

## COMPUTER AIDED DESIGN OF CLAMPING MECHANISMS WITH ARTICULATED ARMS

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### ABSTRACT:

In article is presented a method for developing a library for clamping mechanisms with articulated arms. It is a method of high productivity, especially when the mechanisms are used so often because is no longer necessary to perform the design and modeling the mechanism every time when it has various dimensions.

### KEYWORDS:

Computer Aided Design, clamping mechanism, library

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### 1. INTRODUCTION

Clamping mechanisms using articulated arms are made up of articulated arms which, in certain reciprocal positions, guarantee an amplification of the driving force. This type of mechanism is frequently used, as there are manufactures providing for a wide range of such mechanisms, their main advantage being a very quick and efficient fastening, their rapidity being their main asset, which makes them useful in various situations, ranging from processing devices, control and welding devices to assembly devices.

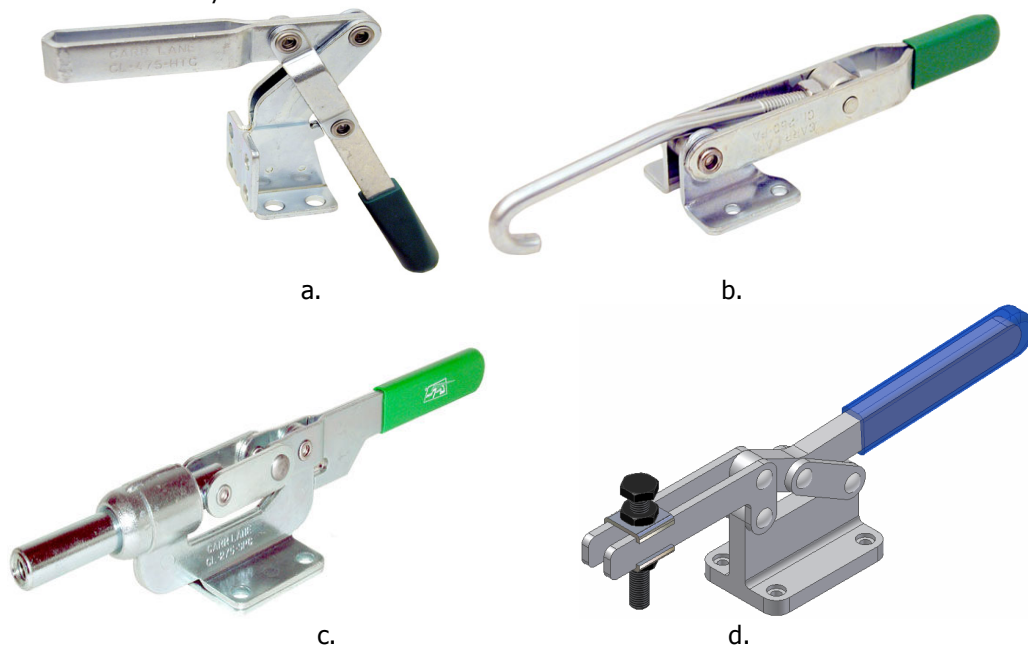


Figure 1. Constructive versions of clamping mechanisms with articulated arms

Some mechanisms are vertically operated, others are horizontally or obliquely operated, some are operated with the foot, others with the hand, whereas others with pneumatic motors.

In figure 1, there are some constructive types of fixing devices with articulated arms developed by specialized companies in device manufacture (GOOD HAND-USA, DE-STA-CO-USA, CARR LINE-USA, GANTER-Germany, AMFO-Germany).

The clamping force  $S$  is obtained by applying an operating force  $Q$  upon the articulations of the two arms 1 and 2 (figure 2), from which the first one is articulated by the body of the device, excluding frictions and is expressed as follows:

$$S = \frac{Q}{2\text{tg}\alpha}$$

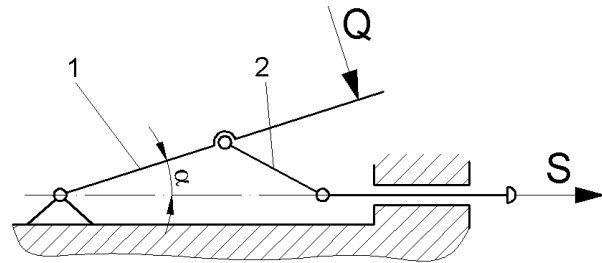


Figure 2. Diagram for determining the clamping force of articulated arms

Depending of an  $\alpha$  angle formed by the arms, the clamping force can be infinitely amplified, in theory, when  $\alpha = 0$ . In fact, due the elasticity of the component parts of the device, the force has a maximal value. Thus, for an angle  $\alpha = 10^\circ$ , there is a 57 time amplification of the force. Regularly, these mechanisms achieve nominal clamping forces within the range of 200... 700 daN.

In order to insure the preservation of clamping force, lever 1 and 2 shall drift beyond the horizontal, which diminishes the clamping force, but insures the vibrations stability of the mechanism.

As the total clamping stroke that can be insured by this type of mechanism is very limited, in order to enable the fastening of various-sized half-finished products, it is necessary to ensure the contact of the fixing lever with the half-finished product, by means of an adjustable element, which is usually executed in the shape of a screw.

Data basis represent useful tools for increasing the productivity, by creating and using families of pieces. Different types of families of pieces can be formed for instance: screws, balls, etc. Generally, their shape and dimension are presented in tables of standards and normative acts.

In order to develop data basis, we need the following soft packages:

- 🔧 Inventor, with this soft the clamping mechanism will be modified parametrical;
- 📊 Excel, with this soft the tables shall be carried out having the dimensional characteristics of constructive variations of the mechanism.

We will make use of the library terminology in order to designate piece collections drawing their dimensions from the tables of values.

## 2. COMPUTER – AIDED DESIGN ALGORITHM OF CLAMPING MECHANISM WITH ARTICULATED ARMS

The first step consists in parametric modeling in Inventor of each piece of the unit.

The piece is developed beginning with drawing a plan (draft) frame, on this basis of which a first 3 D characteristic will be generated. In the first stage, the constructive shape of the piece is of interest, the dimensions being in the second place as they can be modified at any time.

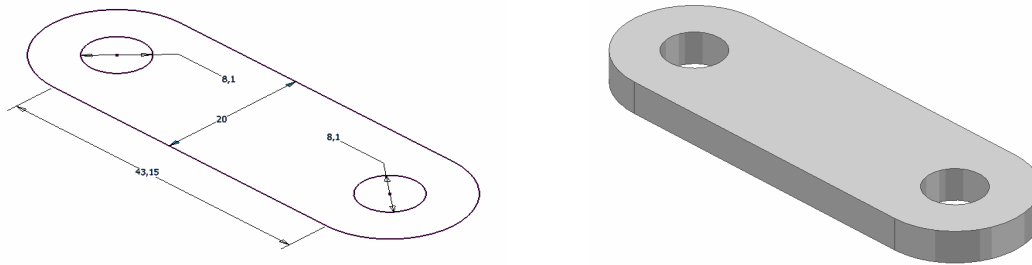


Figure 3. Outline of a unit piece and a shaped piece

After shaping all the pieces making up the mechanism, their assembly follows. The unit consists of 16 pieces, saved within the work project. In Inventor, a design enables some (local or network) folders to be defined, where the files related to the project will be saved.

When inserting a piece within a unit, Inventor does not forget the file where is taken from, so that the alteration of the initial document incurs the alteration of the piece within the unit.

The necessary pieces for the assembly of the mechanism are: the support, 2 intermediary arms, 2 straight arms, a sinuous arm, 4 rivets, a handle, a screw, 2 nuts and two washers.

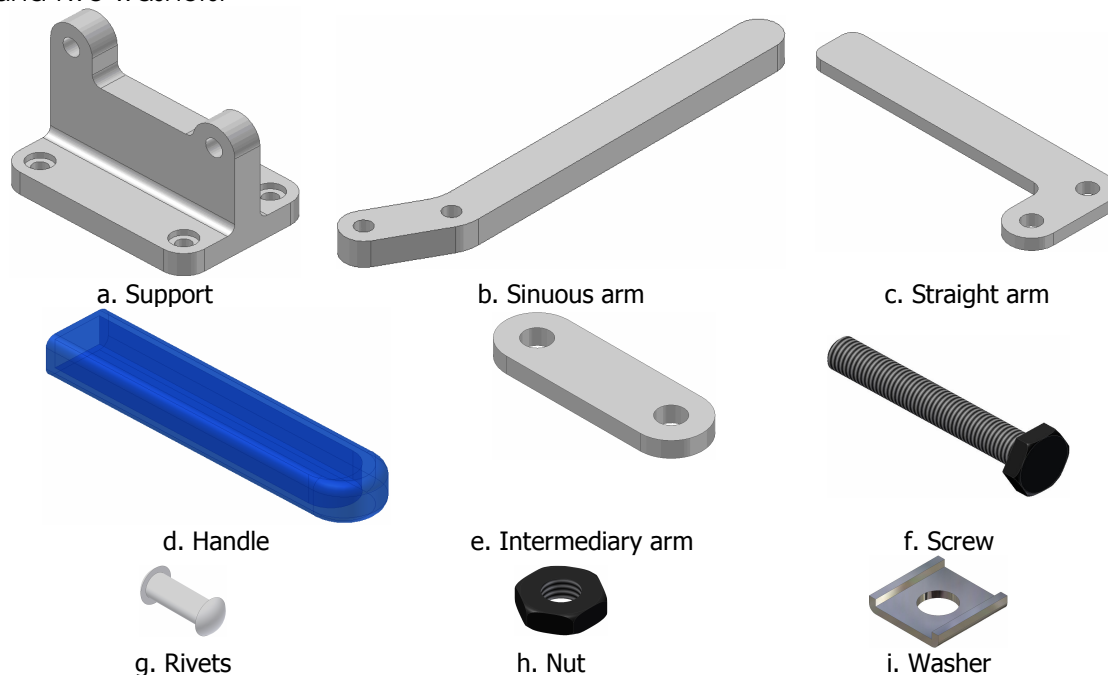


Figure 4. Pieces of the mechanism

The inserting is done the same for all pieces of the unit, following their positioning on the screen in order to be assembled. As sometimes the number of pieces in a unit can be large, the pieces are inserted and assembled separately.

Between the components, there are no links. What follows is the addition of 3 D constrains, the unit begins to take shape. During the assembly, the independence degrees are checked, which can be eliminated up to completely constraining the unit. 3 D constrains represent relative lining and positioning techniques of two pieces. Inventor has 4 types of constrains: mate (superposition), Angle (fixes a relative angle), tangential (tangential angle) and insert (inserts).

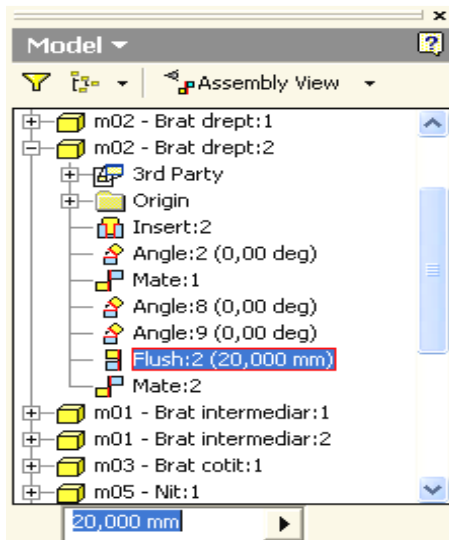


Figure 5. Autodesk Inventor's browser

Applied constraint is found in the Inventor browser as a branch. These can be edited or cancelled / deleted. Figure 5 presents the applied constraints for the piece in the file m02 - Straight Arm. Selecting one constraint determines the related value to be displayed, in bottom of the browser. The value displayed can be edited, and its effect can be seen immediately on the screen. The figure emphasizes the ability of modifying the distance from the end of the arm in order to optimize the position of the terminal screw on the arm.

In order to develop a library for all pieces within a unit it is necessary to create in an Excel file a table containing all dimensions of the pieces. This can be achieved by making a link between the case containing the assembly parameters and the sheet containing the Excel table. The table consists of a number of columns corresponding to the number of parameters from which a dimensional variant can be chosen for the unit.

Table 1. Parameters of the assembly

F <sub>a</sub> (daN)	a (mm)	b (mm)	c <sub>1</sub> (mm)	d <sub>n</sub> (mm)	e (mm)	g <sub>l</sub> (mm)	b <sub>1</sub> (mm)	b <sub>2</sub> (mm)	d <sub>su</sub> (mm)	x (mm)	e <sub>x</sub> (mm)	d <sub>p</sub> (mm)
200	13,63	17,05	27,01	3,2	10,27	8	2	4,7	4,5	18	4,22	3
300	20,86	26,1	41,36	4,9	15,43	12	3	7,2	7	27	6,47	4
400	27,68	34,63	54,87	6,5	20,86	16	4	9,6	9,5	36	8,58	5
500	34,49	43,15	68,37	8,1	26	20	5	12	11	45	10,69	6,5
600	41,3	51,67	81,88	9,7	31,16	24	6	14,4	14	54	12,8	8
700	48,16	60,2	95,38	11,3	36,27	28	7	16,7	16	63	14,91	9
800	55,35	69,25	109,73	13	41,73	32	8	19,3	19	72	17,16	10,5
900	62,17	77,78	123,23	14,6	46,86	36	9	21,6	21	81	19,27	12
1000	68,98	86,3	136,74	16,2	52	40	10	24	23	90	21,38	13,5

Table 2. Dimensions for a mechanism with pressing force of 500 daN

a	34,49	The distance between the holes of the sinuous arm
b	43,15	The distance between the holes of the intermediary arm
c <sub>1</sub>	68,37	The distance between the holes of the horizontal support
d <sub>n</sub>	8,1	Rivet diameter
e	26	The distance between the holes of the right arm
g <sub>l</sub>	20	Arms width
b <sub>1</sub>	5	Straight and intermediary arm thickness
b <sub>2</sub>	12	Sinuous arm thickness
d <sub>sur</sub>	11	Diameter of final screw
x	45	Height from base of the right arm
e <sub>x</sub>	10,69	The distance between the holes of the vertical support
d <sub>p</sub>	6,5	The diameter of holes for fixing the support

The number of lines equals the number of dimensional variations established for the assembly. Within the stage of shaping the assembly pieces, a link is made with Excel page, and these parameters are used in the stage of dimensional constraint of drafts and of editing the characteristics obtained following the application of shaping tools for the pieces making up the unit.

The soft identifies the parameters, and the unit obtained has the shape and the dimensions corresponding to the dimensional variation selected in Excel file.

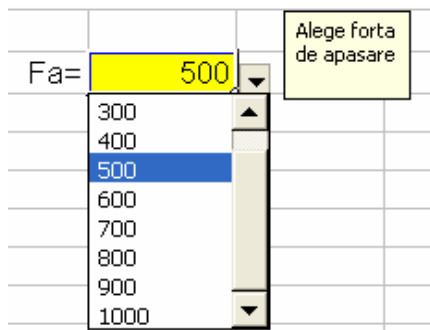


Figure 6. Case for data validation

Choosing the dimensional variations is facilitated by using the LOOK UP function in Excel (figure 6), which enables to choose a dimensional variation of the clamping mechanism from a rolling list where the values of nominal clamping forces are presented.

After developing the library, this can be used easily by any person, by a simple access of the Excel file and by modifying the clamping force depending on the required force for the desired mechanism.

### 3. CONCLUSIONS

Developing a library for any piece or mechanism is a method of high productivity, especially when they are used so often. This is because it is no longer necessary to perform the design and the shaping of a piece every time when it has various dimensions. Both the dimensions in Excel file and the pieces shaped by the Inventor can be modified at any time. The unit, when alterations are identified, shall adjust accordingly. Also, new lines of values can be added in case they have not been achieved by the initial library.

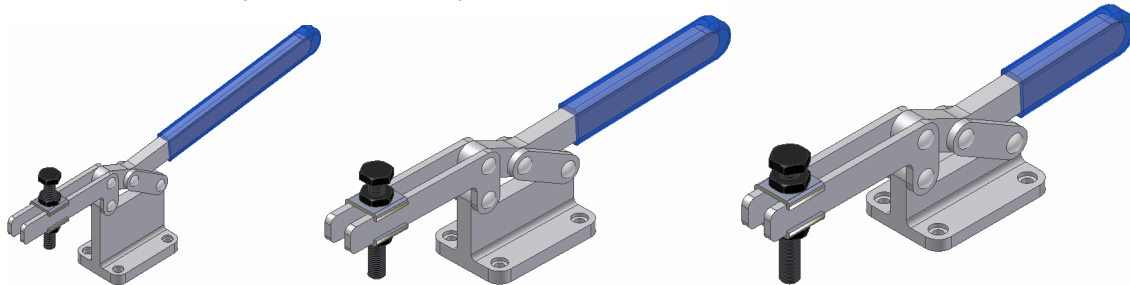


Figure 7. Clamping mechanisms with articulated arms developing clamping forces of 300, 500 and 800 daN

It can be successfully used by anyone because it takes the modification of only one value in order to choose another mechanism. In the same time, it does not need a large storage space as it develops only one unit.

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