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PARAMETRIC MODELLING FOR TOWER CRANE WITH TILTING BOOM

Mast student Eng. Dragos GHEORGHE
Conf. dr. ing. Gina Diana MUSCA
”Dunărea de Jos” University of Galati,
Faculty of Engineering and Agronomy in
Braila, Research Centre for Machines and
Technological Equipment’s Mechanics, Romania

ABSTRACT

This paperwork shows a constructive solution for a tower crane with tilting boom assembly. The 3D model of this assembly is optimized on the basis of a Technical Calculation Method Summary Sheet. For modelling of 3D assembly Inventor 2020 design soft was used. With this soft we have the possibility to create products within a much shorter time period, therefore high productivity.

KEYWORDS: *crane, boom, 3D model, counterweight.*

1. INTRODUCTION

Lifting appliances are operating machines with cyclic functioning, under intermittent mode, serving for moving loads between points located on different heights. Load means any material kind goods that are work objects for lifting machines. Lifting machines are used within the most various fields of economic activity, as regularly all goods like: raw materials, fabrication, storage, transport, mounting, installation, sale, are subject to multiple lifting – lowering operations [1,3].

The cranes with boom are featured by the presence of a boom, regularly a slewing one, around a vertical axis, so that the field of action of the load hanging device is a cylinder shape volume. Possible movements are: load lifting-lowering, boom slewing, boom tilting or clamping device movement along boom – in case of horizontal booms. The presence of crane travelling mechanism properly amplifies the field of action of cranes with boom [2, 4].

Boom tilting and travel of the entire crane can be conceived either as movements that may be performed with load, or movements that which can only be idle performed. In the first situation it is said that the movement in discussion is a work movement, and, in the second one the movement is a position changing one.

2. CONSTRUCTIVE PARAMETERS OF TOWER CRANE WITH TILTING BOOM

In this paperwork, my goal is to achieve an assembly consisting of more elements and sub-assemblies [6]. To achieve such assembly also named crane with tilting boom I started from the following technical features, namely: nominal load = 4000 [kg]; outreach = 10 [m]; maximum lifting height 19 [m]; boom tilting angle $\alpha = 45^o \div 80^o$. Below figures show the main components and dimensions of the tower boom and travelling system.

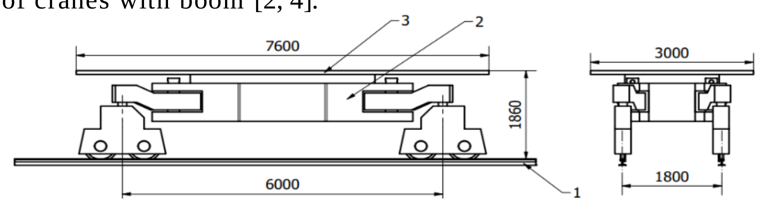


Figure 1. Travelling system of tower crane with tilting boom
1 - rolling gtrack, 2 – Slewing mechanism, 3 – slewing platfo

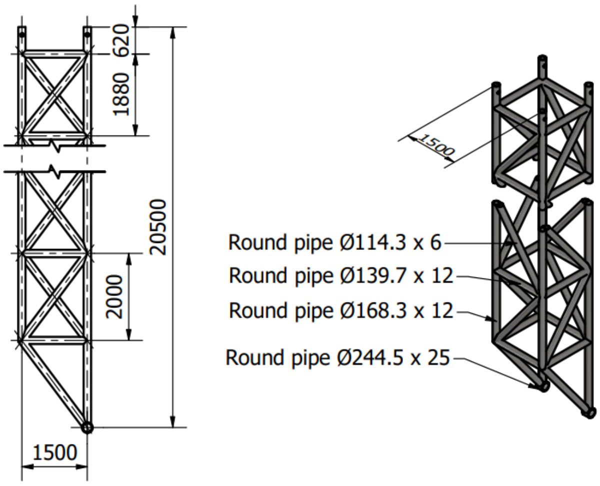


Figure 2. Tower crane

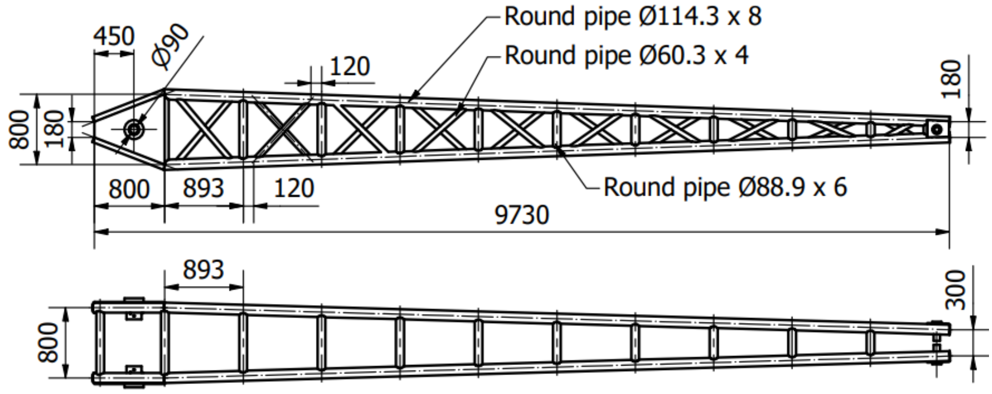


Figure 3. Tower crane boom

For boom driving part including hook muffle, the need was for electric motor, cable, cable drum, guide rolls, whose technical features are calculated, adopted and choosen according to certain Romanian standards (STAS) and will be shown in the tables below.

For boom respectively hook muffle lifting/lowering the option is a double cable under normal construction, with vegetal core, with 6 strands, each strand consisting of 19 wires, and its characteristics being adopted from a cable catalogue according to STAS 1354 – 80 and shown in table 1 respectively table 2.

Table 1. Boom driving cable

Cable component element	Symbol	Value	Measurement Unit
Cable diameter	d_c	20	[mm]
Wire diameter in the strand	d_s	0.9	[mm]
Cable area	A	157.4	$[mm^2]$
Minimum tensile strength of wire in the strand	σ_{tmin}	137	$[daN/mm^2]$
Minimum effective breaking strength of the cable	N	17946	[daN]

Table 2. Hook muffle driving cable

Cable component element	Symbol	Value	Measurement Unit
Cable diameter	d_c	12	[mm]
Wire diameter in the strand	d_s	0.65	[mm]
Cable area	A	73.30	$[mm^2]$
Minimum tensile strength of wire in the strand	σ_{tmin}	137	$[daN/mm^2]$
Minimum effective breaking strength of the cable	N	17946	[daN]

Constructive shape of the drum for boom, respectively, hook muffle, are shown in figure 4, and its design dimensions are shown in table 3 respectively table 4.

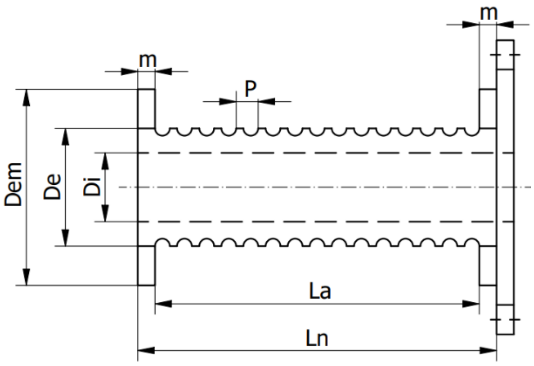


Figure 4. Constructive scheme of the drum

Table 3. Boom driving cable drum

Drum component element	Symbol	Value	Measurement Unit
Outer diameter	D_e	500	[mm]
Inner diameter	D_i	440	[mm]
Diameter on edges	D_{en}	580	[mm]
Nominal length	L_n	730	[mm]
Active length	L_a	700	[mm]
Keyway pitch	p	16	[mm]
Edge thickness	m	15	[mm]
Cable diameter	d	20	[mm]

Table 4. Driving cable drum for hook muffle

Drum component element	Symbol	Value	Measurement Unit
Outer diameter	D_e	500	[mm]
Inner diameter	D_i	468	[mm]
Diameter on edges	D_{en}	584	[mm]
Nominal length	L_n	742	[mm]
Active length	L_a	700	[mm]
Keyway pitch	p	16	[mm]
Edge thickness	m	16	[mm]
Cable diameter	d	12	[mm]

For driving the boom, respectively, hook muffle mobile group, I choose the motor of ASA 160L-6 type from electric motors catalogue, with parameters in table 5.
To drive the cable drum, the electric motor needs a gearbox which is choosen based upon input power and transmission ration [5, 7]

$$i = n_t / n_{me} \qquad (1)$$

where:

n_t - drum speed calculated by relation:

$$n_t = \frac{1000 \cdot v_t}{\pi \cdot D}$$

v_t - warping speed of the drum

Table 5. ASA 160L-6 motor characteristics

P_m [KW]	$n \left[\frac{rot}{min}\right]$	η	$\cos\varphi$	În 380 [V]	$\frac{M_p}{M_n}$	$\frac{i_p}{i_n}$	$\frac{M_{max}}{M_n}$	$GD^2[kg \cdot f \cdot m^2]$	mass[kg]
11	950	86	0.78	24.16 [A]	2	6	2	9.1	165

$$v_t = n \cdot n_{me} = 30\ [m/min] \qquad (2)$$

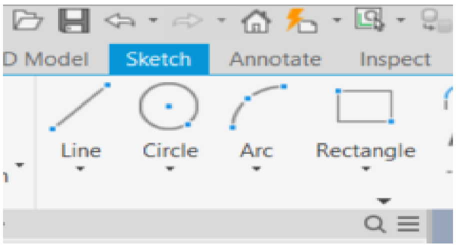
$$n_t = \frac{1000 \cdot v_t}{\pi \cdot D} = 19.098\ [rvt/min] \quad i = 1/20$$

As per previous calculation, according to STAS 2761 – 48, two-stage gearbox among series 2C H – N - 125 with ratio 1:20 was chosen.

3. MODELLING OF TOWER CRANE WITH TILTING BOOM ASSEMBLY

Assembly modelling was achieved within Inventor software. This soft is developed by Autodesk software company, is a 3D program used for design, view and simulation of products.

To obtain the 3D drawing of a part, a wide range of controls like: line, circle, rectangle, fig. 5 a, are succesively used. For easier modelling 2D I used the following controls: move, trim, copy, extend, rotative, offset, mirror, dimension, fig 5 b. 2D drawing of the drum in fig 6c results after modelling. By help of ”revolve” control fig. 6 a, I obtained the 3D model for cable drum shown in fig 6 b.



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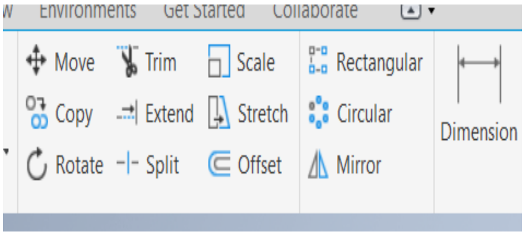

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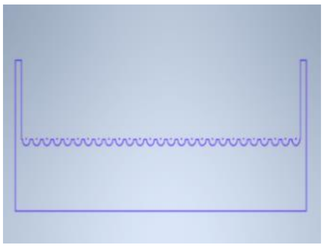
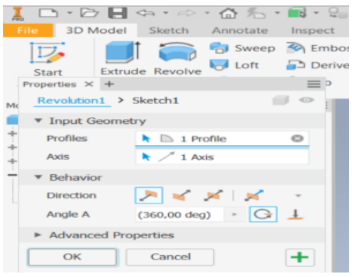


c

Figure 5 Steps for obtaining a 3D drawing



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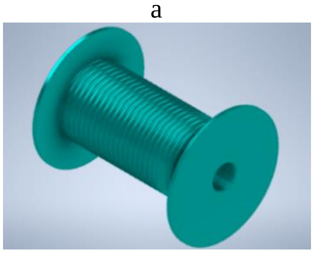
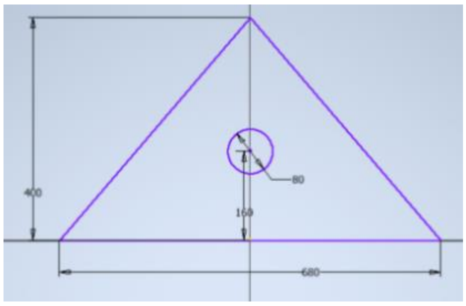


b

Figure 6 - 3D drawing of the drum

Another control we can use to easily obtain a 3D drawing is ”extrude”. To use this control, we have to generate the same as in previous case, just this control has a different approach than ”revolve” as we have to generate the entire 2D drawing, and then, to be able to obtain a 3D drawing, while for ”revolve” control only half of 2D drawing of the said part was enough. For a higher complexity part is necessary to create more 2D sketches and ”extrude” control be used so many times. Some more simple 2D sketches and 3D drawings are shown in figures 7,8 and 9.



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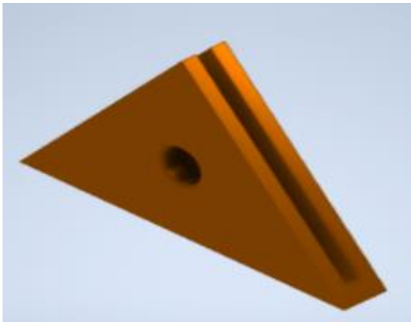

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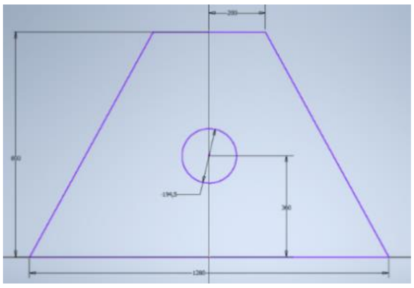
Figure 7 Tower anchoring device



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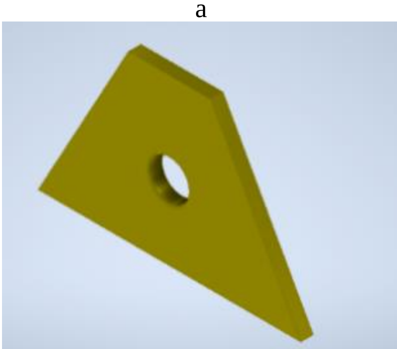

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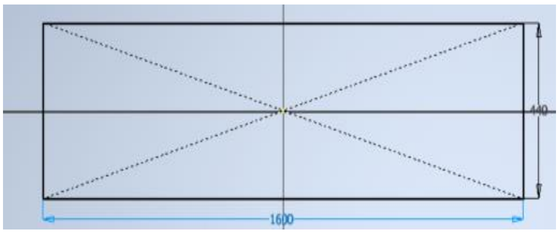
Figure 8 Tower fastening support



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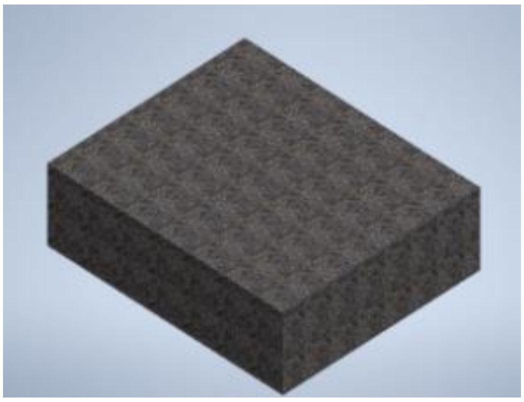

b

Figure 9 Tower crane counterweight

To realize the subassemblies in figures 2 and 3, I made at first their 2D sketch, then by using "insert frame" control in design menu I could insert different pipe shapes, these being shown in figure 10, for these to match on joints I used the "notch" control having the role to remove material from a member to match another one, this being shown in figure 11. Another matching control would be "miter", this control applies oblic cuts as end treatments between two elements of the frame, being shown in figure 12.

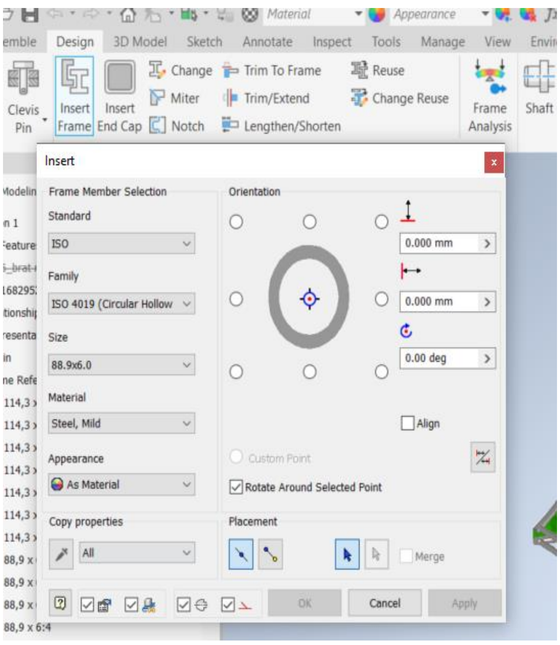

Figure 10 Notch control

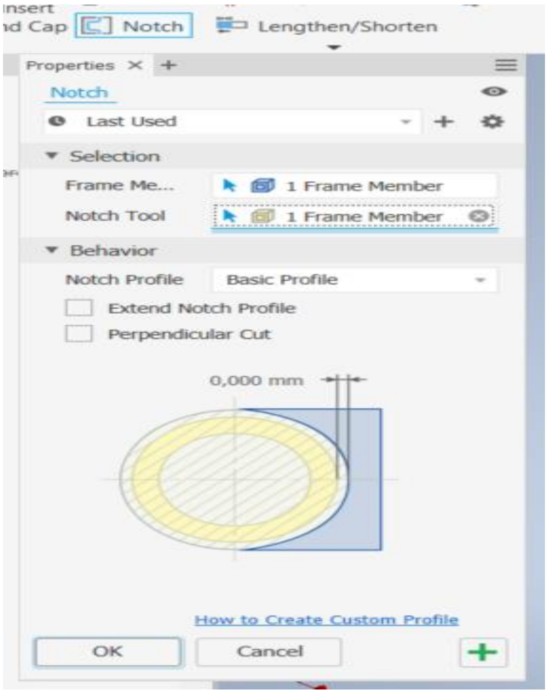

Figure 11 Insert frame control

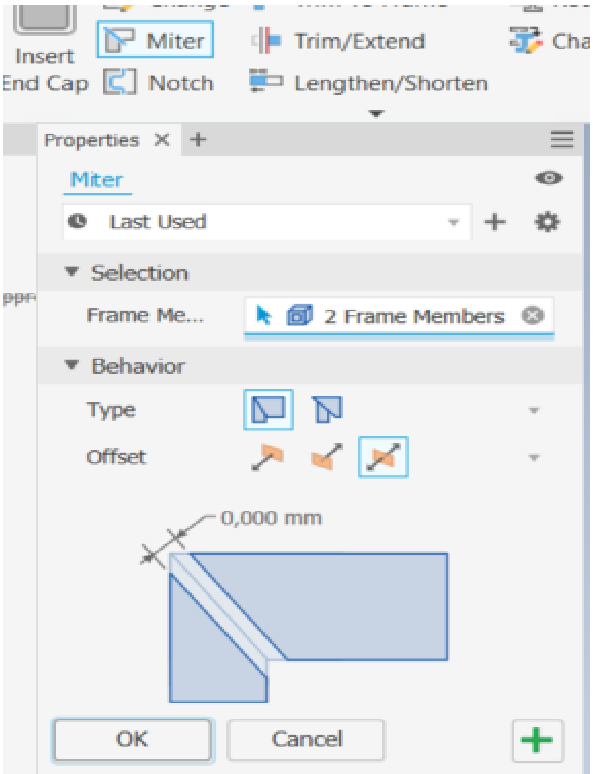

Figure 12 Miter control

Further to realising and assemblying all components, the tower crane with tilting boom assembly resulted, as shown in figure 13.

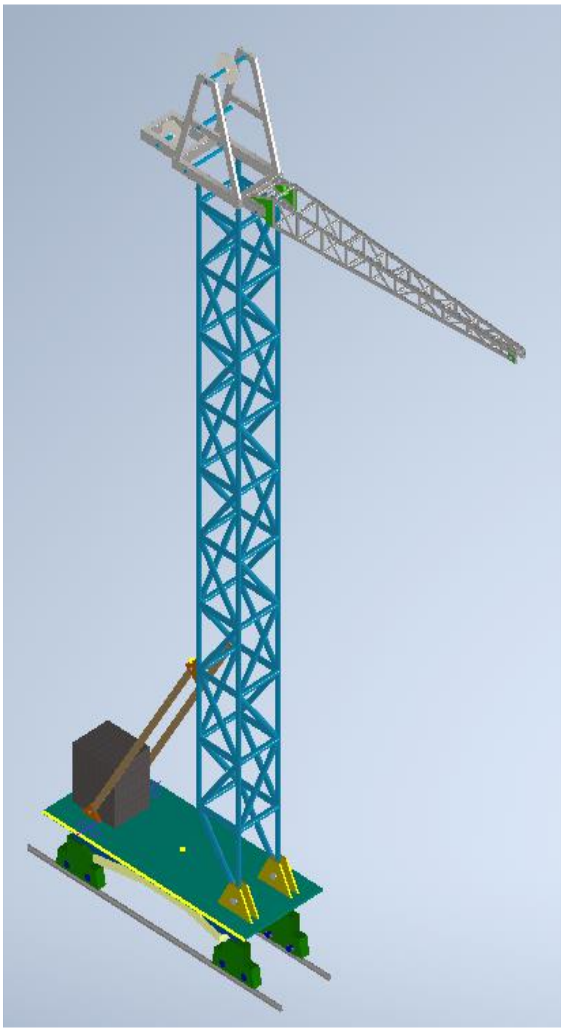

Figure 13 Tower crane with tilting boom assembly

4. CONCLUSIONS

Within this paperwork I achieved design of the tower crane with tilting boom assembly. For modelling the 3D assembly I used Inventor design soft, version 2020. I choose this design software as it gives more advantages such as: professional quality design, 3D modelling is easily achieved within a very short time. This soft provides integrity and compatibility between files of DWG format in 2D AutoCAD. 3D models provide functional design capacities, giving the designer the possibility

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