figure 10 - Schematic diagram of pin-on-disc test system

Table for hardness test result

Sl no.	Specimen INCONEL 625	Micro hardness in HV
1	Normal condition	265
2	Normal condition	285
3	Normal condition	320
4	Normal condition	330
5	At 750^{0}C	550
6	At 800^{0}C	750
7	At 900^{0}C	1000

Table for wear test result for Inconel 625

Sl no.	Wear depth in micron meter
1	6.5
2	6.7
3	8.9
4	9.5
5	10.2
6	11.5
7	14.5

VII. Test Parameters

Load—Values of the force in Newtons at the wearing contact.
Speed—The relative sliding speed between the contacting surfaces in meters per second.
Distance—The accumulated sliding distance in meters.
Temperature—The temperature of one or both specimens at locations close to the wearing contact.
Atmosphere—The atmosphere (laboratory air, relative humidity, argon, lubricant, etc.) surrounding the wearing contact.

VIII. CONCLUSION

1) We can conclude that Aluminium has a greater wear rate than Copper.
2) Thus Aluminium wears more in comparison with Copper.
3) As the loads were gradually being increased, the speed was decreasing and thus the Wear Rate was increasing.
4) For different loads, different durations of time are used i.e., 1200 sec, 900 sec and 600 sec.
5) More the wear rate , more the material wears and gets damaged faster.
6) Thus we can come to a conclusion that as Aluminium wears faster than Copper, it will wear faster and be damaged earlier than Copper
7) The friction coefficient increases when Si3N4 and GCr15 balls slide against inconel 625 superalloy
8) The friction coefficient of SiN4 is less than GCr15 ball
9) Inconel 625areprimarily adhesive wear & abrasive wea rat low temperature and speed
10) At high temperature & speed fatigue role is vast
11) Use of ceramic mold for inconel 625 decreases wear

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