Q.1

It has been established since long, that the surfaces of the bodies are never perfectly smooth. When, even a very smooth surface is viewed under a microscope, it is found to have roughness and irregularities, which may not be detected by an ordinary touch. If a block of one substance is placed over the level surface of the same or of different material, a certain degree of interlocking of the minutely projecting particles takes place. This does not involve any force, so long as the block does not move or tends to move. But whenever one block moves or tends to move tangentially with respect to the surface, on which it rests, the interlocking property of the projecting particles opposes the motion. This opposing force, which acts in the opposite direction of the movement of the upper block, is called the *force of friction* or simply *friction*. It thus follows, that at every joint in a machine, force of friction arises due to the relative motion between two parts and hence some energy is wasted in overcoming the friction. Though the friction is considered undesirable, yet it plays an important role both in nature and in engineering *e.g.* walking on a road, motion of locomotive on rails, transmission of power by belts, gears etc. The friction between the wheels and the road is essential for the car to move forward.

In general, the friction is of the following two types :

1. *Static friction.* It is the friction, experienced by a body, when at rest.

2. *Dynamic friction.* It is the friction, experienced by a body, when in motion. The dynamic friction is also called *kinetic friction* and is less than the static friction. It is of the following three types :

(a) *Sliding friction.* It is the friction, experienced by a body, when it *slides* over another body.

(b) *Rolling friction.* It is the friction, experienced between the surfaces which has *balls* or *rollers* interposed between them.

(c) *Pivot friction.* It is the friction, experienced by a body, due to the *motion of rotation* as in case of foot step bearings.

The friction may further be classified as :

1. Friction between unlubricated surfaces, and

2. Friction between lubricated surfaces.

These are discussed in the following articles.

Friction Between Unlubricated Surfaces

The friction experienced between two dry and unlubricated surfaces in contact is known as *dry* or *solid friction*. It is due to the surface roughness. The dry or solid friction includes the sliding friction and rolling friction as discussed above.

Friction Between Lubricated Surfaces

When lubricant (*i.e.* oil or grease) is applied between two surfaces in contact, then the friction may be classified into the following two types depending upon the thickness of layer of a lubricant.

1. *Boundary friction (or greasy friction or non-viscous friction).* It is the friction, experienced between the rubbing surfaces, when the surfaces have a very thin layer of lubricant. The thickness of this very thin layer is of the molecular dimension. In this type of friction, a thin layer of lubricant forms a bond between the two rubbing surfaces. The lubricant is absorbed on the surfaces and forms a thin film. This thin film of the lubricant results in less friction between them. The boundary friction follows the laws of solid friction.

2. *Fluid friction (or film friction or viscous friction).* It is the friction, experienced between the rubbing surfaces, when the surfaces have a thick layer of the lubrhicant. In this case, the actual surfaces do not come in contact and thus do not rub against each other. It is thus obvious that fluid friction is not due to the surfaces in contact but it is due to the *viscosity* and *oiliness* of the lubricant.

Note : The *viscosity* is a measure of the resistance offered to the sliding one layer of the lubricant over an adjacent layer. The absolute viscosity of a lubricant may be defined as the force required to cause a plate of unit area to slide with unit velocity relative to a parallel plate, when the two plates are separated by a layer of lubricant of unit thickness.

The *oiliness* property of a lubricant may be clearly understood by considering two lubricants of equal viscosities and at equal temperatures. When these lubricants are smeared on two different surfaces, it is found that the force of friction with one lubricant is different than that of the other. This difference is due to the property of the lubricant known as oiliness. The lubricant which gives lower force of friction is said to have greater oiliness.

Limiting Friction

Consider that a body A of weight W is lying on a rough horizontal body B as shown in Fig. In this position, the body A is in equilibrium under the action of its own weight W, and the

normal reaction R_N (equal to W) of B on A. Now it
A acting through its centre of gravity as shown i
frictional force which prevents the motion. This sh
by the force of friction F_1 acting in the opposite di

If we now increase the applied force to P_2
equilibrium. This means that the force of friction
time the effort is increased the force of friction als
applied force. There is, however, a limit beyond wh
in Fig. 10.1 (*d*). After this, any increase in the appli
force of friction, as shown in Fig. 10.1 (*e*), thus th
applied force. This maximum value of frictional
begins to slide over the surface of the other body,
limiting friction. It may be noted that when the appl
remains at rest, and the friction into play is called
zero and limiting friction.

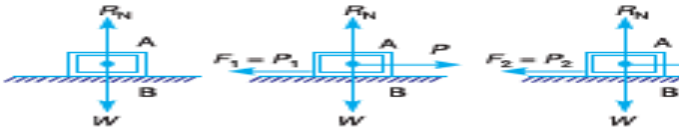

Fig. 10.1. Lim

Q.2

The belts or ropes are used to transmit power from one shaft to another by means of pulleys which rotate at the same speed or at different speeds. The amount of power transmitted depends upon the following factors :

1. The velocity of the belt.
2. The tension under which the belt is placed on the pulleys.
3. The arc of contact between the belt and the smaller pulley.
4. The conditions under which the belt is used.

It may be noted that

(*a*) The shafts should be properly in line to insure uniform tension across the belt section.

(*b*) The pulleys should not be too close together, in order that the arc of contact on the smaller pulley may be as large as possible.

(*c*) The pulleys should not be so far apart as to cause the belt to weigh heavily on the shafts, thus increasing the friction load on the bearings.

(*d*) A long belt tends to swing from side t
which in turn develops crooked spots i
(*e*) The tight side of the belt should be at t
loose side will increase the arc of cont
(*f*) In order to obtain good results with fla
should not exceed 10 metres and the
diameter of the larger pulley.

11.2. Selection of a Belt Drive

Following are the various important factors

1. Speed of the driving and driven shafts,
3. Power to be transmitted,
5. Positive drive requirements,
7. Space available, and

11.3. Types of Belt Drives

The belt drives are usually classified into t

1. *Light drives.* These are used to transmit
in agricultural machines and small machine tools.

2. *Medium drives.* These are used to transı
up to 22 m/s, as in machine tools.

3. *Heavy drives.* These are used to transm
compressors and generators.

11.4. Types of Belts

Fig. 11.1. Typ

Though there are many types of belts used
the subject point of view :

1. *Flat belt.* The flat belt, as shown in F
workshops, where a moderate amount of power is t
the two pulleys are not more than 8 metres apart.

2. *V-belt.* The V-belt, as shown in Fig. 1
shops, where a moderate amount of power is to be t
two pulleys are very near to each other.

3. *Circular belt or rope.* The circular belt
in the factories and workshops, where a great amou
to another, when the two pulleys are more than 8 m

If a huge amount of power is to be transı
such a case, wide pulleys (for V-belts or circular b
in each groove is provided to transmit the require