The following table shows the co-efficient of friction at different pressures and velocities which Mr. Tower obtained.

He used a bath of olive oil, and kept his apparatus at ninety degrees Fah.

When these results are plotted in the form of curves (see Figure 2), the relation existing between pressure, velocity and friction is very clearly seen. They show that with pressures of 100 to 500 lbs. per square inch, as the load increases the co-efficient of friction decreases.

Co-efficient of Friction at Speeds Below.

| Nominal Load Per sq. inch. | 100 | 150 r/m | 200 r/m | 250 r/m | 300 r/m | 350 r/m | 400 r/m | 450 r/m |
|---|---|---|---|---|---|---|---|---|
| 520 | | .0008 | .0010 | .0012 | .0013 | .0014 | .0015 | .0017 |
| 468 | | .0011 | .0013 | .0014 | .0015 | .0017 | .0018 | .0020 |
| 415 | | .0012 | .0014 | 0015 | .0017 | .0019 | .0021 | .0024 |
| 363 | | .0013 | .0016 | .0017 | .0019 | 0020 | 0022 | .0025 |
| 310 | | .0015 | .0017 | .0019 | .0021 | .0022 | .0024 | .0027 |
| 259 | .0014 | .0017 | .0020 | .0023 | .0025 | .0026 | .0029 | .0031 |
| 205 | .0018 | .0021 | .0025 | .0028 | .0032 | .0033 | .0036 | .0040 |
| 153 | .0023 | .0030 | .0035 | 0040 | .0044 | .0047 | .0050 | .0057 |
| 100 | .0036 | .0045 | .0055 | .0063 | .0069 | .0077 | .0082 | .0089 |

The following table and curves, also by Mr. Tower, show the rise of the co-efficient under heavy loads (see Figure 3):—

| Load lbs. / sq. in | 150 r/m. Co-eff. of limit. |
|---|---|
| 625 | .00130 |
| 520 | .00123 |
| 415 | .00123 |
| 310 | .00142 |
| 205 | .00205 |
| 100 | .00415 |

The limit of the possible amount of load per square inch permitting free lubrication is reached when the oil is squeezed out and the surfaces begin to rub. With constant pressure and comparatively slow motion this point is believed to be not much above 500 lbs, to the square inch.

If, however, the load is intermittent, such as at the crank pin of an engine, the load can be greater, because, while there is less pressure, the lubricant gets a chance to flow between the surfaces, and consequently to keep a film of oil always there.

The Effect of Velocity on Friction.

Friction may be said to be divided into two kinds—First, Static Friction, or Friction of Rest. Second, Dynamic Friction, or Friction of Motion.

It is generally, in fact always, found that the co-efficient of friction in the former case is much greater than in the latter case.

In the proc. of the Mechanical Engineers of England for 1883, we find some interesting accounts of experiments in connection with this subject.

Professor Fleeming Jenkin has shown, by experimenting at very low velocities, that in certain cases where there is considerable difference between the co-efficient of static friction and that of dynamic friction, the co-efficient decreases gradually as the velocity increases between speeds of 0.012 and 0.6 feet a minute; and his experiments indicate a probability of a continuous rather than a sudden change in the value of the co-efficient between the conditions of rest and motion.

Where there was little or no difference between the conditions of rest and motion, no difference was found at the velocities between which he experimented.

His experiments were made with a very small steel spindle of 0.1 inch diameter, resting in rectangular V notches, the pressure being constant and due to the weight of a disc carried by a spindle and revolving with it.

In the same paper are to be found the experiments of Professor A. S. Kimball, made on spindles running at moderate speeds. He took a wrought iron shaft of 1 inch diameter acting under a pressure of about 67 lbs. per square inch. The shaft rested in cast-iron bearings well oiled. By increasing the velocity from 6 feet to 110 feet per minute, the co-efficient of friction fell to 0.3 of its original value.

Professor R. H. Thurston also carried out some experiments, but he included not only velocity but also pressure and temperature. His conclusions are, however, that the co-efficient of friction at first decreases, but after a certain point increases with the velocity; the point of change varying with the pressure and temperature.

The Effect of Temperature on Friction.

It is a generally accepted rule that, with well-oiled bearings, the friction varies approximately inversely with the temperature. The following results of Mr. Tower show this (see Figure 4). P.I.M.E., 1883:—

| | | | | | | |
|---|---|---|---|---|---|---|
| Temp. (Cent.) | 43.4 Deg. | 37.8 Deg. | 32.2 Deg. | 26.7 Deg. | 21.1 Deg. | 15.6 Deg. |
| Co-eff. of Frict. | .0044 | .0051 | .0060 | .0073 | .0092 | .0119 |

This was with an oil bath. The rule does not hold good with an oiled pad or siphon lubricator, but in this case the co-efficient increases more rapidly.

Mr. W. Stroudley, a member of the Inst. of C.E., has experimented with oil pads, and gives as his results the following (see also Fig. 5):—

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Temp. Cg. | 40.56 Deg. | 43.34 Deg. | 46.1 Deg. | 48.9 Deg. | 51.7 Deg. | 54.4 Deg. | 57.2 Deg. | 60 Deg. | 62.8 Deg. |
| Co-eff. of Frict. | .0220 | .0180 | .1060 | .0140 | .0125 | .0115 | .6110 | .0106 | .0102 |

Material of the Surfaces in Contact.

In dealing with the subject of friction and lubrication, it is essential to know of just what material the surfaces are made, for all substances have not the same co-efficient of friction.

It can be taken as a general rule that there is less friction between surfaces of different material than between those of like material. If it is of the nature of wood, i.e., has a grain, there will be less friction if the grain is placed at right angles.

However, after tests to find the co-efficient of friction between two metals, it has been found that under similar condition this co-efficient is very similar for all metals. It is not because metals such as babbitt have a lower co-efficient that they are used, and that such great things are claimed for them in the way of running cool. They may run cooler than ordinary bearings, but this is because they are able to take the shape of the journal more easily after any injury to shape or surface.

Lubricants and Methods of Testing them.

Among the factors which govern the suitability of a lubricant is its fluidity and freedom from gumming, its flash and burning points, whether it contains an acid or not, and the co-efficient of friction which it will give.

In a paper by Mr. Woodbury, about which more shall be said later in connection with the co-efficient of lubricating oils, is given a method of testing the fluidity of oil. A pipett was placed within a glass water-jacket, where the temperature was kept constant by circulation from a reservoir kept at the desired temperature. The capacity of the bulb was 28 c.c., and the orifice measured three and one-half inches long and .039 inches diameter. The oil was drawn into the bulb of the pipett, and afterwards the whole was brought to the desired temperature. The time required for its discharge was accurately noted. The oil was forced out of the tube by means of the water pressure, which amounted to a head of about five inches.

Again, an oil must not dry quickly, so as to form a thick gummy substance in parts which ought to be well lubricated.

The method used in the mechanical laboratory of the Stevens Institute of Technology for testing these two qualities of an oil is to take a long slab of glass, say, four inches by six feet, and start a drop of oil at the top, and see how far it will run down after several days.

For instance, suppose we have six kinds of oil to test, we would start them simultaneously at the top. At the end of the first day we would find that some had outdistanced the others down the plane. At the end of the second day we would find that some of the slower ones had pulled up on the first ones, if not passed them. At about the end of the fourth or fifth day the real qualities of the