Air Bearings by Moldable Congruent Surfaces

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Abstract

Common denominator to most air bearing devices is a mated pair of quasi congruent monotonic rather macroscopic mating surfaces. Combinations in optical wringing quality are obtained by a dedicated process of replication which is less well known than , and being much different from the majority of replications by injection molding as in CD plate replication, or one day eye contact lenses. Surface texture is known to replicate details for electron-microscopy. Both methods start with the injectable, moldable "paste", both are hardening with time and controlled temperature. The pasty substance of the former is of one component and is called thermosetting –and is not wetting; hence it can be separated (= pulled away) from master after curing.. A tribologic, adhesive lining for gliding engineering bearing surfaces produced by a moldable hardening paste was introduced 50years ago and continuously developed to be highly reproductive and reliable by ref.1. Details of the molding process are described in ref.2.

The pasty substance of the latter consists of two well mixed adhesive components. The mixture is enriched with such additives as Alum.Oxide and graphite powders and some 20 others proprietary to ref.1. The well mixed paste is well wetting to clean surfaces and is highly adhesive after curing to both clean surfaces.. An anti-wetting agent (= separator thin film of molecular thickness) applied to the master lets one expect to obtain a lining bonded to a blank with a true negative surface of the positive master. The mating surfaces are quasi congruent. Fig.1 shows the schematic. All parameters, though, are controllable:. Mixing homogeneity, freedom of air inclusions, curing time until separation, temperature during curing except shrinkage.

The schematic of this process is represented in fig.1. The blue foot is given the green lining, which after hardening and separation may be loaded and shifted across its "congruent" base without a cross-motion. Since this is near optical wringing quality,

the friction found will be high. We will not discuss the widely used habit of lapping as it will not be commensurate with the aimed at two to three micrometer air-gap.

Air fed between master surface and the hockey puck like work (yellow in Fig.1) will reduce friction for about 1000. So far this is trivial – we now look at some pecularity of the lining

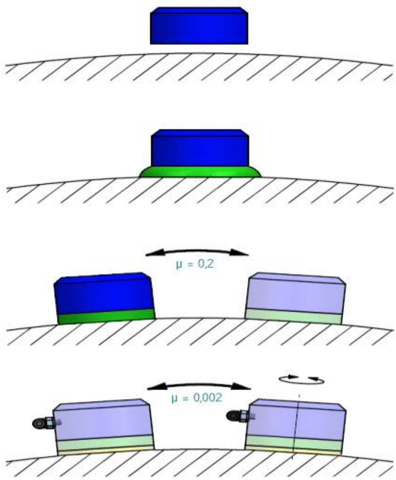

Fig.1 Quasi-congruent surfaces: Scheme of generating an air bearing by replication using a tribologic moldable lining (ref.1). Hockey-puck like disc molded off its future way, will perform low friction (friction coefficient = 0.02) motion on master. The motion will be “frictionless” 3D (X, Y and rotation around Z), with constant air pressure fed between mated surfaces. Desirable, or prevented by preload: Variation of air pressure will cause a minute ΔZ motion; (it will be desirable in nano-operations)

A 60 mm diam. Alum. Blank was given a 1 mm thick lining molded off an optical flat. The expectation: straight equispaced interference fringes. Like the master. So it was after 6 hrs curing. The unexpected surprise came two days later when looking at the sample just for curiosity: Fig.2. Fringes having a fringe equivalent of 1.5 micro-meter, represent about one fringe both up and down deformations of the initially flat surface. The instant suspicion: Lack of mixing homogeneity, strias and associated variable extended period of post-curing. All this together evidenced by a different amount of shrinkage.

The finesse of the fringes indicates near perfect reproduction of the smoothness of optical flat.

Control of shrinkage leads one to surface modifications, that will be useful in air bearing designs. Foremost will be the chance to not modify the bearing surface by lapping. as is customary in the bearing production. The following examples are replications off an optical flat with the only differences being the contour of the raw blanks.

Fig. 2 Interferometric view (1.5µm fringes) of post curing Moglice lining; undulation due to mixing-inhomogeneities. Immediately after premature unmolding (6 hrs) surface was “marvellously flat” showing straight fringes.
Thickness of lining ca.1 mm. Record taken two days later.
The amount of differential shrinkage within the 1 mm thick layer is in the category of 1 mikrometer

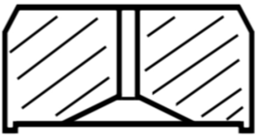

Fig.3 Contour of 60 mm OD blank to be molded off an optical Flat

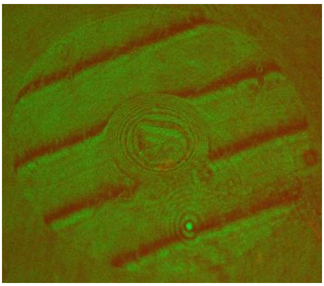

Fig. 4 The Moglice paste hardens sooner within the thin land than within the central 3mm dish. Shrinkage within the dish enforces a vacuum volume between the anti-adhesion coated flat master and the bubble-shaped concave paste.

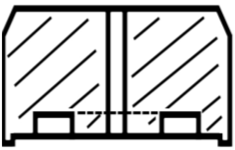

Fig. 5 Test – blank with rough machined flat surface speculating for better adhesion and with typical supply groove, 2 mm deep.

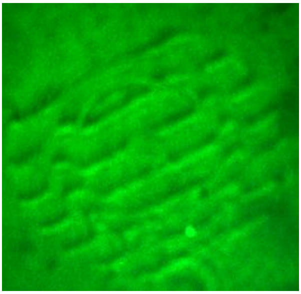

Fig. 6 Mold off optical flat onto blank as shown in fig.5. Unmolded after 8 hrs. Depression atop groove ca. 1µm measured by the interference fringes representing 1.5μm topography lines. Over-all flatness reproduced well.

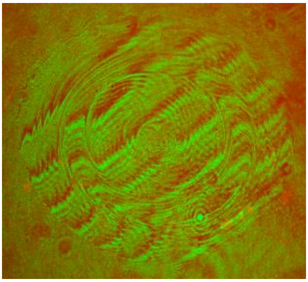

Fig. 7 Obviously some long-term shrinkage of the paste into the relatively gross machining marks (grooves) being about 0.5mm deep and produced on purpose, anticipating stronger bonding of the paste to blank. Depth of undulation molded off flat is ca. 20% of fringe-equivalent = 0.3μm.

Conclusion:

1. Exact determination of shrinkage of injectable, hardenable, tribologic lining possible.
2. Purposely provided deep recesses in blanks permit design of grooves and pockets in the linings surface without machining (else creating burrs and elevations).
3. Dishes produced this way can be deep enough to permit drilling holes for orifice insertion without interfering with bearing surface.
4. No more need to lap or else mistreat the lining surface for producing "pockets". No more sharp edges on pockets, rather smooth profile well becoming to the air flow without turbulence
5. Price for utilization of this surface structuring technique: The lining layer must be thick enough to let the 1 to 3 % shrinkage take care of the desired surface structure.

References:

[1] Product AB Coating by DIAMANT – METALPLASTIC (www.diamant.ph)

[2] Chap.III in Engl. translation of Wirtschaftliche Mikrobearbeitung (www.mikrobearbeitung-langenbeck.de)