ANTI-FRICTION MATERIALS.

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THE use of oil as a lubricant in machines is to separate the rubbing parts and diminish the friction of metal upon metal by an intervening film of the lubricant. If the oil is supplied in sufficient quantity to cause the entire separation of the metals, the friction may be reduced to a measure of the viscidity of the unguent used; where oil is furnished in less quantity, the friction of metal upon metal is usually resistance due to interlocking particles of the revolving and stationary parts, the oil used under this condition finding its way from the bearing, loaded with the metal that is gradually torn from either the revolving shaft or the bearing in which it has worked.

In discussing the subject somewhat over a year ago before the British Association for the Advancement of Science, the author remarked it to be a well-known fact that heavy lubricants effect a better separation of the metals than those that are more limpid, although the power required to slide the surfaces one upon the other is much less with the latter than with the former, but at the same time the wear and tear of the metal may be greater. It has been stated by more than one authority, that it makes little difference what metal is used for the bearing of a revolving shaft, provided oil in sufficient quantity can be introduced, so as to separate the shaft from the bearing in which it revolves. This is proved by the success which attends the use of cast iron for the bearings of ordinary shafting, it being no unusual occurrence to find the cast-iron sleeve of an adjustable hanger showing the tool marks after running several years with an excess of lubrication. Such a bearing would, however, quickly seize if the oiling were neglected, and therefore the friction may be said to vary according to the attention paid to the oiling. For very low pressures, amounting to only a few pounds on the square inch on the rubbing surfaces, oil causes a loss of power, so as to make it advisable, wherever possible, to dispense with it altogether. Professor Coleman Sellars even goes further than this and states that even when the pressure on the rubbing surfaces is less than 50 pound per square inch, the viscidity of the unguent acts as a sensible retardent.

Engineers have for a long time been looking for a material capable of being used for bearing surfaces and having a low co-efficient of friction when worked dry and without any oil. The idea is not one of recent date only, but may be said to go back to the time of the Romans, as some of the hand flour-mills found at Pompeii have the lower stone fitted with an iron bearing which evidently worked dry in the stone socket of the upper stone. The celebrated Coulomb experimented with an iron axle moving in a bush of elm, the friction being stated to be "1/20th of the force of pressure." He also made numerous experiments with wood axles slightly smeared with tallow, and also recommended the use of blacklead. The material which he found to give the best results was green oak on elm, and I believe the wooden axles of wagons which are used in some parts of England at the present time to transport heavy grindstones from the quarries, are constructed with axles of oak in a similar manner. Throughout Egypt, in the Nubian water-wheels, which are everywhere employed for irrigation, unlubricated wooden bearings are used, which appear to wear very slowly, the surface of the bearing acquiring a fine glaze. Stone bearings have also been employed for shafts. According to Rankine, the natural stones fit for this purpose are those which are wholly free from grittiness and are somewhat inferior in hardness to iron, such as gypsum, pure clay slate, compact limestone, marble and silicate of magnesia. From the latter the substance called "adams" was made by calcining the magnesia, grinding and molding it by hydraulic pressure into blocks, which were then baked.

In addition to these oilless bearings there are others in which, perhaps, a small quantity of grease might have been employed, such as the leather bushes used in spinning wheels, and the leather band on that part of the oar which works in the oarlock may be quoted as an instance of leather working on wood. Glass has also been tried, but the only kind which has survived to the present, and has been the most successful of all, is the plumbago bearing. The author has been told by the old millwrights that this material was often used in the footstep bearing of the upright shafts in water mills, and most of us have seen plumbago employed instead of tallow for lubricating wooden bearings, and there is the familiar example of the carpenter's screw. The first adaptation of plumbago in a more practical form was the invention of Gordon, who inserted a number of molded plumbago plugs in the standard-size axle-box of an ordinary carriage wheel. It is said that the vehicles ran successfully without any lubricating.

Graphite or plumbago is the principal ingredient in numerous inventions for dry bearings, many of which have not got further than the Patent Office. It has been mixed with pulverized iron, asbestos, vegetable fibre, paper pulp, blood and in one curious instance sponge is used. In nearly all these applications the anti-friction omposition is packed into suitable grooves, which are used in the bearing in very much the same way as asbestos is used in cocks. A substance which has been termed "metalline," which, although it contains graphite, appears to be composed of finely divided lead, has been rather extensively employed. The chief disadvantages were the expense due to the way the material was used, in the form of little plugs let into drilled holes, and the necessity for oiling when the plugs were worn sufficiently to cause contact between the metallic surfaces, thereby changing the character of the bearing.

The latest form of dry bearing is of solid material, which can either be molded so as to fit any plummer-block, or can be tooled or worked in the same manner as an ordinary brass. A new material for this kind of bearing, recently tried in the United States, is termed fibre-graphite, and consists of finely ground plumbago, mixed with wood fibre in a moist condition, and pressed into a mold of proper form. It is then saturated with some drying oil and oxidized in hot dry air. This bearing has been favorably reported on by a committee of the Franklin Institute, and a shop has been fitted up complete, so that the whole of the machinery, including the steam engine, runs without any lubrication at all. The report, which may be taken to apply to dry bearings generally, states "that an invention of this kind by diminishing the use of lubricants, diminishes the cost of machine construction by doing away with the many devices incident to oil—oil cups, oil-hole covers, the oil-hole themselves which have to be carefully placed, oil tubes to lead the lubricants to the inaccessible parts of machinery, as well as the cost of the personal attention and the cost of the lubricant required to keep the machinery in perfect order."

My own investigations on a suitable material for an oil-less bearing began with the use of plumbago, which was molded so as to form a circular bush, but this was soon discovered to be a failure on account of its rapid wear. I then constructed bearings of ordinary carbon, such as is used in batteries, and for producing the electric light by means of the voltaic arc. The first experiment was made with the bearings of a small dynamo, which ran for a considerable time, but the drawback of using carbon was mainly on account of the impurities which it often contained. A small amount of silica in the carbon was found to cut the shaft very badly, while if soft carbon was used the wear was as rapid as with plumbago. In order to lessen the cutting action and the friction, finely powdered steatite was mixed with the carbon, and thenceforth no difficulty was experienced, even when the load was unequally distributed on the bearing. The name of carboid has been given to this mixture, its specific gravity being 1.66, that of carbon as used in arc lamps being about 1.68; therefore carboid is about one-fifth the weight of brass. It can be molded with the same ease as carbon, and can be turned, bored or shaped to any desired form. In practice it is found that the cylinders, as they leave the molds, are quite true enough to be put into bearings without any tooling, although it is preferable to run for a short time with half the load and then remove and scrape the bearing, so as to equalize the surface of contact.

Professor Sellers, writing on the Franklin Institute report, states that "the co-efficient of friction is lower with he dry bearings experimented on than that of many oiled oearings in good condition, and that it is undoubtedly lower than with metal bearings, as usually operated with moderate attention and poor qualities of oil. It seems to be constant in its frictional resistance, whether warm or cold, while it does not run lighter when worn by use, as some oiled bearings do. Its uniform action is better than many oiled bearings and very much safer; the constant amount of frictional resistance being known can be provided for in the power of the machine." The above agrees in the main with Professor Unwin's experimental results with carboid. A bearing 1½ inches in diameter by 2½ inches long, cut in halves, was tested under loads varying from 100 pounds to 1800 pounds, or about 15 pounds to 170 pounds on the square inch, at speeds from 110 to 490 revolutions per minute, the period of test extending over six days, during which the bearing was kept almost constantly running without any lubrication or attention.

Summarizing the experiments, it appears: 1st. That the co-efficient of friction is almost the same and has not diminished as the carbon became worn to a better bearing surface. 2nd. That the co-efficient of friction increased as the temperature increased during the run, but is practically the same for any increase of pressure, and diminished with increase of speed, the maximum number of revolutions per minute being 490. 3rd. That no injury is caused to the shaft even if the bearing gets very hot, as it was found to be impossible to make it seize.

The conclusion arrived at by the author with regard to dry bearings is that the frictional resistance is governed by the conductivity of the shaft and the holder or support of the bearing; if this be so arranged that any heat generated be dispersed, the co-efficient of friction will not exceed that of a lubricated bearing.

If the bearing works under such conditions that any heat, generated at starting a new bearing, may readily be conducted away, the first cost of a dry bearing will be less than any form of brass, but taking a case of a dynamo bearing where any excess heat might be disadvantageous, it will be necessary to carefully true the bearing by scraping so as to fit the shaft, and under certain conditions where there is a great pull on the belt, it may be necessary to keep the bearing cool by means of a circulating flow of water. The economy of working is very marked. Besides the cost of the lubricants used in large establishments, there is also the attention required to apply the oil and keep the parts clean. In laundries and in those trades where unskilled labor is employed, the danger of oiling machinery in motion is very great; besides this there are instances where the lubricant used is in itself a source of danger, such as the risk of oil waste taking fire by spontaneous combustion, and the dip from bearings certainly renders the floors of the mills highly inflammable.

The principal application of carboid up to the present time has been for the bearings of ordinary shafting, and for bushing loose pulleys. It has also been applied for the bearings of steam heated rolls such as are used in cloth mills and paper works. The result of two years' experience and many experiments with light trucks seem to point out the desirability of extending its use to the axle-boxes of tramcars, and perhaps railways generally, as it involves no change in the axle-boxes; even the existing brass can remain and be faced with carboid, which can be cemented to either a smooth or rough surface.—Cassier's Magazine.

MIX THE MOVEMENTS.

DOUBTLESS many of our readers, who are not experienced engineers, may have noticed that frequently the oscillations of the main belt in a mill come in unison with the beat of the engine, and a perceptible slapping about of the belt is noticeable. The beat of an engine will often come in sympathy with the sway of the building, and so increase it as to be very perceptible. If this were continually going on in exact time it would become so great in time as to be dangerous, but one or the other gets ahead and mixes the movements so that it gradually ceases until they are again in unison. If the speed of the engine is changed in either case the swaying will be kept mixed all the time instead of occasionally. On long lines of shafting this will appear also, the pull on the belt at the commencement of the stroke being in unison with the spring of the shaft, thus causing a marked oscillation. The remedy is applied here—to mix the movements purposely—and the trouble is partly if not entirely removed.—Machinery.