SNS COLLEGE OF TECHNOLOGY
(An Autonomous Institution**)**
COIMBATORE–35
DEPARTMENT OF AUTOMOBILE ENGINEERING

19AUT203 - MECHANICS OF AUTOMOBLE SYSTEMS

Unit- 1

Introduction

The subject **Theory of Machines** may be defined as thatbranchofEngineering-science,whichdealswiththestudy of relative motion between the various parts of a machine, andforceswhichactonthem.Theknowledgeofthissubject isveryessentialforanengineerindesigningthevariousparts of amachine.

Note: A machine is a device which receives energy in some available form and utilizes it to do some particular type of work.

SUB-DIVISIONS OF THEORY OF MACHINES

Kinematics: It is that branch of Theory of Machines which deals with the relative motion between the various parts of the machines.

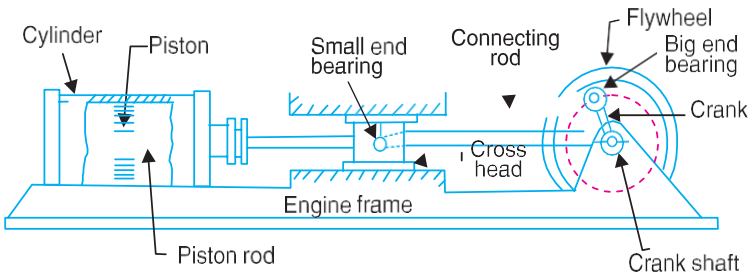
Dynamics: It is that branch of Theory of Machines which deals with the forces and their effects, while acting upon the machine parts in motion.

Kinetics: It is that branch of Theory of Machines which deals with the inertia forces which arise from the com- bined effect of the mass and motion of the machine parts.

Statics: It is that branch of Theory of Machines which deals with the forces and their effects while the ma- chine parts are at rest. The mass of the parts is assumed to be negligible.

Kinematic Link or Element:

Each part of a machine, which moves relative to some other part, is known as a kinematic link (or simply link) or element.



Reciprocating steam engine.

TYPES OF LINKS

Rigid link: A rigid link is one which does not undergo any deformation while transmitting motion. Strictly speaking, rigid links do not exist. However, as the deformation of a connecting rod, crank etc. of a reciprocating steam engine is not appreciable, they can be considered as rigid links.

Flexible link: A flexible link is one which is partly deformed in a manner not to affect the transmission of motion. For example, belts, ropes, chains and wires are flexible links and transmit tensile forces only.

Fluid link: A fluid link is one which is formed by having a fluid in a receptacle and the motion is transmitted through the fluid by pressure or compression only, as in the case of hydraulic presses, jacks and brakes.

STRUCTURE

It is an assemblage of a number of resistant bodies (known as members) having no relative motion between them and meant for carrying loads having straining action. A railway bridge, a roof truss, machine frames etc., are the examples of a structure.

DIFFERENCE BETWEEN A MACHINE AND A STRUCTURE

The following differences between a machine and a structure are important from the subject point of view :

The parts of a machine move relative to one another, whereas the members of a structure do not move relative to one another.

A machine transforms the available energy into some useful work, whereas in a structure no energy is transformed into useful work.

The links of a machine may transmit both power and motion, while the members of a structure transmit forces only.

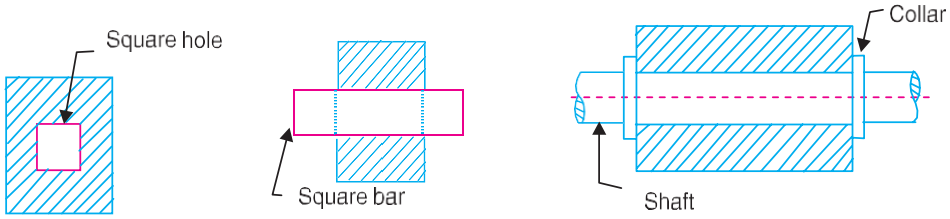
KINEMATIC PAIR

The two links or elements of a machine, when in contact with each other, are said to form a pair. If the relative motion between them is completely or successfully constrained (i.e. in a definite direction), the pair is known as kinematic pair.

TYPES OF CONSTRAINED MOTIONS

Following are the three types of constrained motions :

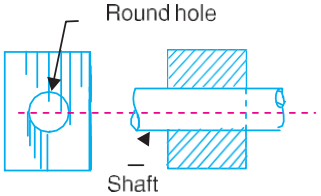
Completely constrained motion: When the motion between a pair is limited to a definite direction irrespective of the direction of force applied, then the motion is said to be a completely constrained motion. For example, the piston and cylinder (in a steam engine) form a pair and the motion of the piston is limited to a definite direction (i.e. it will only reciprocate) relative to the cylinder irrespective of the direction of motion of the crank, as shown in Fig.

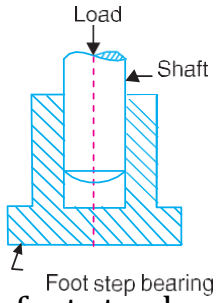


Square bar in a square hole. Shaft with collars in a circular hole.

The motion of a square bar in a square hole, as shown in and the motion of a shaft with collars at each end in a circular hole, as shown in Fig. are also examples of completely constrained motion.

Incompletely constrained motion. When the motion between a pair can take place in more than one direction, then the motion is called an incompletely constrained motion. The change in the direction of impressed force may alter the direction of relative motion between the pair. A circular bar or shaft in a circular hole, as shown in Fig. 5.4, is an example of an incompletely constrained motion as it may either rotate or slide in a hole. These both motions have no relationship with the other





Shaft in a circular hole Shaft in a foot step bearing

Successfully constrained motion. When the motion between the elements, forming a pair,is such that the constrained motion is not completed by itself, but by some other means, then the motion is said to be successfully constrained motion. Consider a shaft in a foot-step bearing as shown in Fig The shaft may rotate in a bearing or it may move upwards. This is a case of incompletely con- strained motion. But if the load is placed on the shaft to prevent axial upward movement of the shaft, then the motion of the pair is said to be successfully constrained motion. The motion of an I.C. enginevalve (these are kept on their seat by a spring) and the piston reciprocating inside an engine cylinder are also the examples of successfully constrained motion.

Classification of Kinematic Pairs:

According to the type of relative motion between the elements. The kinematic pairs ac- cordingtotypeofrelativemotionbetweentheelementsmaybeclassifiedasdiscussedbelow:

Sliding pair.When the two elements of a pair are connected in such a way that one can onlysliderelativetotheother,thepairisknownasaslidingpair.Thepistonandcylinder,cross-head and guides of a reciprocating steam engine, ram and its guides in shaper, tail stock on the lathe bed etc. are the examples of a sliding pair. A little consideration will show,that a sliding pair has a completely constrainedmotion.

Turningpair.Whenthetwoelementsofapairareconnectedinsuchawaythatonecan onlyturnorrevolveaboutafixedaxisofanotherlink,thepairisknownasturningpair.Ashaftwith collarsatbothendsfittedintoacircularhole,thecrankshaftinajournalbearinginanengine,lathe spindle supported in head stock, cycle wheels turning over their axles etc. are the examples of a turningpair.Aturningpairalsohasacompletelyconstrainedmotion.

Rollingpair.Whenthetwoelementsofapairareconnectedinsuchawaythatonerolls over another fixed link, the pair is known as rolling pair. Ball and roller bearings are examples of rollingpair.

Screwpair.Whenthetwoelementsofapairareconnectedinsuchawaythatoneelement canturnabouttheotherbyscrewthreads,thepairisknownasscrewpair.Theleadscrewofalathe withnut,andboltwithanutareexamplesofascrewpair.

Spherical pair.When the two elements of a pair are connected in such a way that one element (with spherical shape) turns or swivels about the other fixed element, the pair formed is called a spherical pair. The ball and socket joint, attachment of a car mirror, pen stand etc., are the examples of a sphericalpair.

Accordingtothetypeofcontactbetweentheelements.Thekinematicpairsaccordingto thetypeofcontactbetweentheelementsmaybeclassifiedasdiscussedbelow:

Lowerpair.Whenthetwoelementsofapairhaveasurfacecontactwhenrelativemotion takes place and the surface of one element slides over the surface of the other, the pair formed is knownaslowerpair.Itwillbeseenthatslidingpairs,turningpairsandscrewpairsformlowerpairs.

Higher pair.When the two elements of a pair have a line or point contact when relative motiontakesplaceandthemotionbetweenthetwoelementsispartlyturningandpartlysliding,then thepairisknownashigherpair.Apairoffrictiondiscs,toothedgearing,beltandropedrives,balland roller bearings and cam and follower are the examples of higherpairs.

According to the type of closure. The kinematic pairs according to the type of closure betweentheelementsmaybeclassifiedasdiscussedbelow:

Selfclosedpair.Whenthetwoelementsofapairareconnectedtogethermechanicallyin suchawaythatonlyrequiredkindofrelativemotionoccurs,itisthenknownasselfclosedpair.The lower pairs are self closedpair.

Force-closedpair.Whenthetwoelementsofapairarenotconnectedmechanicallybutarekeptincontactbytheactionofexternalforces,thepairissaidtobeaforce-closedpair.Thecam andfollowerisanexampleofforceclosedpair,asitiskeptincontactbytheforcesexertedbyspring andgravity.