DESIGN OF AN AUTOMATIC MACHINE TO PRODUCE SOAP

Functional Mechanical Design A.Y. 2018/2019

The automatic machine depicted in Fig. 1 has been designed to produce soap with a production rate of 7200 pieces/h (that is 1800 cycles/h). The machine is made of 4 main functional groups:

1. Press subsystem
2. Upload of raw material subsystem
3. Turning pad subsystem
4. Discharge of products subsystem

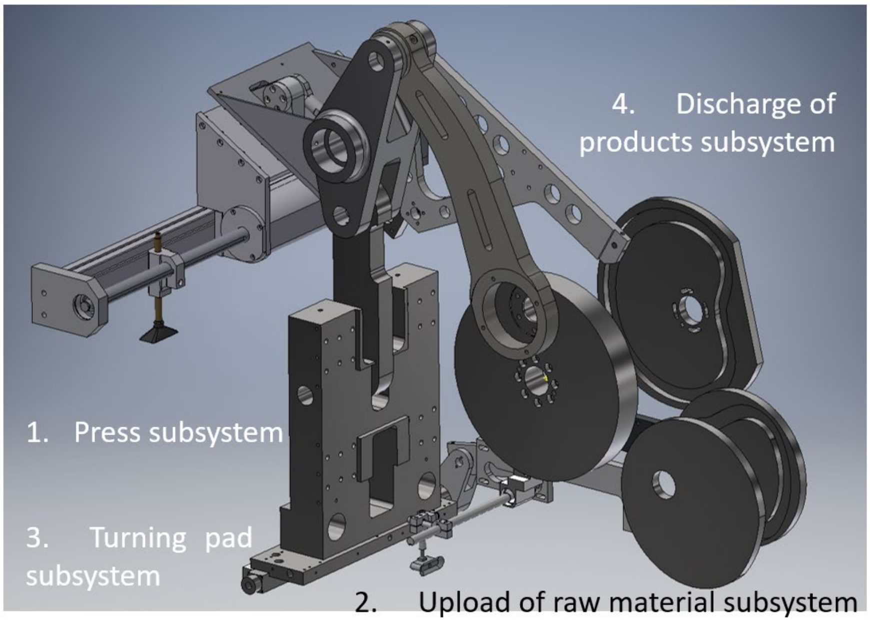
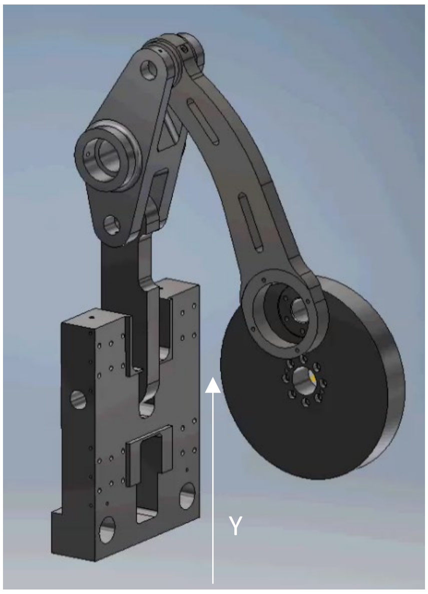


Fig.1 – The automatic machine and its functional groups

The Press



This subsystem has the purpose of applying a high force on rough pieces of soap in order to deform them and make them assume the desired shape. To obtain a high force, a hitting mass of 20 kg is used (other links have a negligible inertia). The mass is moved through a slider crank mechanism in series with a four-bar linkage.

For the description of the work cycle, let's consider a vertical axis with the origin corresponding to the product. Compared to the master angle, the mass has the following requirements in terms of displacement:

α=0; y=300mm

α=170°; y=0mm

α=180°; y=5mm

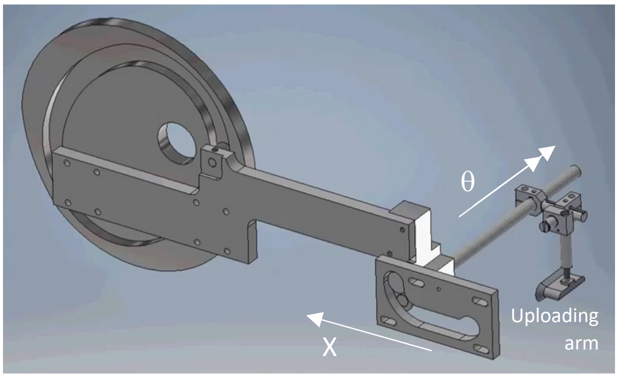
α=190°; y=0mm

α=360; y=300mm

Considering that the driving element moves with a constant angular speed, it is necessary to:

1. Design the motion law of the moving mass in order to maximize the force exerted on the raw soap;
2. Synthesize the linkage mechanism (slider crank & four-bar linkage) or, alternately, the slider crank mechanism moved by a cam
3. Analyse the mechanism through kinematic parameters (transmission/pressure angles) and compute the motion law obtained with the designed mechanism
4. Calculate forces transmitted and the motor torque with a multibody model.
5. Critically evaluate the feasibility of the system

The uploading subsystem



This subsystem is design to obtain a complex motion of the uploading element that can be divided into a linear displacement along a horizontal axis (x) and a rotation around the orthogonal axis (θ). The slider has a mass m_1=4.5 kg and the moving arm is characterized by a mass m_2=1.2 kg and a momentum of inertia (with respect to the axis of rotation) J=0.5kgm^2.

According to the described displacements, the motion law of the arm can be described as follows:

α = 0°	X = 0 mm	θ = 0°
α = 100°	X = 160 mm	θ = 0°
α = 130°	X = 180 mm	θ = 90°
α = 170°	X = 180 mm	θ = 90°
α = 200°	X = 160 mm	θ = 0°
α = 360°	X = 0 mm	θ = 0°

Considering that the driving element moves with a constant angular speed, it is necessary to:

1. Design the motion law of the moving arm along the two directions;
2. Synthesize the two cam mechanisms
3. Analyse the mechanism through kinematic parameters (pressure angles and undercut) and compute the motion law obtained with the designed mechanism
4. Calculate forces transmitted and the motor torque with a multibody model.
5. Critically evaluate the feasibility of the system

Turning pad subsystem

The subsystem has the purpose of discharging the soap once the product has been definitively made. The tilting pad motion is a pure rotation and takes place around a fixed axis. The movement is realized through a slider crank mechanism in which the slider is moved by a translating cam.
The slider has a mass of 2.3 kg and the tilting pad is characterized by a momentum of inertia (with respect to the axis of rotation) J=1.1 kgm^2.
The motion law of the tilting pad is:

α = 0°	θ = 45°
α = 70°	θ = 0°

$\alpha = 200°$	$\theta = 0°$
$\alpha = 360°$	$\theta = 45°$

Considering that the driving element moves with a constant angular speed, it is necessary to:

1. Design the motion law of the tilting pad
2. Synthesize the slider crank mechanism and the cam mechanisms with a translating follower
3. Analyse the mechanism through kinematic parameters (transmission angle, pressure angle and undercut) and compute the motion law obtained with the designed mechanism
4. Calculate forces transmitted and the motor torque with a multibody model.
5. Critically evaluate the feasibility of the system