MECHATRONICS ENGINEERING DEPARTMENT

MECE 307 MACHINE ELEMENTS

TERM PROJECT (Due Date : 28/12/2023 15:00)

In this project, the main parts of a telescopic boom mini-crane will be designed. These cranes are powerful and compact solution to accurate and safe load positioning in civil engineering and other industrial applications, particularly when access and working conditions are restricted. This particular crane is equipped with a winch driven by an electric motor for lifting and pulling heavy loads.

Figure 1 - Telescopic boom

The lifting mechanism of the crane consists of three telescopic booms that rest one inside the other. The booms can extend up to a certain ratio of their own lengths. A hydraulic piston-cylinder arrangement mounted on Link 1 on the main frame on the crane at point D supports the mechanism. The hydraulic piston-cylinder mechanism between links 1&2 is used to change the working angle θ of the crane.

The pulling mechanism attached to the crane is activated through an electric motor connected to the drum of the winch through a chain drive. Rope carrying the load can be assumed to be in the middle of the drum.

Considering the fact that the weights of the links are negligible compared to the weights to be carried, the only force acting on the system can be taken as the weight to be lifted by the crane. Also the operating temperature of the system is 25 $°C$.

Design the system for the horizontal position of the telescopic booms.

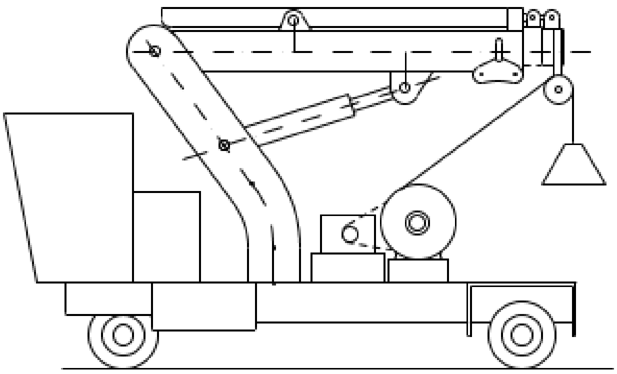
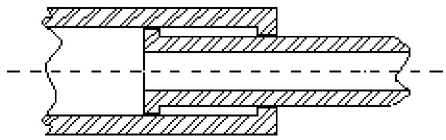
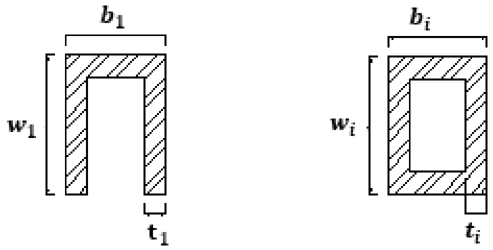


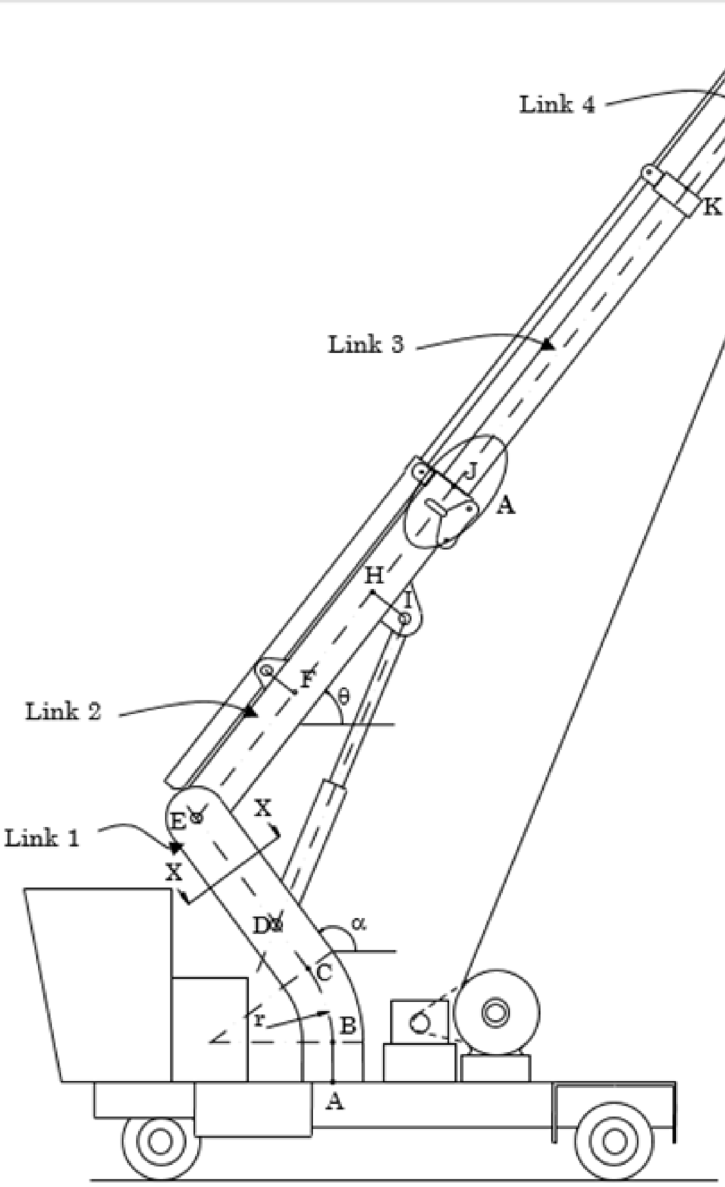
Figure 2 - Crane in Closed Position



Detail A



Cross Section of Link 1 Cross Section of Link 2,3,4



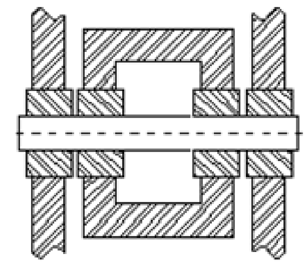


Figure 4 - Pin Detail at Point E

Figure 3 - Crane in Open Position

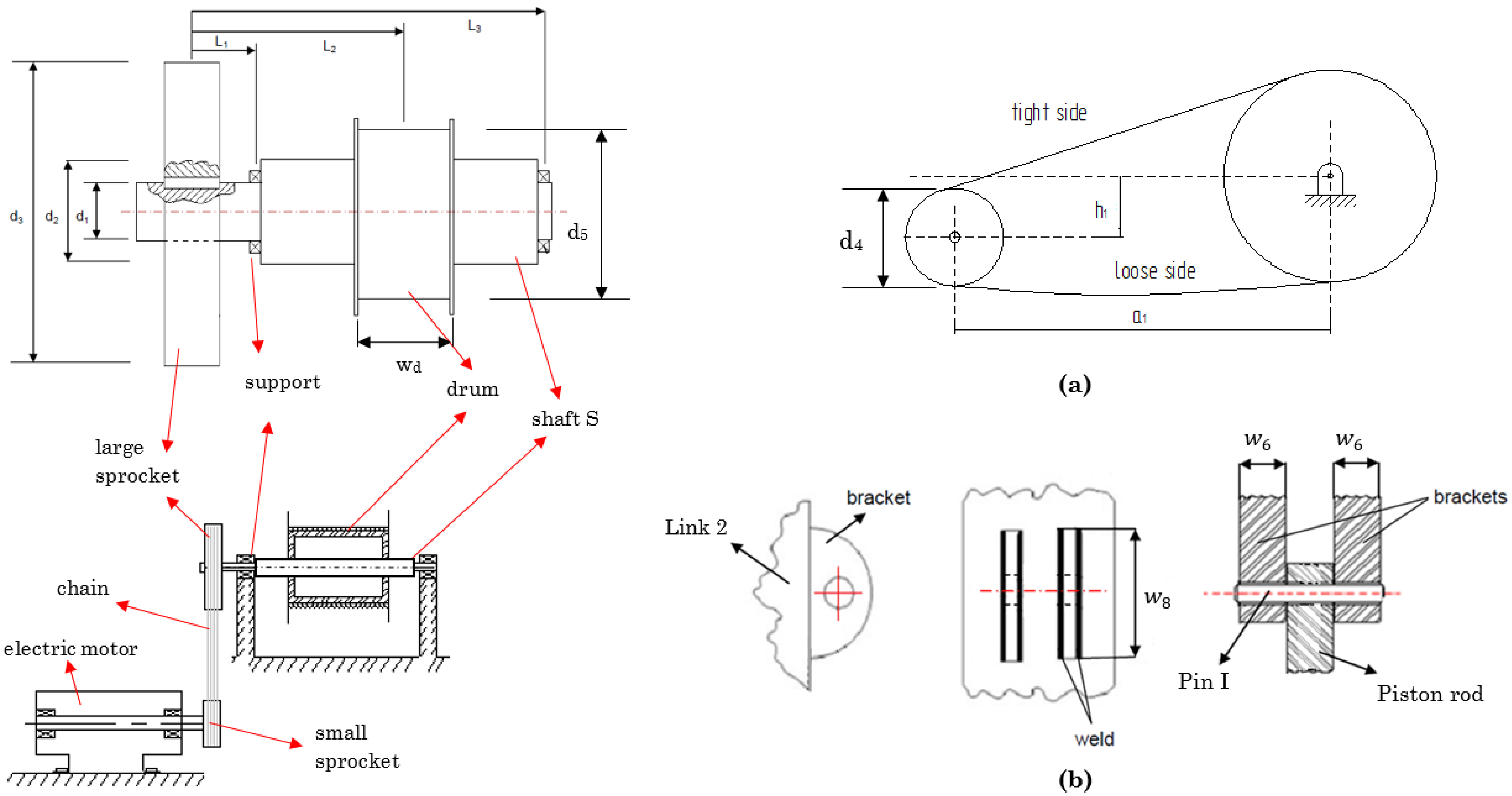


Figure 5 - Detailed drawing of shaft S, chain drive system (a) and the weld region (b)

In the project do the followings in the given order. Your data set is given in the class. Check it! (Reports with wrong data sets will be graded as zero).

A. Force Analysis

Draw the free body diagrams of the following parts and determine the forces acting on the following parts.

1. Link 1,2,3,4
2. Pin I
3. Piston DI
4. Shaft S
5. Sprockets

B. Shaft Design

1. Draw the shear force and the bending moment diagrams of the shaft S.
2. Design the shaft for fatigue loading. Use the distortion energy theory and Soderberg criterion in the design. Note that the shaft is machined. The large sprocket is fixed to the shaft with sled runner type of key.

C. Links Design

The cross section of the links are given in the technical drawing section and the ratios of outer width (b) to height (w) for Link 1 and 4 are in the dataset.

1. Draw the shear force and the bending moment diagrams of the links.
2. Design all the links by considering the maximum shear stress theory. Note that there are clearance fit at link contacts and the exaggerated view is depicted in detail A. Note also that BC portion of link 1 is curved.

D. Piston Design

The maximum available pressure in the piston is in the dataset. Use the maximum shear stress theory.

E. Pin Design

The fit of the pin I is H11/d11.

1. Draw the shear force and the bending moment diagrams of pin I.
2. Design pin I for static case by considering bending, contact and shear stresses. Use the maximum shear stress theory.

Note that results should be compatible with Preferred Sizes.

F. Weld Design

Find the size of the welds between the Link 2 and the brackets at I considering static loading.

G. Find the required motor power.

H. Make an engineering drawing of the following parts:

1. The shaft S
2. Link 1 and Link 2
3. Details of the weld section

The technical drawings should

- be prepared using CAD tools and be scaled.
- contain templates (i.e. material, work-piece name, tolerance, scale…)

While preparing the report, follow the rules given in the website of the course.

SURNAME, NAME: STUDENT NUMBER:

		DATA SETS			
	(Steel HR)	**1**	**2**	**3**	**4**
MATERIAL DATA	Material of the links	1040	1030	1040	1030
	Material of the pistons and cylinders	1045	1035	1035	1045
	Material of the pins	1060	1060	1060	1060
	Material of the shaft	1080	1095	1080	1095
	Material of the key	1035	1010	1010	1035
LINK LENGTHS, DISTANCES (mm), GEOMETRIC PARAMETERS	**LINK 1**				
	AB	500	600	400	700
	CD	400	300	500	600
	DE	750	700	650	800
	r	450	500	550	400
	α	110°	110°	110°	110°
	LINK 2				
	EF	600	650	700	550
	FG	150	170	180	140
	FH	800	700	600	900
	HI	230	280	270	250
	HJ	850	900	800	950
	LINK 3				
	L3	1800	1600	2000	1400
	LINK 4				
	LM	250	300	200	350
	L4	1200	1000	900	1400
DESIGN SPECIFICATIONS	Weight to be carried (kN)	30	25	35	40
	Available pressure in cylinder DI (MPa)	15	12	14	16
	Cross section detail of link 1	$w_1=1.5b_1$	$w_1=1.2b_1$	$w_1=1.7b_1$	$w_1=1.6b_1$
	Cross section detail of link 4	$b_4=10t_4$ $w_4=14t_4$	$b_4=8t_4$ $w_4=12t_4$	$b_4=10t_4$ $w_4=12t_4$	$b_4=6t_4$ $w_4=10t_4$
	The extension ratio of telescopic booms	0.8	0.8	0.8	0.8
	Rod length/Total piston cylinder length	1/1.8	1/1.8	1/1.8	1/1.8
	Rope angle for open horizontal boom position, γ_o	20°	20°	20°	20°
	Factor of safety	2.5	2.4	2	2.2
	Motor Speed (rpm)	1500	2000	2500	1000
	Reliability	0.99	0.999	0.9	0.9999
	Drum width (w_4 [mm])	180	100	150	125
	Drum Diameter (d_5 [mm])	300	250	275	225
	Diameters of the sprockets (d_4 & d_3 [mm])	25 & 208	30 & 210	35 & 212	40 & 214
	d_2/d_1	1.45	1.3	1.75	2.05
	L_1 [mm]	70	80	100	60
	L_2 [mm]	270	280	300	260
	L_3 [mm]	470	480	500	460
	r/d of fillets on the shaft	0.15	0.14	0.13	0.16
	a_1 [mm]	500	480	460	520
	h_1 [mm]	175	200	225	250
	w_5 [mm]	150	175	125	140
	w_6 [mm]	226	282	156	225