MECHATRONICS ENGINEERING DEPARTMENT

MECE 307 MACHINE ELEMENTS

TERM PROJECT (Due Date : 20/12/2025 15:00)

Flying Shear machines (Uçar Makas) are heavy industry equipment used in square or round profile steel billet and rebar production [1]. This machinery is crucial for cutting steel products to a predetermined length at continuous casting lines with constant speed. Steel billets are heated to above 400 °C temperature. Since their yield strength becomes considerably small, it is markedly easier to deform when they are heated. The billets are needed to be cropped into smaller sizes for later purposes or logistics considerations. During this process, the size of the steel material is reduced by the hot rolling process. The roll-deforming material attains much higher velocities than its initial speed. Since they are very long materials, their handling is always a problem. Cutting the bars during their manufacturing is a viable method. However, the rebar manufacturing line is not interrupted, so that machine productivity is maximized. The flying shear machines do this process while the material flows at high speed in the manufacturing line.

In this project, we have a design problem of a flying shear mechanism for steel rebar production. The yield strength of structural steel during the final rolling stage drops to 480 MPa at 400 °C [2] operating temperature. The flying shear machine's design criteria require that it should cut the rebar of a standard diameter of a maximum of 57 mm. The preliminary design requirement enforces us to neglect the strain rate dependence in the cut material.

Figure 1 illustrates an example of a crank flying shear machine.

Figure 1- An Example of Crank Flying Shear Machine (Not Our Project Image)

Figure 2 shows the flying shear mechanism. Its components are comprised of the following parts;

- the crack (input) shaft (1),
- the rocker arm (2),
- the crank (3),
- blade (4)
- knife link (5),
- blade-knife link welded joint (6),
- knife assy-crank connection pin (7),
- rocker arm-knife assy connection pin (8),
- rocker arm-bracket connection pin (9),

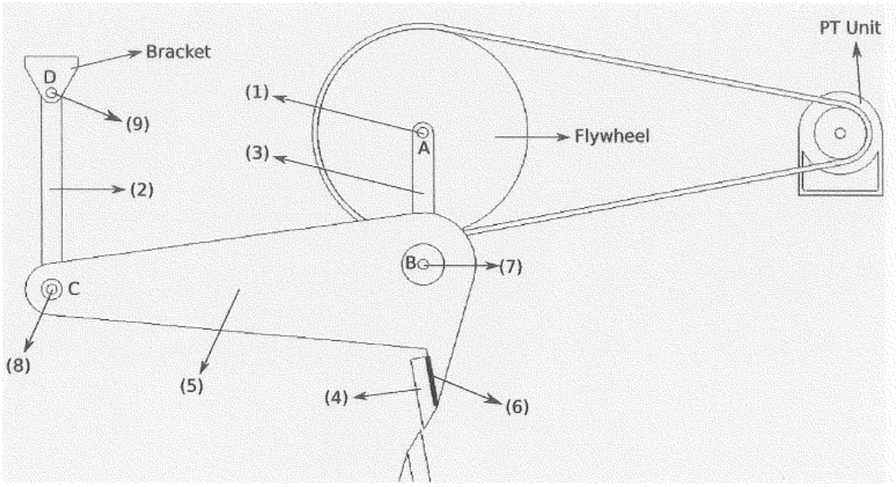

Figure 2- Flying Shear Machine Schematics

The power transmission unit (PT Unit) provides continuous rotation of the flywheel of the mechanism. The crankshaft is connected to the flywheel and rotates at a rated speed. Cut section of the flowing material immediately leaves from the knives' movement envelope due to its line speed (initial speed given by rolls). Pins (7-8-9) connect the links. The knife assembly is constructed by welding (6) blade (4) to the knife link (5). A detailed image of the knife link while material cutting is shown in Figure 3.

Further geometrical aspects of the flying shear mechanism are provided in Figure 4.

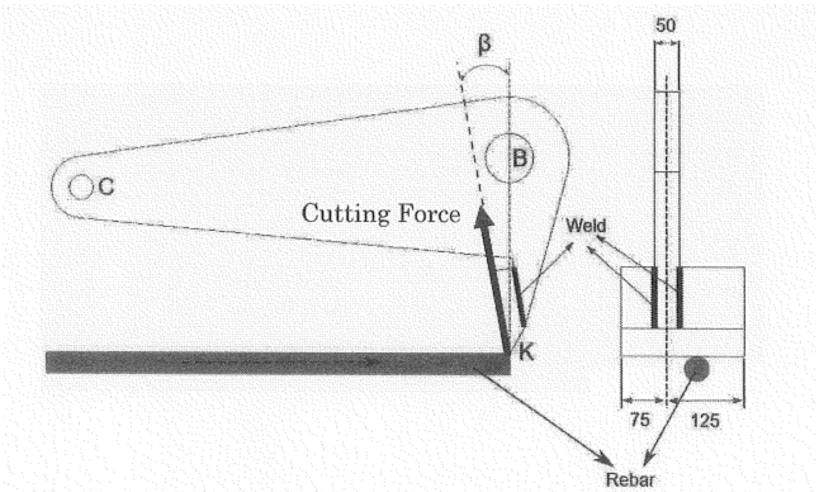

Figure 3 Knife Assembly Front and Right View

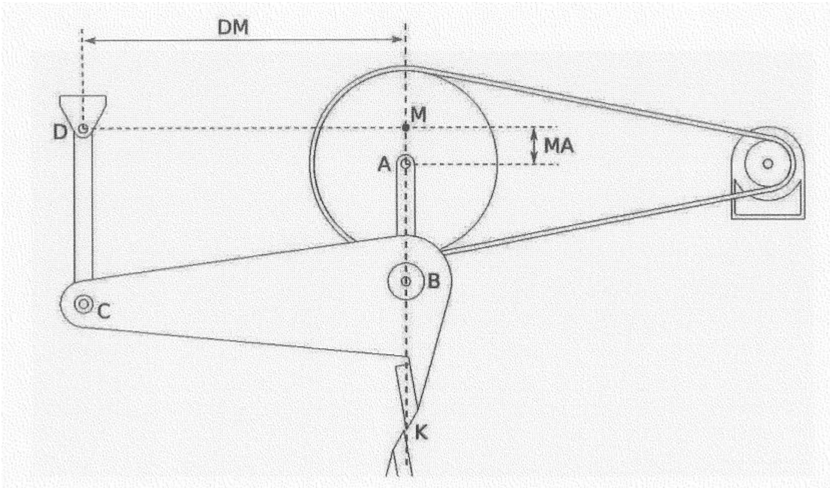

Figure 4 Some Dimensional Details

In the critical position (Figure 4) DC// AB.

Detailed drawings of the shaft and the belt drive are given in Figure 5 and Figure 6, respectively. According to Figure 7, brackets are welded to the ground. Link 2 is connected to the bracket by pin (9).

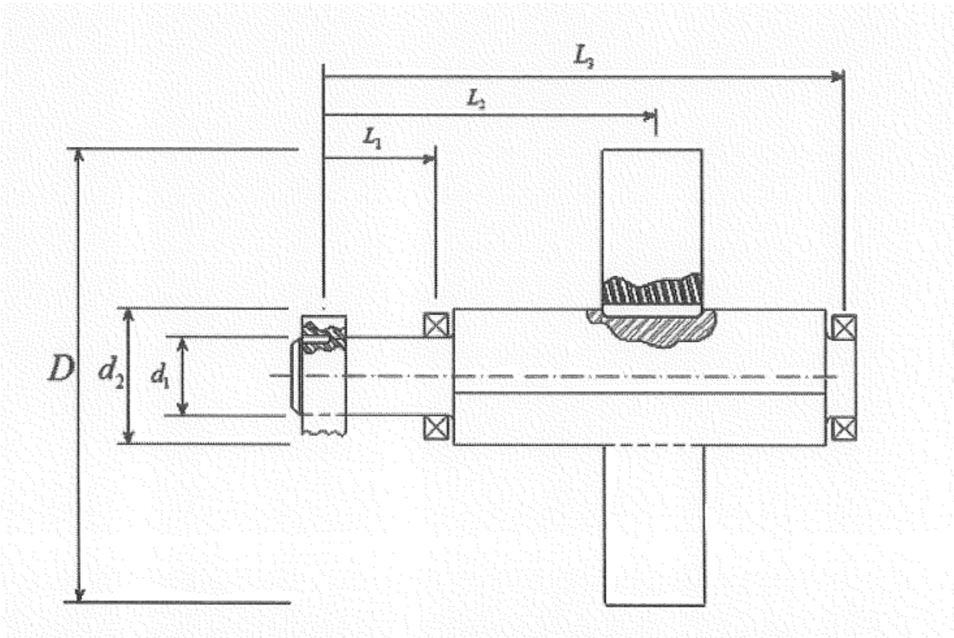

Figure 5 Detailed Drawing of the Crank Shaft

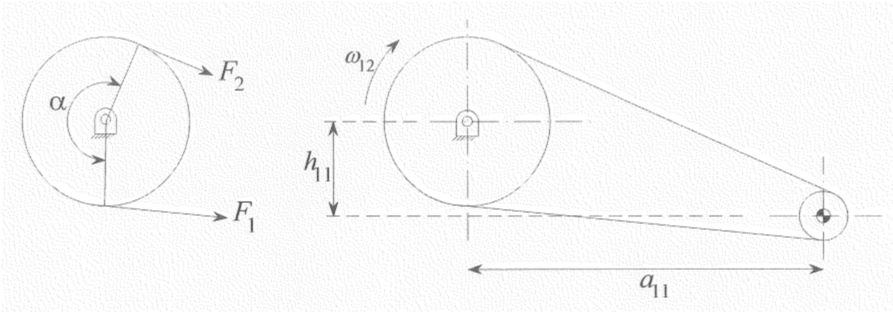

Figure 6 Details of Belt Drive

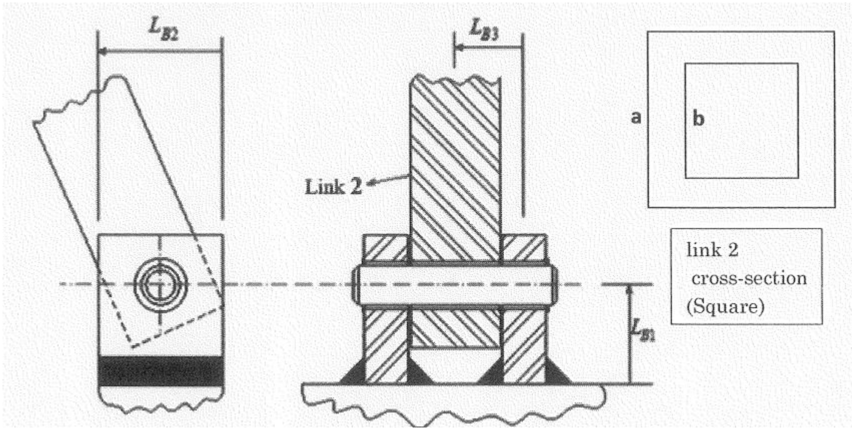

Figure 7 Detailed view of pin (9)

In the project, do the followings in the given order:

A. Force Analysis

Note that the magnitude and direction of the reaction forces acting on the members are functions of the crank angle. Properly speaking, for the critical locations, you need to plot the bending moment with respect to the crank angle and angular position of the members. After then, you should determine the critical position from the 3D plot. However, you are given the critical position, as shown in Figure 2.

Neglect weights of all links.

Draw the free-body diagrams of the following parts and determine the forces acting on them by neglecting all the inertias.

- The parts (2), (3), (5)
- The pin (9)

- The crankshaft (1)

B. Shaft Design

You are expected to design the crankshaft for fatigue loading as if the loadings on the shaft changes between 0 and the value corresponding to the critically loaded case (see Figure 2).

- Draw the shear force and the bending moment diagrams of the shaft.
- Designing the shaft for fatigue loading, use the distortion energy theory and Soderberg criterion. Note that the shaft is machined. The crank is connected to the shaft with a sled runner type of keys. Determine the required shaft dimensions d_1 and d_2.

C. Link Design

The cross section of the link (2) is a hollow-square and the ratio of a side on the outer perimeter to a side on the inner perimeter is given in the dataset. Design the link (2) by considering buckling (assume Euler column) and maximum shear stress theory (MSST), i.e., determine the dimensions of the cross-section.

D. Pin Design

The specified fit for the pin (9) is H7 /f7.

a. Draw the shear force and the bending moment diagrams of pin **(9).**

b. Design pin (9) for the static case by considering bending, contact, and shear stresses. Use the maximum shear stress theory.

Note that one should select a pin diameter that is compatible with the Preferred Size.

E. Weld Design

Since the blade's exact cutting location cannot be specified precisely, assume the rebar sits in the worst position it can have while being cut. Find the leg size of the welds of the blade considering fatigue loading. Assume each weld length is 300 mm. Ignore blade thickness when handling the cutting force.
Find the size of the welds between the ground and the brackets. Use Goodman criterion in the design.

F. Engineering Drawings

The technical drawings of the following parts should be prepared using CAD tools.

Also, it should contain templates (i.e., material, work-piece name, tolerance, scale...)

a. The crankshaft

b. The link (2)

c. Details of the Weld Section

NOTE:

- ✓ **If you think that any of the parameters are not provided here, you may assume a suitable value by using your engineering perception.**
- ✓ **The projects must be typed. Hand writings, hand drawings/sketches will not be accepted and will not be evaluated.**
- ✓ **Reports wrong data sets will not be graded.**

SURNAME, NAME: STUDENT NUMBER

	(Steel HR)	DATA SETS 1	2	3
MATERIAL DATA	The material of the links	1040	1050	1040
	The material of the pins	1095	1095	1095
	The material of the shaft	1040	1030	1030
	The material of the brackets	1050	1030	1040
LINK LENGTHS, DISTANCES, GEOMETRIC PARAMETERS (mm)	AB	255	265	245
	CB	712	716	702
	CD	380	390	375
	BK	320	330	315
	DM	710	715	700
	MA	75	85	75
	a_{11}	1052	1070	1045
	h_{11}	280	260	290
	β	12	14	10
DESIGN SPECIFICATIONS	Side to side ratio of link 2	1.2	1.27	1.3
	Factor of safety	2.2	2.5	2.1
	Motor Speed (rpm)	1850	1700	2000
	Reliability	0.999	0.99	0.9
	Total speed ratio from the motor to the flywheel	6	6	6
	Temperature	20°	20°	20°
	f	0.29	0.26	0.27
	D	880	980	780
	d_2/d_1	1.1	1.2	1.05
	L_1 [mm]	185	170	190
	L_2 [mm]	260	240	300
	L_3 [mm]	550	500	580
	r/d of fillets on the shaft	0.125	0.125	0.15
	L_{B1} [mm]	40	35	35
	L_{B2} [mm]	45	50	48
	L_{B3} [mm]	25	24	26