TECHNICAL SPECIFICATION

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Plain bearings — Surface modification by press fitting solid lubricants combined with micro dimple processing

Paliers lisses — Modification de la surface par fixation par pression de lubrifiants solides combinée à un traitement par micro-cavités

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Foreword

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This document was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 7, *Special types of plain bearings*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

As a general surface modification method, heat treatment such as carburizing or nitriding, hard film coating by chemical vapour deposition (CVD) or physical vapour deposition (PVD), solid lubricant coating using a resin binder, etc. are used. However, these conventional surface modification methods have problems such as the need for a special device, insufficient adhesion strength of the coating film, etc. Therefore, the purpose of this document is to provide a method for forming a lubricating film firmly bonded to the base metal by a simple method.

This document specifies surface modification method by a combination of processes capable of quickly processing with general purpose equipment in order to obtain excellent friction characteristics by a method excellent in mass production.

Plain bearings — Surface modification by press fitting solid lubricants combined with micro dimple processing

1 Scope

This document specifies the method of surface modification that improves the friction characteristics of plain bearings, by press fitting a solid lubricant onto the bearing metal surface mechanically in combination with processing a lot of micro dimples on the surface.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
hybrid media
shot media having a surface modifying material attached to the media surface

Note 1 to entry: A shot media coated by carbon black is described in A.2 as an example of hybrid media.

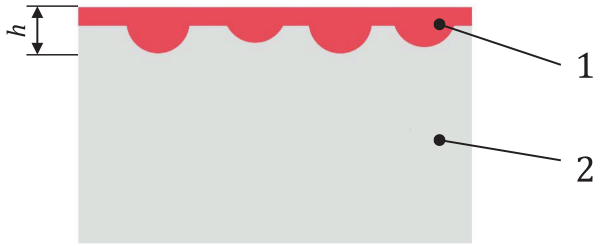
3.2
Almen strip
rectangular metal strip used for evaluating the shot peening intensity

3.3
arc height
height of the arched deformation of an Almen strip

Note 1 to entry: An arc height shows the intensity of the shot peening and is expressed in millimetres.

4 Structure

The structure of the surface modified layer obtained by the surface modification method specified in this document is shown in Figure 1. The thickness of the surface modified layer is several micro meters. Dimensions such as the thickness of the surface modified layer and the diameter/depth/area ratio of dimples are determined by the application and its operating conditions.



Key

1 modified layer

2 target material

h thickness of the surface modified layer

Figure 1 — Structure of surface modified layer

5 Materials

5.1 Target materials

The materials to be surface-modified by the method specified in this document shall be metal materials. In particular, materials having high work hardening property are suitable. Typical such materials include steel, aluminium alloy, titanium alloy, etc.

5.2 Solid lubricants

Typical solid lubricants used for the surface modification specified in this document are molybdenum disulfide, graphite, carbon black, etc. Table 1 shows a typical combination of solid lubricant and target material with their applications.

Table 1 — Typical combination of solid lubricant and target material, and their applications

Solid lubricant	Target material	Application
Molybdenum disulfide	Steel, Aluminium alloy, etc.	High load, vacuum
Graphite	Steel, etc.	High temperature
Carbon black	Steel, Titanium alloy, etc.	Dry condition, low humidity

6 Process

6.1 General

The surface modification process specified in this document should be based on a combination of formation of dimples on the surface, supply of solid lubricant to the surface and press fitting of solid lubricant to the surface. General process steps of surface modification are shown in Figure 2.

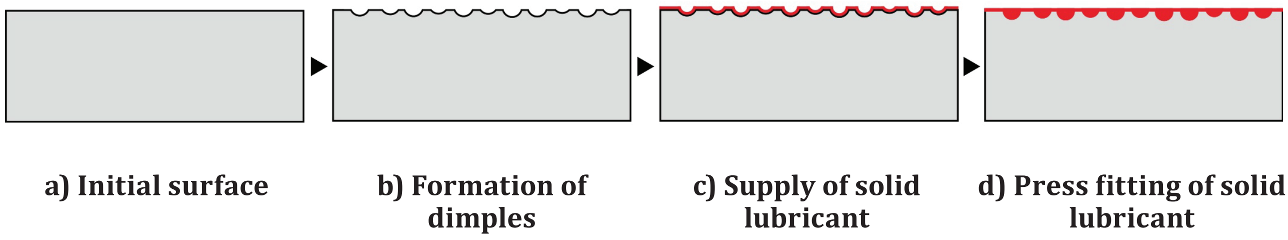


Figure 2 — General process steps of surface modification

Examples of friction test results of samples obtained by the surface modification method specified in this document is shown in Annex A.

6.2 Formation of dimples

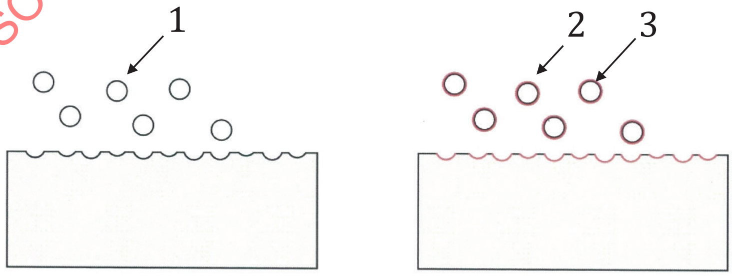
6.2.1 General

Typical examples of the method of dimple formation are described below. However, the method is not limited to them. Other methods can be used if the required dimples are obtained.

6.2.2 Shot peening

Shot peening, by applying out at high speed media (hard particles) nearly spherical surface of the material, is a cold working method for work hardening the target material surface by providing compressive residual stress. By this method, fatigue strength and stress corrosion cracking resistance can be improved. In the surface modification of bearings specified in this document, it is mainly used as a pre-treatment before "press fitting" the solid lubricants on the surface. By using hybrid media having a surface modifying material attached to the media surface, it is possible to adhere the modifying material to the target material surface simultaneously with formation of dimples. In this case, the dimple formation process, the solid lubricant supplying process and part of the press fitting process specified in this document are done simultaneously.

A schematic diagram of surface modification by shot peening process is shown in Figure 3.



Key

1 raw shot media

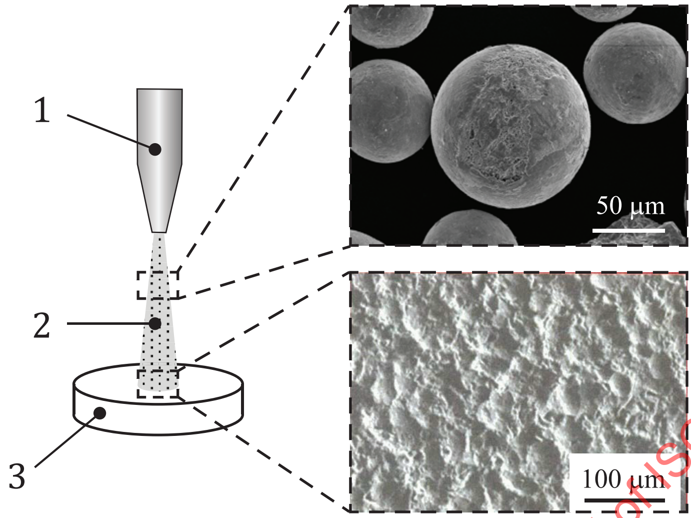
2 hybrid shot media

3 surface modifying material attached to the media surface

Figure 3 — Formation of dimples by shot peening process

Because of its aim for formation of dimples, unlike in the case of shot peening for the purpose of general surface hardening, the diameter of media should be about five times the expected dimple diameter and the hardness should be about 70 % as compared with the target material. A projection flow rate of about 5 g/s and a projection pressure of about 0,3 MPa are suitable. It is recommended to measure the arc height beforehand using Almen strips in order to evaluate the shot peening conditions. A schematic diagram of the shot peening process is shown in Figure 4.

General shot peening procedures and conditions are defined in ISO 12686 and ISO 26910-1.



Key

1 nozzle

2 compressed gas containing shot media

3 target material

NOTE The upper photo is the enlarged view of shot media and the lower photo is the enlarged view of the shot peened surface of the target material.

Figure 4 — Shot peening process

6.2.3 Interrupted micro cutting

Like shot peening, interrupted micro cutting is a processing method for making dimples on the surface. Since cutting is performed with a rotating tool, it is useful when processing dimple with pattern property. An arbitrary pattern can be generated by controlling the combination of the shape of the cutting edge, the feed speed, and the rotation speed. The feature of this processing method is that it can control the pitch, size and depth of the dimple, so that it is superior in terms of homogeneity of the surface properties. It is also suitable for processing in places where shot peening processing is difficult, such as the inside of a cylinder. A schematic diagram of the interrupted micro cutting process is shown in Figure 5.

a) View of cutting tool (left) and enlarged view of cutting tip part (right)

b) Explanatory diagram of micro cutting process by spoon-shaped cutting edge

a Feed direction of tool.

b Rotational direction of tool.

Figure 5 — Interrupted micro cutting process

6.3 Supply of solid lubricant

Supply of solid lubricant to the dimple-formed surface should be performed as follows.

Solid lubricant particles are suspended in a solvent such as ethyl alcohol (ethanol), terpineol, etc. and the suspended solid lubricant particles are sprayed or painted to the dimple-formed surface. The solvent is then volatilized to coat the surface with solid lubricant particles.

However, the method is not limited to them. Other methods can be used if the required coating of the solid lubricant is obtained.

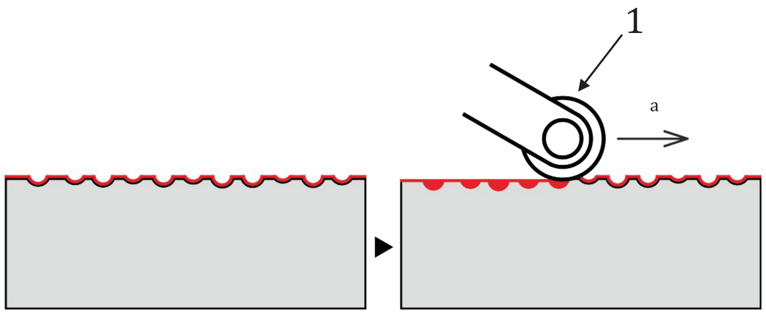
WARNING — Cleaning fluids are volatile and flammable. Care shall be taken for the Global Harmonized System of Classification and Labelling of Chemicals (GHS) hazard pictograms.

6.4 Press fitting of solid lubricant

Roller burnishing is a processing method in which a tool having a hard surface such as a metal roller is rotated while pressing against a material to smooth the surface. In the surface modification of bearings specified in this document, it is used as a processing method for press fitting a solid lubricant onto the surface, and shot peening should be used as a pre-treatment thereof.

It is necessary to adjust the pressing force of the roller on the target material. It is recommended that the contact surface pressure is 1,5 GPa to 2,5 GPa for applying to aluminium alloy, steel and titanium alloy. Plateau of the surface after burnishing should be as desirably smooth as possible. A schematic diagram of the roller burnishing process is shown in Figure 6.

Methods other than roller burnishing can also be used if the required surface is obtained, that is, a method which can smooth the target surface and press fit the solid lubricant onto the surface.



Key

1 metal roller

a Running direction.

Figure 6 — Roller burnishing process

Annex A
(informative)

Test results

A.1 Aluminium alloy surface modified by molybdenum disulfide

A.1.1 Example of procedure of surface modification

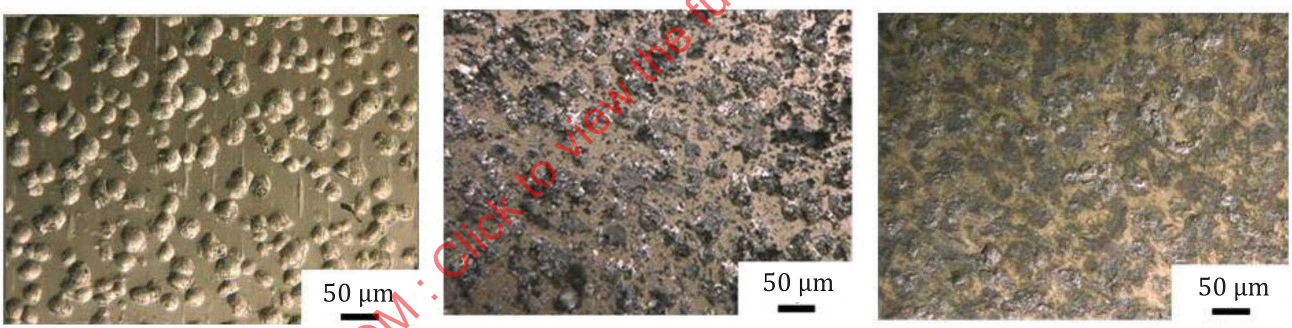
An example of the procedure of surface modification in which molybdenum disulfide (MoS_2) is press fitted to the surface of an aluminium alloy by combining shot peening and burnishing is shown below.

a) Apply shot peening treatment to the target surface.

b) MoS_2 powder is suspended in a low volatile aromatic solvent such as hydro-terpineol and painted on the surface.

c) Apply burnishing.

Pictures of surface condition in each process are shown in Figure A.1.



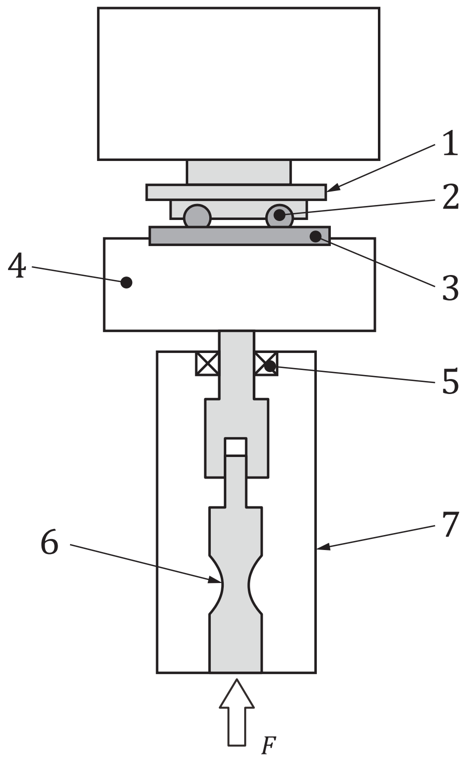
a) Shot peened surface | b) MoS_2 painted surface | c) MoS_2 press fitted surface by burnishing

Figure A.1 — Surface pictures in each process

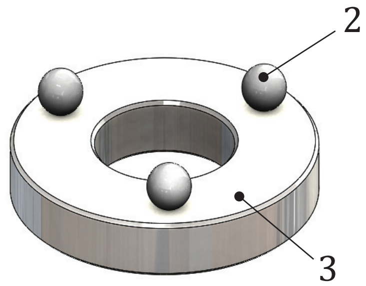
A.1.2 Example of friction characteristics

Test examples of friction characteristics of the modified surface are described below.

Figure A.2 shows the friction tester and Figure A.3 shows the test results. The test was carried out on a ball-on-disc type rotary friction tester in which the sliding contact was brought between fixed ball(s) and rotating disc. The balls used for the test were flatten on facing part for the disc specimen. The dimensions of the flattened surface are determined by the test conditions and should be set so that the average contact pressure is approximately between 10 MPa and 100 MPa. The test results show the change with time of the friction coefficient at a constant load, 20 N and speed, 0,5 m/s at room temperature under dry condition. Comparing unpeened surface, and shot peened and burnished one, the latter showed long life and low friction coefficient.



a) Schematic diagram of tester

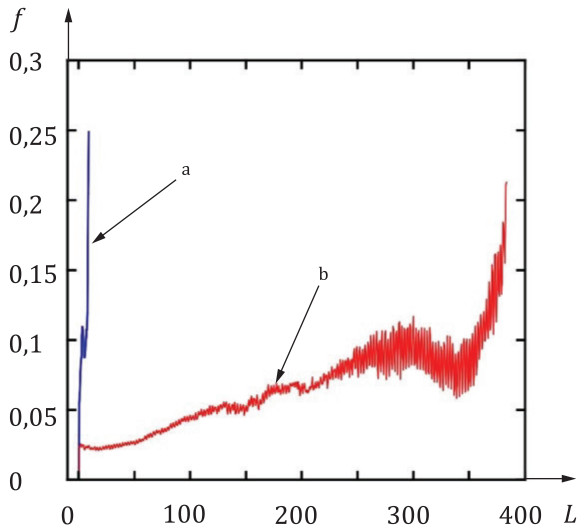


b) Flattened ball-on-disc part

Key

1 jig for three balls
2 flattened ball
3 disc specimen
4 base plate
5 support bearing
6 torque measurement rod
7 holder
F contact load

Figure A.2 — Friction tester (flattened ball-on-disc type rotary friction tester)



Key

L sliding distance, expressed in metres (m)

f friction coefficient

[a] The blue line represents the friction coefficient of normal surface (unpeened surface).

[b] The red line represents the friction coefficient of the surface supplied with shot peening, MoS_2 painting and burnishing.

Figure A.3 — Test results of a ball-on-disc type rotary friction test

A.2 Stainless steel surface modified by carbon black

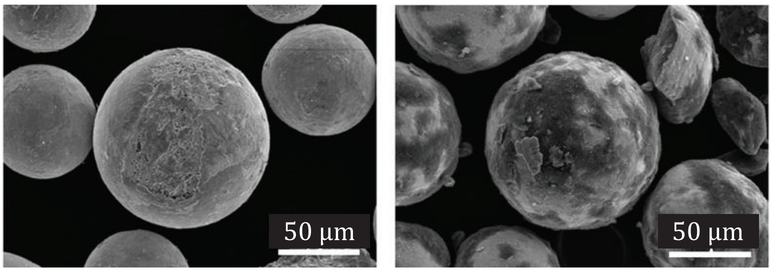
A.2.1 Example of procedure of surface modification

An example of the procedure of surface modification of stainless-steel material by shot peening using hybrid shot media which surface is coated with carbon black is shown below. If this hybrid shot media is used, the process of "supply of solid lubricant" described in 6.3 can be skipped. In this case, the roller burnishing process is omitted.

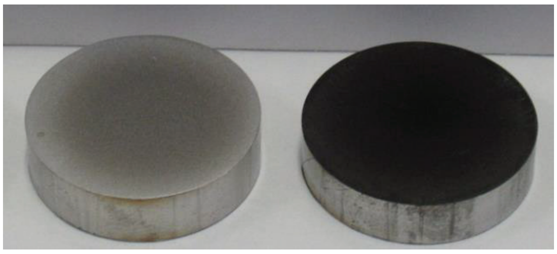
a) Prepare hybrid shot media.

b) Apply shot peening treatment to the target surface.

Surface pictures in each process are shown in Figure A.4.



a) Enlarged view of raw shot media (left) and hybrid shot media (right)



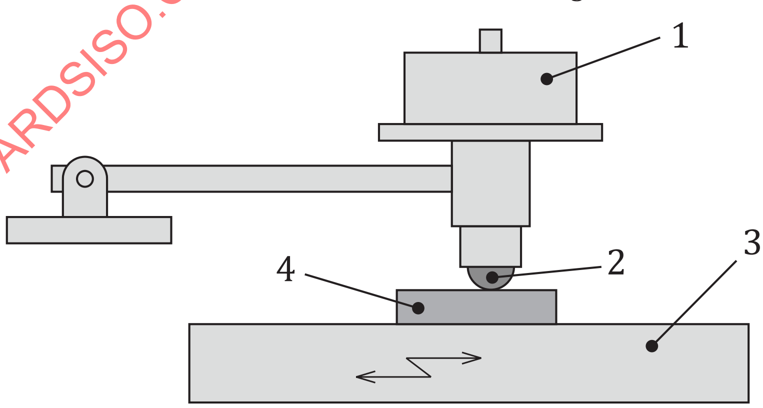
b) Surface conditions of target materials with surface shot by raw shot media (left) and surface shot by hybrid shot media (right)

Figure A.4 — Pictures of shot media and surface conditions

A.2.2 Example of friction characteristics

Test examples of friction characteristics of the modified surface are described below.

Figure A.5 shows the friction tester and Figure A.6 shows the test results. The test was carried out on a ball-on-disc type reciprocating friction tester in which the sliding contact was brought between a fixed ball and a reciprocating disc. A stainless-steel ball (ISO X5CrNi18-10) was used. The test results show the change with the time of the friction coefficient at a constant load, 1,96 N and speed, 3,3 m/s (stroke: 5 mm) at room temperature under dry condition. Compared to the untreated ones, the ones press fitted with carbon black showed stable and low friction coefficient during the test time.



Key

1 weight

2 mating material: stainless steel ball

3 reciprocating stage

4 specimen

Figure A.5 — Schematic diagram of tester (ball-on-disc type reciprocating friction tester)