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Al-Mustaqbal University College

Air Conditioning and Refrigeration Techniques

Engineering Department

Blended Learning

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{Third Stage}

Theory of Machine Laboratory

Experiment No.(1): **Simple Four-Bar Linkage Mechanism**

Lecturer, **Dr. Sami Mohsen .**

Engineer, **Aliyaa Mahmood .**

Lecturer: Dr.Sami & Engineer Aliyaa .
E-mail: AliyaaMahmood@mustaqbal-college.edu.iq

Experiment Number :- (1) .

Experiment Name :- Simple Four- Bar Linkage Mechanism.

Purpose of Experiment :-

The experiment is designed to give a better understanding of the performance of the four-bar linkages in its different conditions according to its geometry.

Measuring the Dead point angles φ and transmission angles β at two positions

Theory:-

Definitions :-

In the range of planar mechanisms, the simplest groups of lower pair mechanisms are four bar linkages. A *four bar linkage* comprises four bar-shaped links and four turning pairs as shown in Figure 1.1.

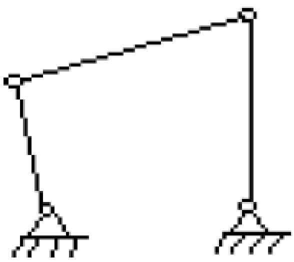


Figure 1.1: Four bar linkage

The link opposite the frame is called the *coupler link*, and the links which are hinged to the frame are called *side links*. A link which is free to rotate through 360 degree with respect to a second link will be said to *revolve* relative to the second link (not necessarily a frame). If it is possible for all four bars to become simultaneously aligned, such a state is called a *change point*.

Some important concepts in link mechanisms are:

1. **Crank**: A side link which revolves relative to the frame is called a *crank*.
2. **Rocker**: Any link which does not revolve is called a *rocker*.
3. **Crank-rocker mechanism**: In a four bar linkage, if the shorter side link revol and the other one rocks (*i.e.*, oscillates), it is called a *crank-rocker mechanism*.
4. **Double-crank mechanism**: In a four bar linkage, if both of the side links revol it is called a *double-crank mechanism*.
5. **Double-rocker mechanism**: In a four bar linkage, if both side links rock, i called a *double-rocker mechanism*.

Before classifying four-bar linkages, we need to introduce some basic nomenclature. In a four-bar linkage, we refer to the *line segment between hinges* on a given link as a **bar** where:

- s = length of shortest bar
- l = length of longest bar
- p, q = lengths of intermediate bar

Grashof's theorem states that a four-bar mechanism has *at least* one revolving link if

$$s + l <= p + q \quad (1.1)$$

and all three mobile links will rock if

$$s + l > p + q \quad (1.2)$$

The inequality 1.1 is *Grashof's criterion*.

All four-bar mechanisms fall into one of the four categories listed in Table 1.1:

Table 1.1 Classifications of Four-Bar Mechanisms

Case	l + s vers. p + q	Shortest Bar	Type
1	<	Frame	Double-crank
2	<	Side	Rocker-crank
3	<	Coupler	Double- rocker
4	=	Any	Change point
5	>	Any	Double-rocker

From Table 1. 1 we can see that for a mechanism to have a crank, the sum of the length of its shortest and longest links must be less than or equal to the sum of the length of the other two links. However, this condition is necessary but not sufficient. Mechanisms satisfying this condition fall into the following three categories:

1. When the shortest link is a side link, the mechanism is a crank-rocker mechanism. The shortest link is the crank in the mechanism (Figure 1.2).
2. When the shortest link is the frame of the mechanism, the mechanism is a double-crank mechanism (Figure 1.3).
3. When the shortest link is the coupler link, the mechanism is a double-rocker mechanism (Figure 1.4).

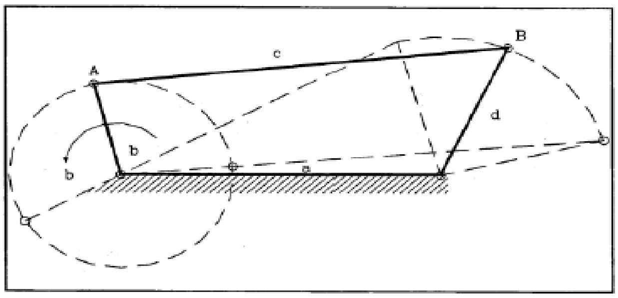


Figure 1.2: Crank and Rocker Mechanism

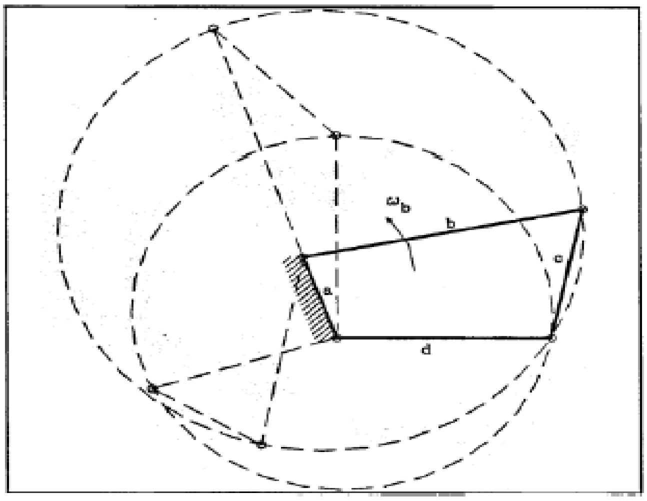


Figure 1.3: Drag Link Mechanism

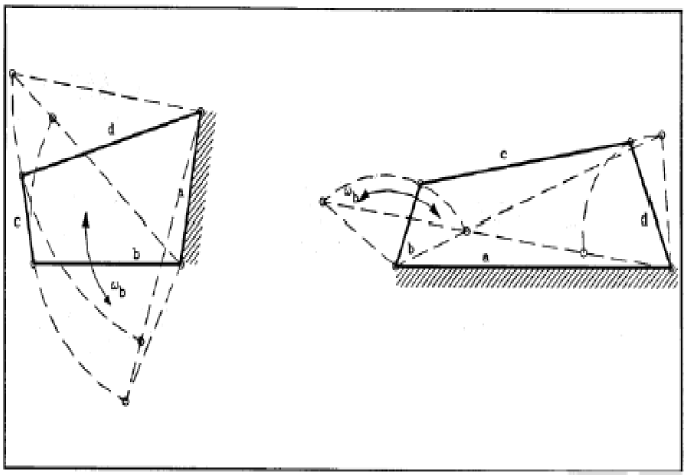


Figure 1.4: Double Rocker Mechanism

Transmission Angle

In Figure 1.5, if *AB* is the input link, the force applied to the output link, *CD*, is transmitted through the coupler link *BC*. (That is, pushing on the link *CD* imposes a force on the link

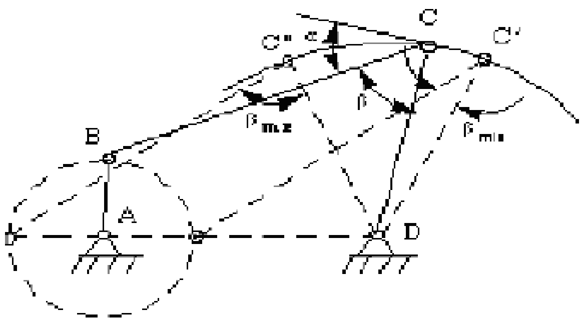


Figure 1.5: Transmission angle

AB, which is transmitted through the link *BC*). The angle between link BC and DC is called *transmission angle*, β, as shown in Figure 1.5. For sufficiently slow motions (negligible inertia forces), the force in the coupler link is pure tension or compression (negligible bending action) and is directed along *BC*. For a given force in the coupler link, the torque transmitted to the output bar (about point *D*) is maximum when the transmission angle approaches to π /2.

When the transmission angle deviates significantly from $\pi/2$, the torque on the output bar decreases and may not be sufficient to overcome the friction in the system. For this reason, the *deviation angle* $\alpha = |\pi/2 - \beta|$ should not be too great. In practice, there is no definite upper limit for α, because the existence of the inertia forces may eliminate the undesirable force relationship that is present under static conditions. Nevertheless, the following criterion can be followed.

$$\alpha_{max} = |90^o - \beta|_{min} \langle 50^o \qquad (1.3)$$

Dead Point

When a side link such as *AB* in Fig 6, becomes aligned with the coupler link *BC*, it can only be compressed or extended by the coupler. In this configuration, a torque applied to the link on the other side, *CD*, cannot induce rotation in link *AB*. This link is therefore said to be at a *dead point* (sometimes called a *toggle point*). In order to pass the dead points a flywheel is usually connected to the input shaft particularly.

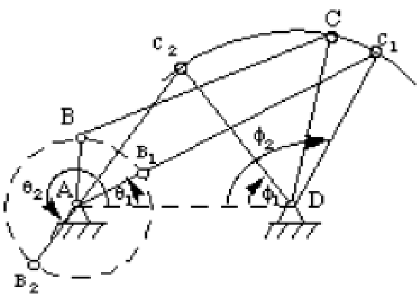
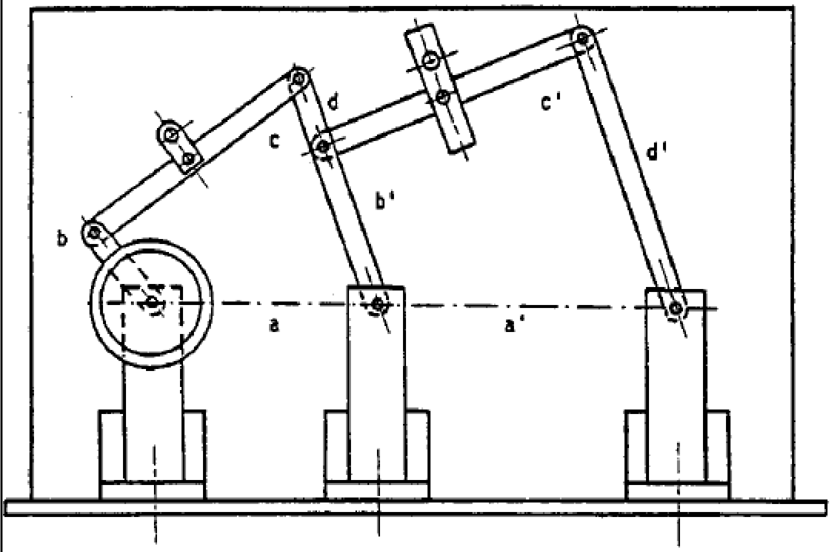


Figure 1. 6: Dead point

In Figure 1.6, if *AB* is a crank, it can become aligned with BC in full extension along the line AB_1C_1 or in flexion with AB_2 folded over B_2C_2. We denote the angle *ADC* by Φ and the angle DAB by θ. We use the subscript 1 to denote the extended state and 2 to denote the flexed state of links *AB* and *BC*. In the extended state, link *CD* cannot rotate clockwise without stretching or compressing the theoretically rigid line AC_1. Therefore, link *CD* cannot move into the *forbidden zone* below C_1D, and Φ must be at one of its two extreme positions; in other words, link *CD* is at an extreme. A second extreme of link *CD* occurs with $\Phi = \Phi_1$.

The apparatus:-



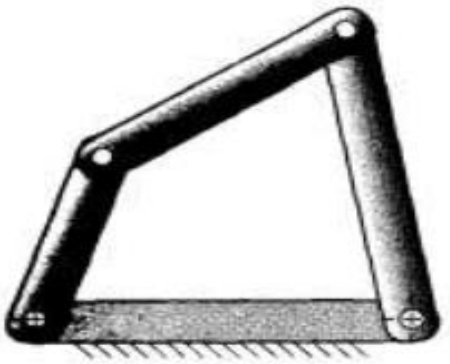


Figure 1.7: Four bar linkage Mechanism

The experimental setup consists of two four-bar linkage mechanism trains as shown in Figure 1.7. Careful examination of the setup should result in the correct categorization of the linkages. There is an arm following the coupler curve trace, a software generated linkage similar to the actual linkage is studied using the Working Model simulation package.

Lecturer: Dr.Sami & Engineer Aliyaa .
E-mail: AliyaaMahmood@mustaqbal-college.edu.iq

Procedure :-

1.) Fix the crank arm on the frame and make his angle equal to zero .

2.) Rotate the crank arm at angle (30^0)&(60^0)&(90^0) and continuous in rotate the crank when the angle reach to (360^0).

3.) We get many points on each side of crank then connect it to draw space and velocity and acceleration diagrams .

Results and calculations:-

Ground Length (in)	Transmission Angle (β)		Angle at Dead points (φ)	
	β_1	β_2	φ_1	φ_2
4				
6				

Input Angle	0^0	60^0	90^0	150^0	180^0	240^0	270^0	320^0	360^0
Output Angle	74^0	83^0	65^0	45^0	30^0	25^0	30^0	49^0	74^0

Discussion:-

1.) When the mechanism stop from movement ?

2.) What are the advantage from use four bar linkage mechanism ?

3.) Write the the relationship to describe Grashof's theorm state ?

4.) Draw the curve between input & output angle ?

5.) What are the conditions which act on motion ?