German University in Cairo

Mechatronics Lab (MCTR704)

Bending a Metal Sheet

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Project Description

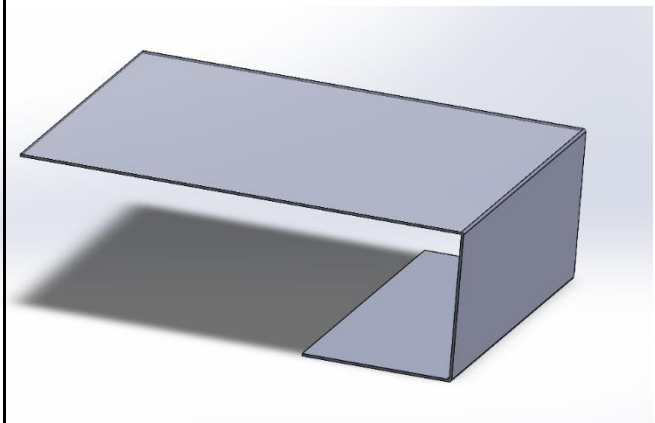
Pneumatic sheet metal bending machines are critical in many industries such as manufacturing, construction, and metalworking. They are a type of machine that harness pneumatic power to bend metal sheets. This project's objective is to create a model of this operation using pneumatic cylinders and classical control circuits. It is a goal to create a project which is similar to its industrial counterpart, thus it would be functional, safe, and cost efficient.

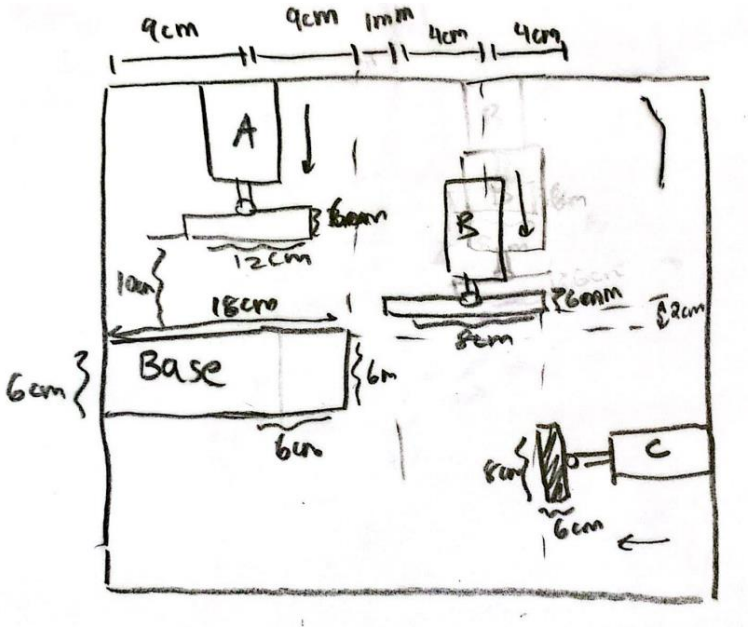
Our design of this metal bending machine consisted of three pneumatic cylinders; cylinder A is for clamping the metal sheet in position. cylinder B moves in a vertical motion to bend the metal sheet in the Y direction and cylinder C moves in a horizontal motion to bend the metal sheet in the X direction.

Before assigning any dimensions for the machine, the workpiece dimensions must first be determined. It will be a metallic sheet with dimensions (30 cm *15 cm * 1mm; length*width*thickness). According to the design, 18 cm of the length will be stabilized on the base of the machine while 6 cm will be bent in the y-direction and the other 6 cm in the x-direction. A picture of the fully bent workpiece is attached below.

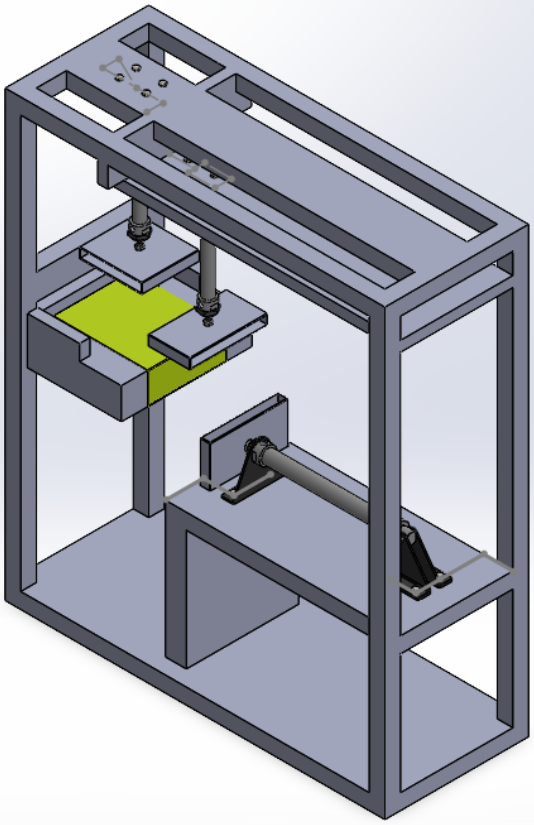
The operation of the machine will be as follows: cylinder A will first clamp the metal sheet, then cylinder B will bend it in the y-axis and then return, then cylinder C will bend it in the x-direction forming the fully bent sheet. After the workpiece is bent in both directions, cylinder A will unclamp the metal sheet and thus, it can be extracted from the machine.

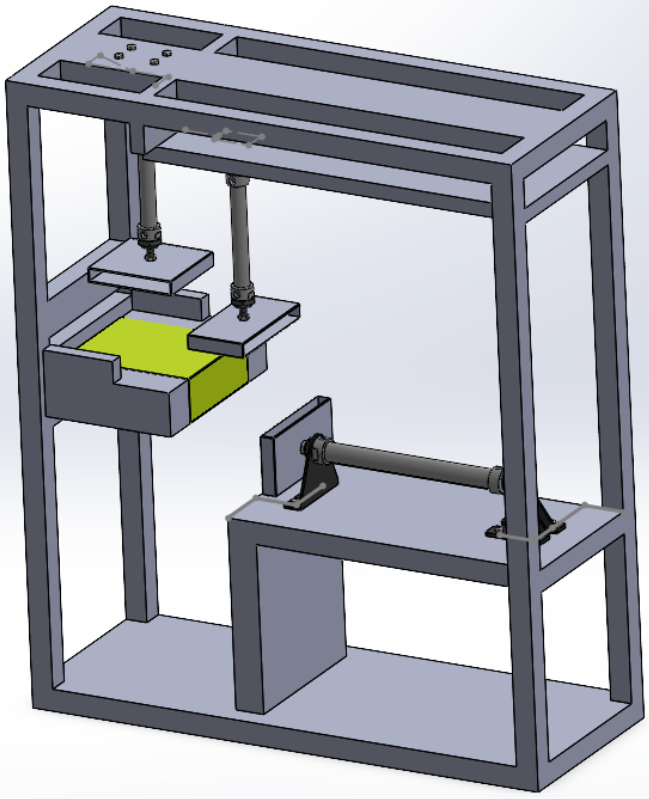
The stroke of cylinders A and B are 10 cm while the stroke of cylinder C is 20 cm. The base plates' length is 18 cm, its width 25 cm, and its thickness 6 cm. The length is chosen such that this 18 cm of the workpiece will rest on the base and will not be bent. The width is chosen as the workpiece's width is 15 cm and hence 25 cm will give the workpiece stability to be on. Finally, the thickness is 6 cm as the workpiece is supposed to be bent 6 cm in the y-axis. Additionally, each cylinder has an end effector to make sure the bending operation is completed correctly. They are designed such that the distance between the effector and base as it bends is equal to the thickness of the metal such that bending occurs. Furthermore, a spring back compensation is added to the base for 90-degree bends. Below is a rough 2D sketch to explain positioning and operation.

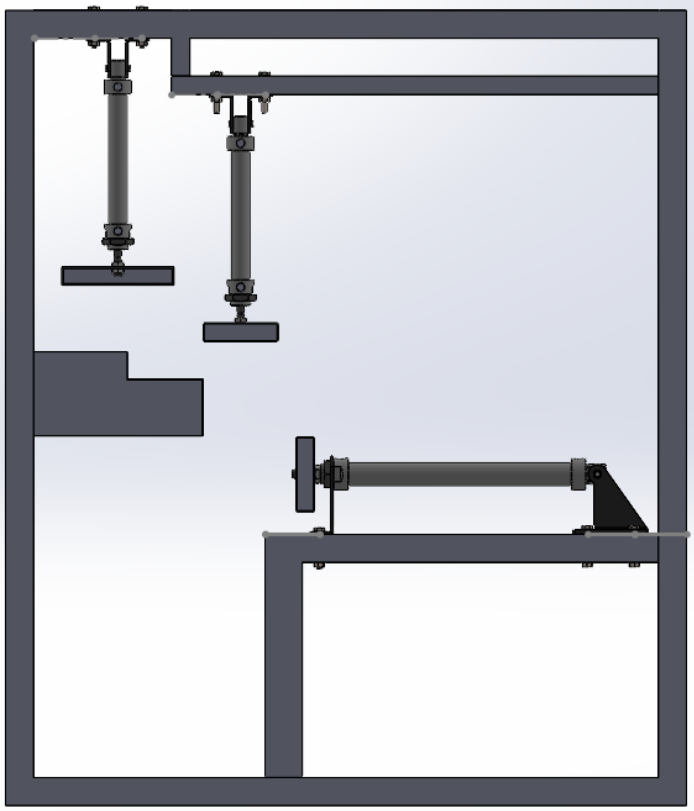


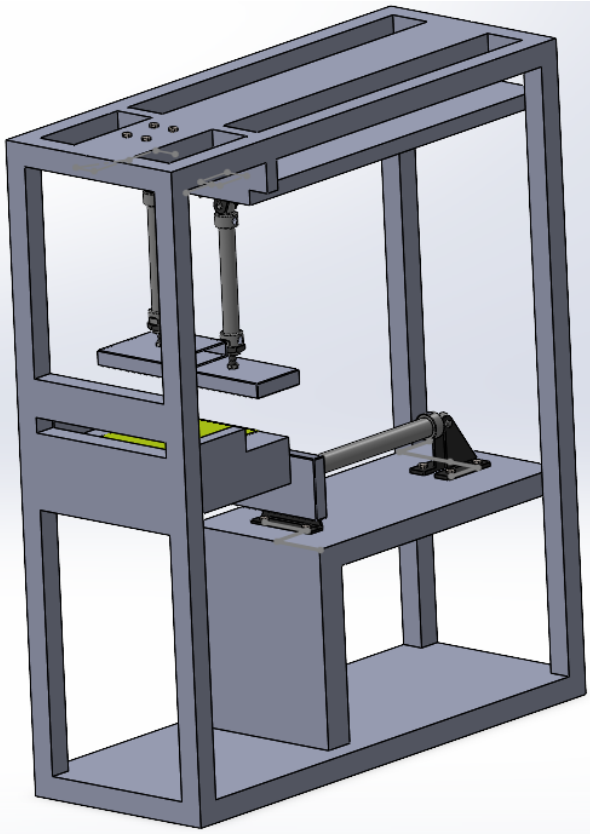


Solid works Design: 3D Schematic Diagram

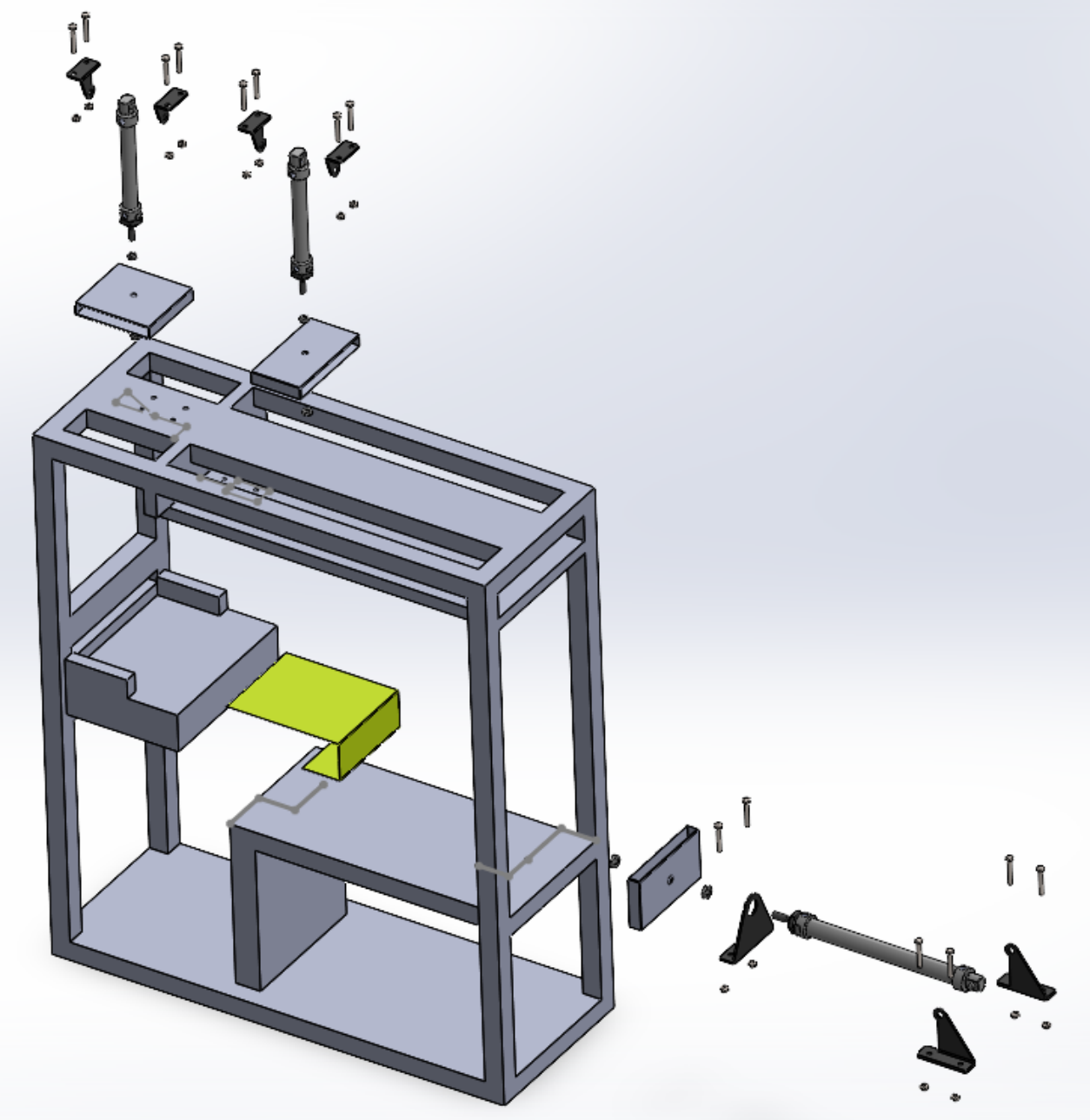


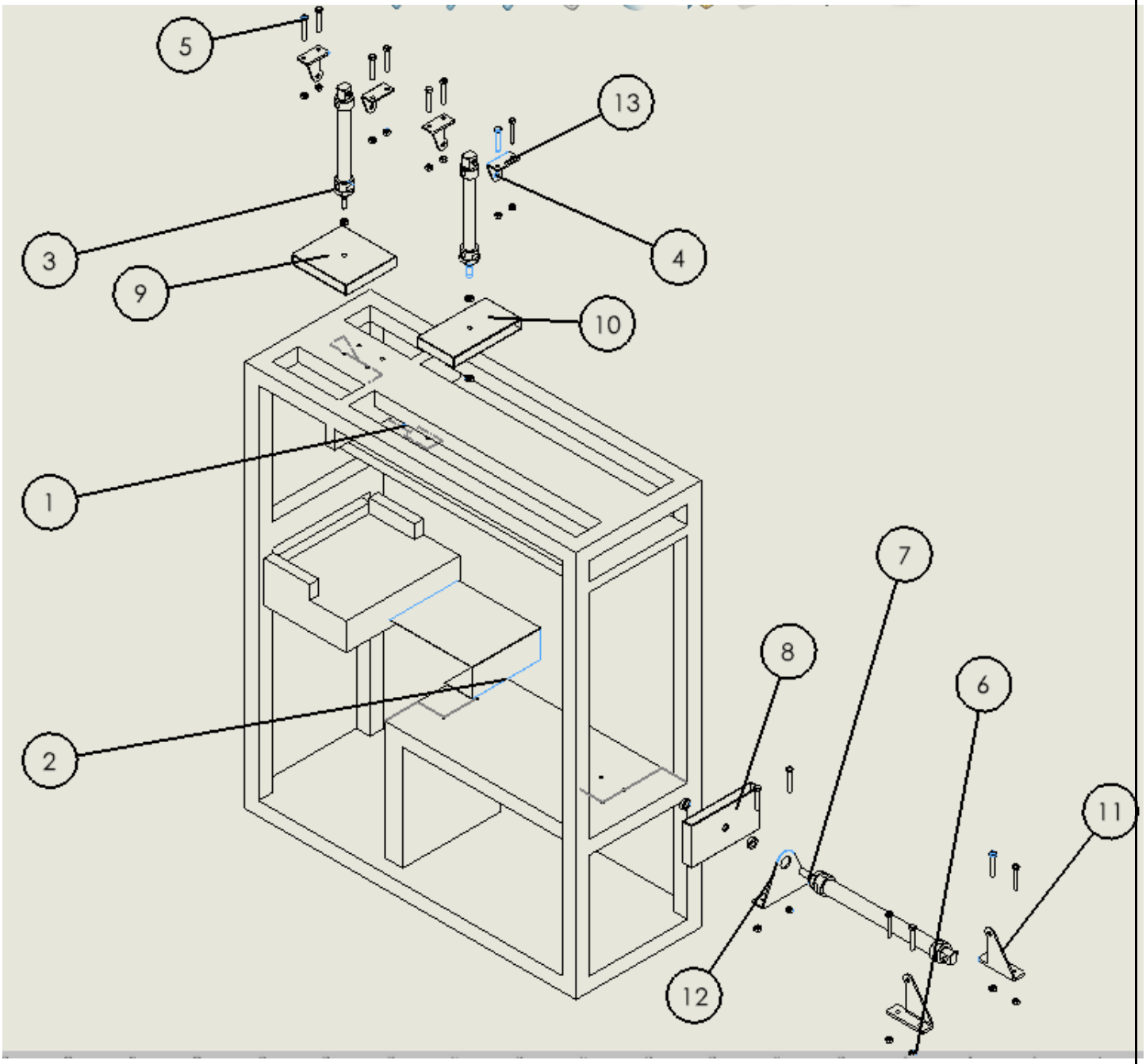






Exploded View




5
13
3
4
9
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1
7
8
6
11
2
12

Note: All dimensions below are in millimeter

Part Number	Name	Quantity
1	Frame (727 x 850 x 275)	1
2	Workpiece (30 x 15 x 0.5)	1
3	Cylinder A (20 x 100S)	1
4	Cylinder B (20 x 100S)	1
5	Cylinder C (25 x 200S)	1
6	B 18.2.3.2M – Formed hex screw, M6 x 1.0 x 40 – 18WN	14
7	B 18.2.4.1M – Hex nut, Style 1, M6 x 1– D-N	14
8	End Effector A	1
9	End Effector B	1
10	End Effector C	1
11	Rear Bracket C	2
12	Front Bracket C	1
13	Rear Bracket A & B	4

Project Components list and PDF Description

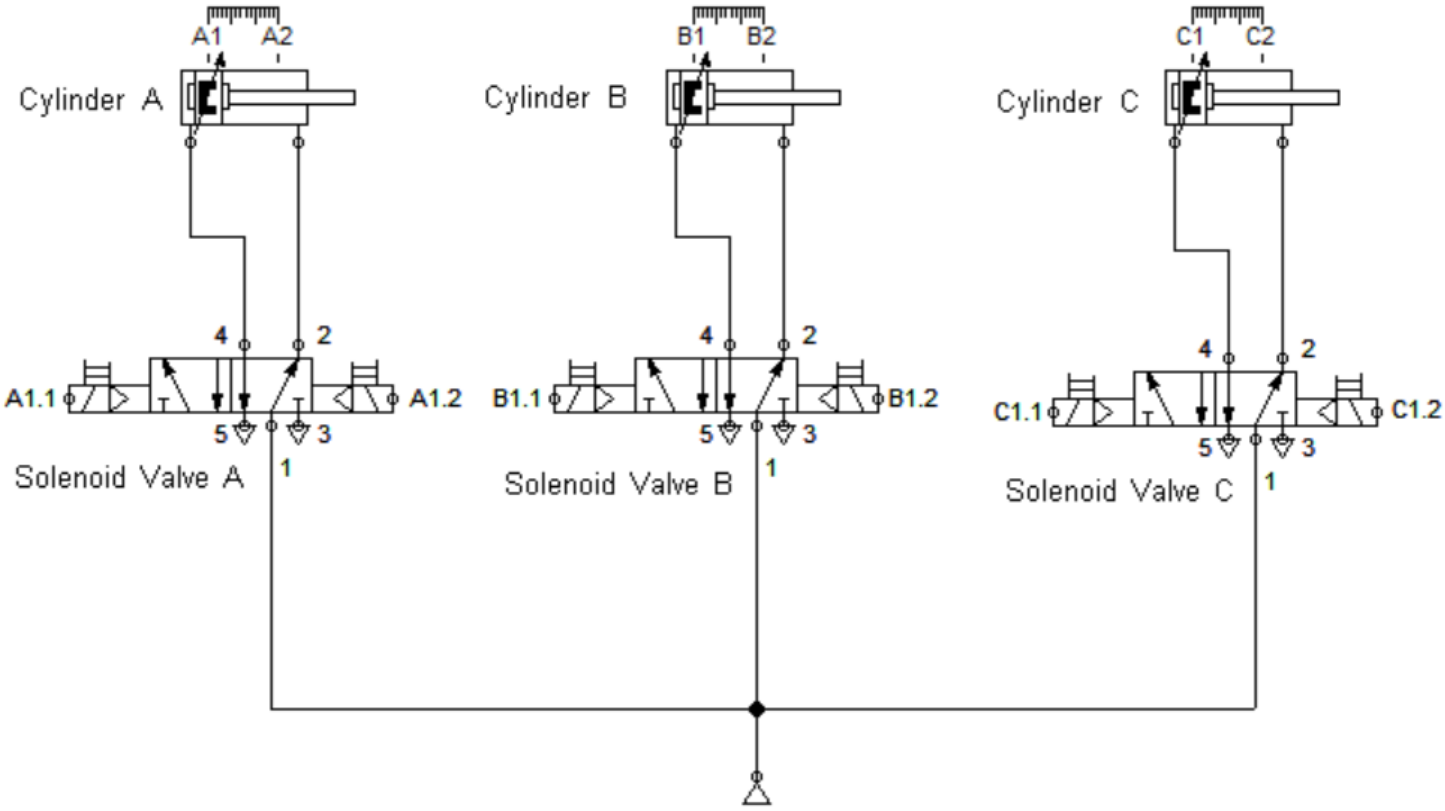
	Name	Description	Quantity	Photo
1	Wooden Frame	The frame structure of the machine (725 x 850 x275 mm)	1	Drawn above
2	Workpiece	The workpiece to bend (30*15*0.5 mm)	1	
3	Cylinder A, B	20x100S cylinder	2	
4	Cylinder C	25x200S cylinder	1	
5	End Effector A	End effector for cylinder A (80 *150 mm)	1	
6	End Effector B	End effector for cylinder B (110*120 mm)	1	
7	End Effector C	End effector for cylinder C (80*150 mm)	1	
8	Rear Bracket C	Fix cylinder C from rear	1	
9	Front Bracket C	Fix cylinder C from front	1	

10	Rear Bracket A&B	Fix cylinders A and B vertically	4	
11	B 18.2.3.2M – Formed hex screw, M6 x 1.0 x 40 – 18WN	Bolt to connect cylinders with Frane	14	
12	B 18.2.4.1M – Hex nut, Style 1, M6 x 1– D-N	Nut to connect cylinder to frame	14	
13	Reed switch	Magnetic sensor to detect cylinder's position	6	
14	Solenoid Valve	Electrical signals to control pneumatic cylinders	3	
15	Push buttons	Start and Stop push buttons	2	
16	Relays	Base 24V DC , 4 connectors	10	

17	PVC Hose	8mm hose	10 mt	
18	Pipeline fixations	Connectors for pneumatic circuit	10	
19	Power Supply	220 V AC/ 24 V DC	1	
20	Tie rap	10cm	1 pack	
21	Electrical panel conduits	20 x 20 mm	1 mt	
22	LED indicator	Green	1	
23	Wire terminals	3mm	2 packs	

Pneumatic Circuit

Note: A1, A2, B1, B2, C1, C2 are the reed switches to be attached to the cylinders

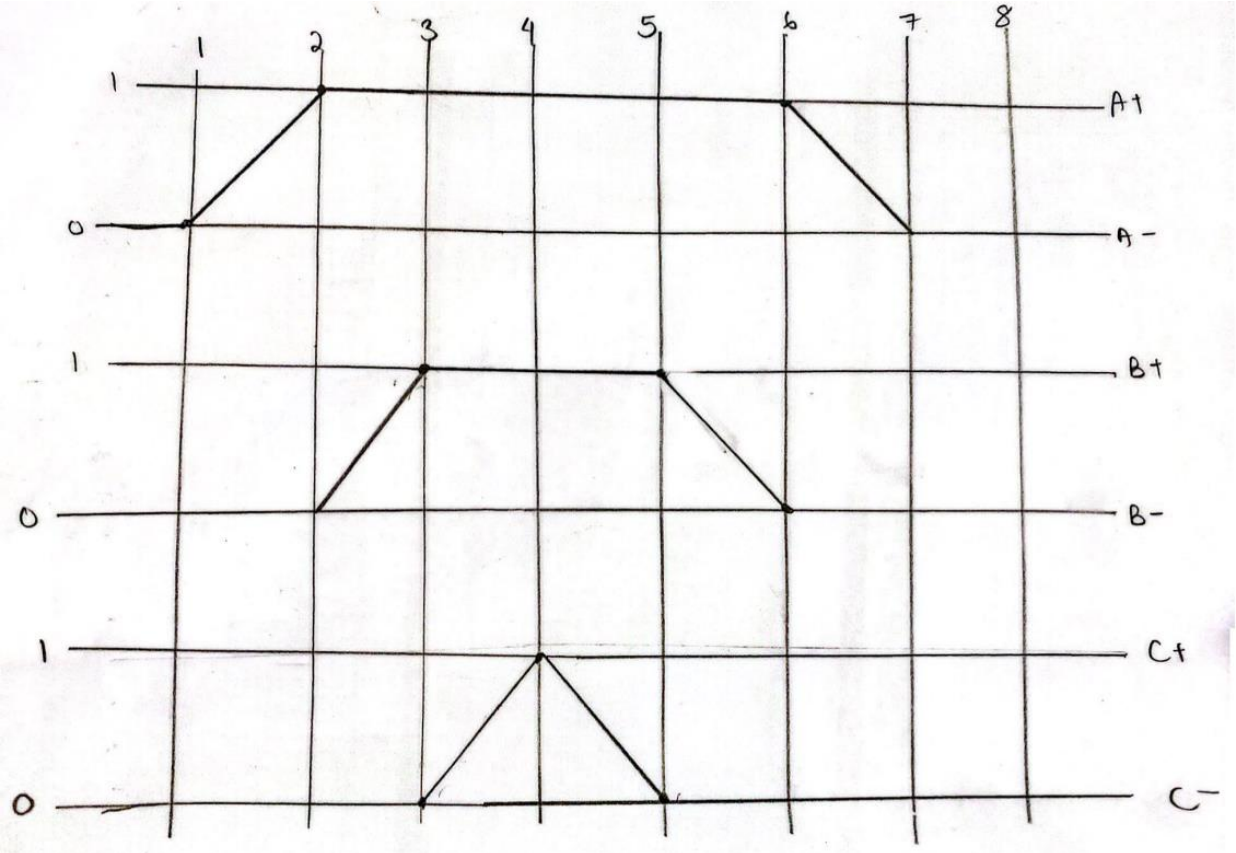


Pneumatic Step Diagram and Description

Regarding this project, there are three cylinders which are cylinder A, cylinder B, and cylinder C. Cylinder A is responsible for clamping the metal workpiece while cylinder B bends the workpiece in the Y-direction. Finally, cylinder C bends the workpiece in the X-direction.

The proposed sequence of operation is described as follows. First, cylinder A extends to clamp the metal workpiece. Then, cylinder B extends to bend the workpiece in the Y-direction. After that, cylinder C extends to bend the workpiece in the X-direction. It is important to note that cylinder C extends while cylinder B is extended and this is incorporated in the mechanical design to reduce spring back effect of the metal which is due to its elasticity. After the three cylinders are extended, cylinder C retracts then cylinder B retracts and finally cylinder A retracts. After cylinder A retracts, the workpiece is unclamped and may be removed by the operator.

Hence, the sequence is: A+ B+ C+ C- B- A-



Hardware Model (Electrical + Mechanical)

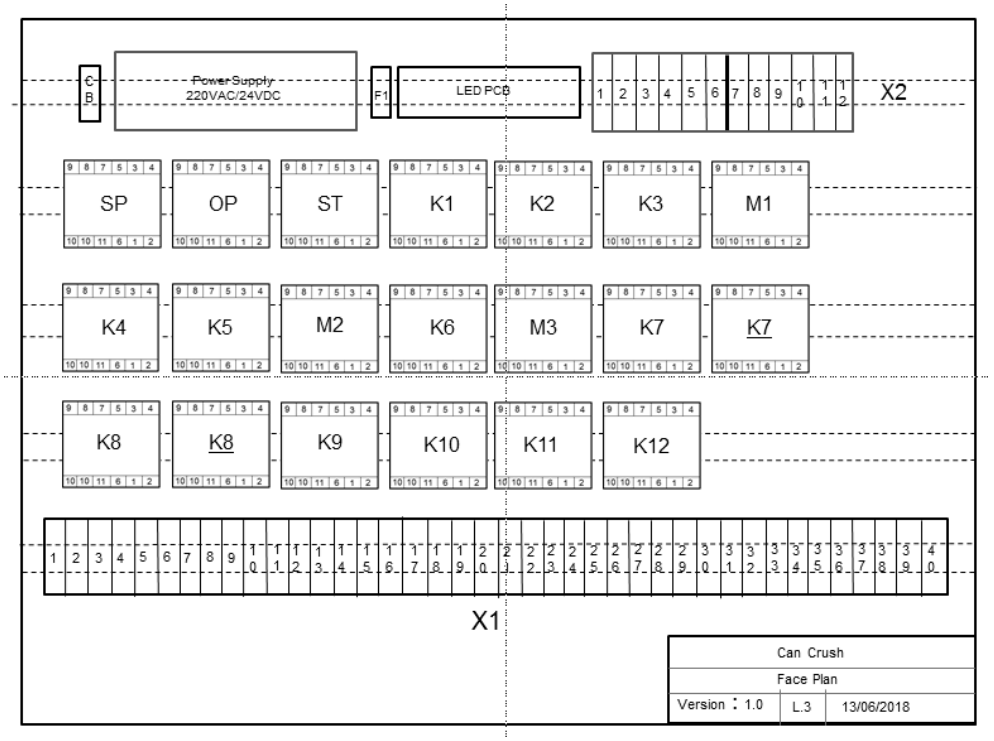
Including

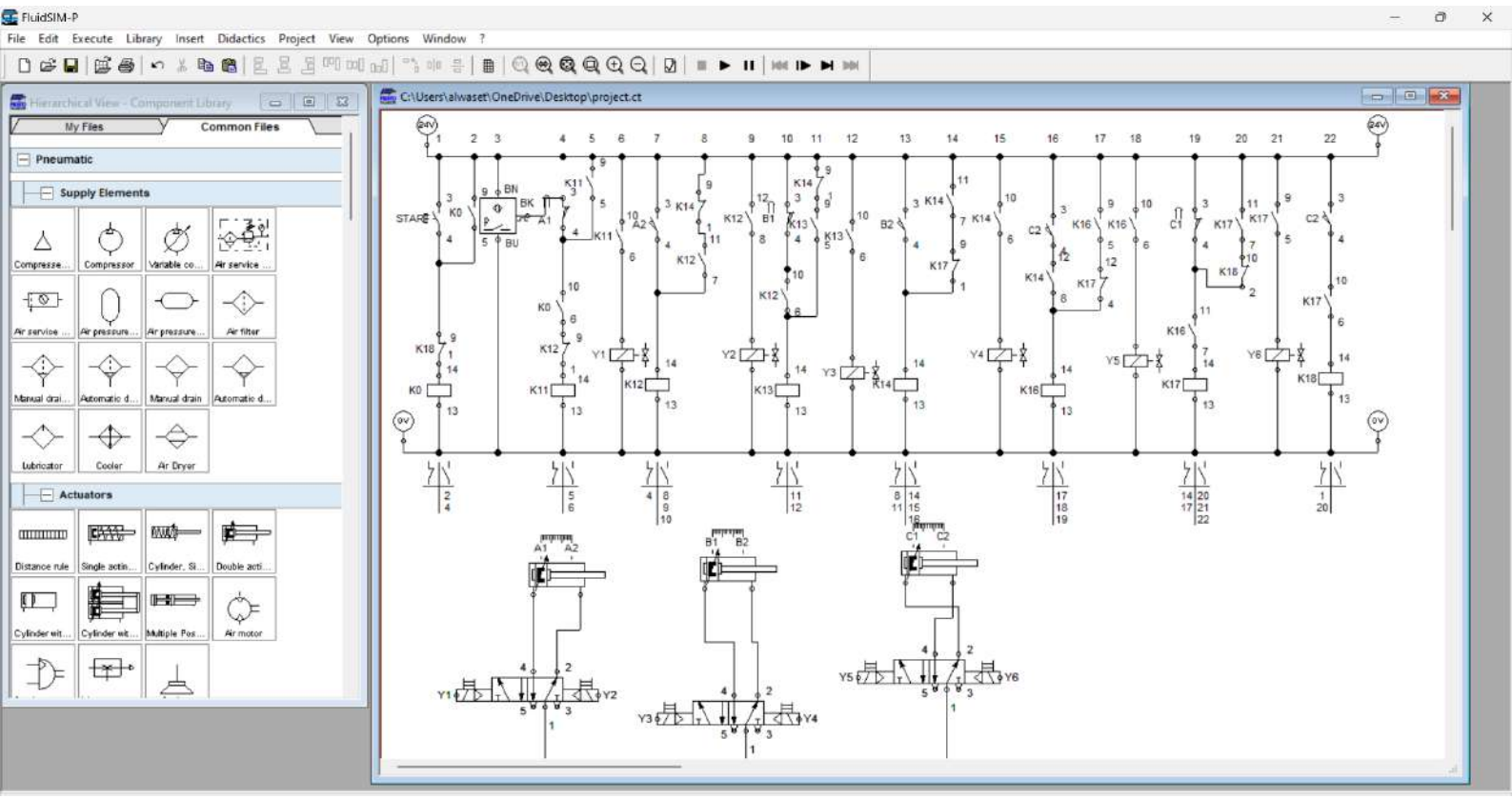
Controller Operating Panel/ Classic Control Implementation

Part A: Electrical
Step 1: Prepare the list of materials.
Step 2: Implement the classic control circuit on FluidSim.
Step 2: Implement the classic control hardware as face plane with labels; as you already have the information for each component (power supply, solenoids, relays, I/O terminals…), you can configure the size of the panel you need for your project.

Part B: Mechanical
Step 1: prepare the list of materials
Step 2: assembly all components on the the project frame structure including the electrical panel.

Shown below: an example for a panel face plane configuration

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A1 A2
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24V
0V