Engineering Model

PRESENTATION

In order to produce an antivenom solution accessible to all, it is necessary to create the ideal incubation conditions of the bacterial solution. The process takes place on three major stages which are:

- Proliferation and culture of bacteria in the bioreactor
- The sonication of bacterial solution to lyse the cells.
- Decantation of the solution by the centrifuge
- Purification by columns (phases)

Each of these steps requires different mechanical and electronic components that allow the sequence of processing protocols automatically. The control and maintenance of the conditions (temperature, pH) of the solution ensure a smooth functioning of the machine.
These stages and their transitions are possible thanks to the valves, pumps and sensors that will be controlled by a microcontroller.

EQUIPMENT

The goal of the project is to make our 'Biomaker factory' accessible to anyone, so it will be completely autonomous. For this we used different mechanical and electronic components to automate every task.

1. The microcontroller

Because of its large community and its notorious effectiveness, we chose the arduino card. This easy-to-use microcontroller can be programmed to analyze and produce electrical signals that can be used in different areas such as home automation, robotics, industry... Thanks to this we can automate all the tasks that are performed in different steps of the treatment of our "solution". Via its multiplatform development interface we can easily order all the motors and servomotors present in our factory. Thus scheduling the tasks and linking them one after the other without human intervention will allow a simple and ergonomic use.

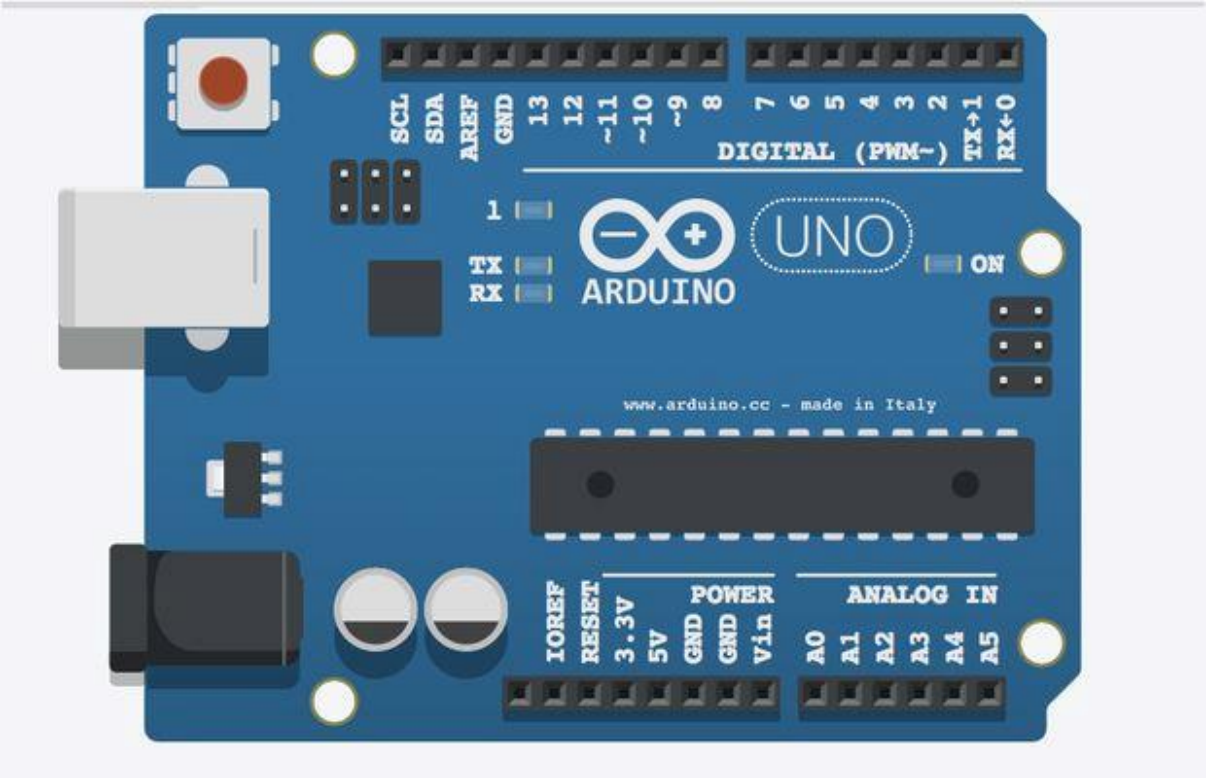
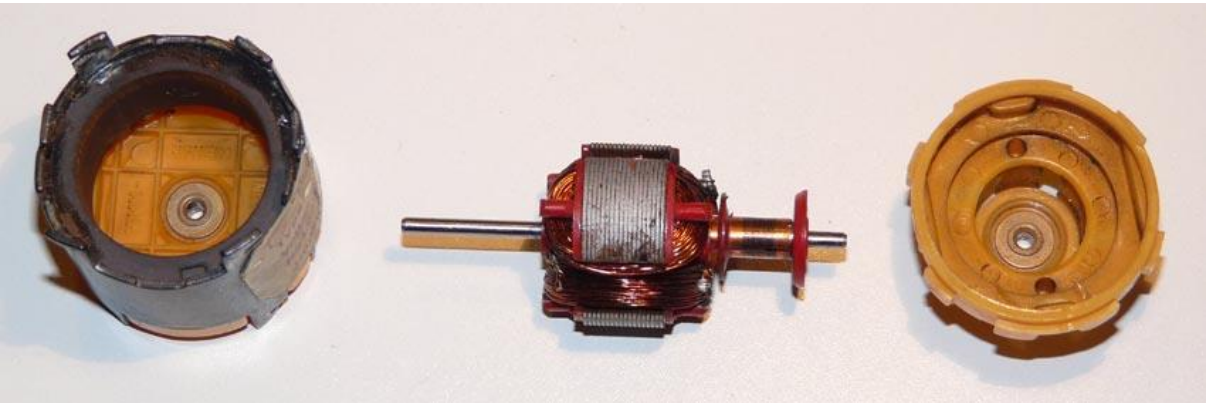


Fig 1: Arduino microcontroller

2. Motor and Pumps

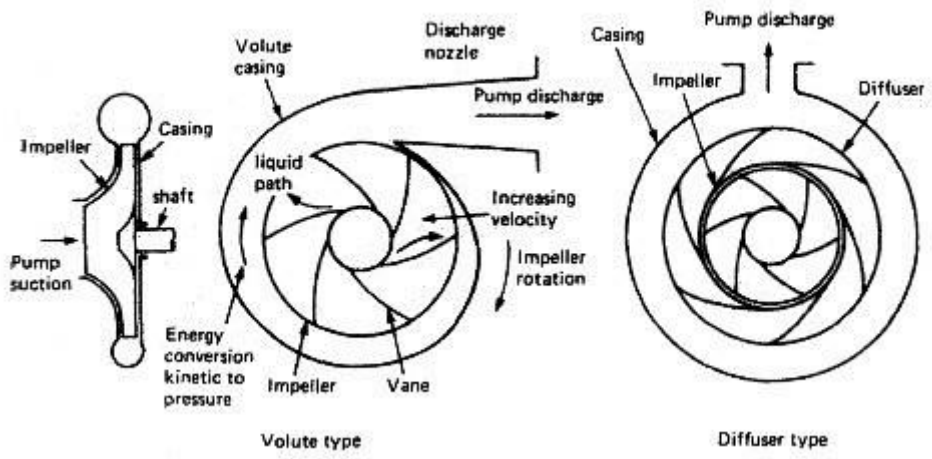
For the centrifuge as well as the pumps, electric motors are essential. These components work in the same way but have different powers. They consist in a DC motor, rotating thanks to magnets fixed on the block and a winding on the axis of rotation. The magnets and their support constitute the stator and the axis and coil assembly represents the rotor.



3. Pump

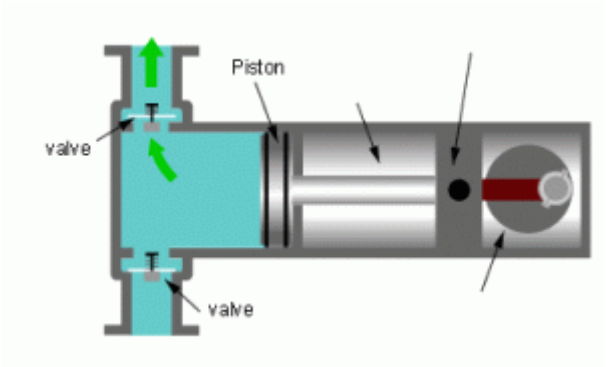
We will use 2 pump technologies:

- One operating by centrifugation



The operation of this pump is based on the same principle as the centrifuge. Indeed, it is used to move a certain amount of fluid at high rotational speed, and thus exert a pressure at the exit of the pump. In addition, the shape of the outlet improves the displacement of the fluid in question. The flow rate of fluid produced by this pump can be considered as continuous.

- Pump running through check valves



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In the same way as the illustration, the one that we will use acts by aspiration, then discharge of the fluid.

Thus, it is distinguished from the first pump by its ability to create a much larger vacuum during its suction phase. Moreover, because of the periodicity of the discharge phase, the flow is jerky.

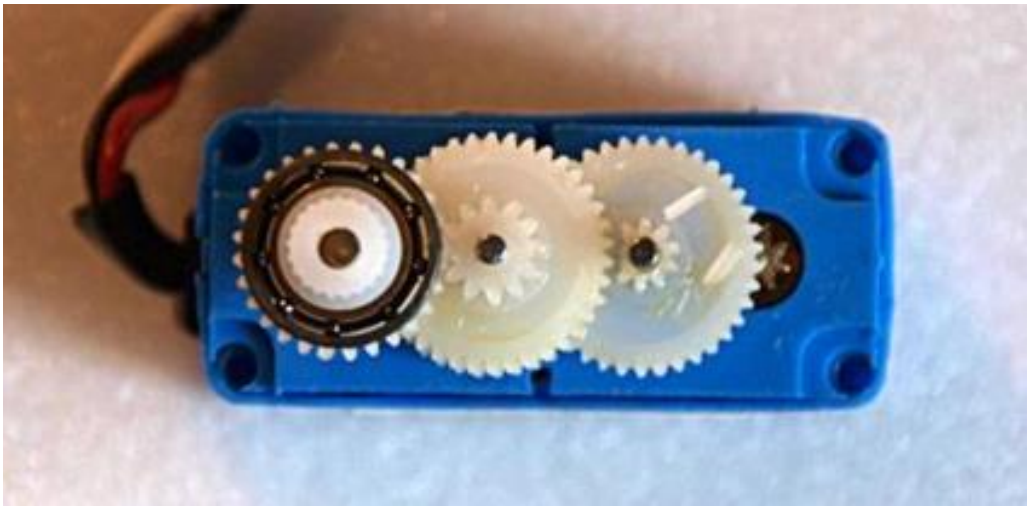
4. Servomotor / Valves

Since the valves make it possible to choose the direction of circulation of the different solutions, it is necessary to have an accurate and robust actuator. The actuator meeting this need, and can be controlled by a microcontroller is the servomotor. It is a system consisting of gear reduction stages and a DC micro electric motor.

Its particularity is that it is equipped with a regulator that fixes the last gear on a position. To do this, different elements are necessary:

- A potentiometer: returns the position of the output shaft

- DC motor: performs rotation in both directions
- A PWM signal: transmits the desired position between 0° and 180°
- A regulator: defines the direction of rotation, the duration and the amplitude of rotation of the motor to arrive at the good position.



5. Sensors

Sevral sensors are set up to control the temperature or monitor the pH. The temperature control is carried out automatically. Depending on the sensor feedback, different actions are performed automatically such as heating the solution in one case, or cooling it in the other. The cooling is carried out by pumping an ice-cold solution into the refrigerator located in the compartment below and heating with the aid of a heating resistor glued to the container. The pH will have to be stabilized by a biologist and the sensor will be present for information.

Design

Bioreactor

This step is a main step, on which all the following depend. It must strictly respect the culture conditions of the bacteria. The elements to be regulated are the following:

- Temperature at 37°C
- Continuous agitation during the mixing phase
- Permanent ventilation

Temperature

Considering that the machine will be subjected to external conditions peculiar to the tropical regions, therefore between 20°C and 40°C, the assembly must be able to be cooled or reheated according to the outside temperature.

For heating, 2 resistors of 180W or 360W are placed in direct contact with the surface of the container. If the exchange is perfect, and the specific heat capacity of the water is known to be about 4.18 kJ/kg/K between 17°C and 40°C. These data make it possible to estimate the time required to heat 5 liters of water.

Determination of the time required to raise 5l by one degree.

$$Q = m.cv.\Delta T$$

or P = Q / t1

t1 = Q / P

t1 = 5 *4,18.10^3/360

t1 = 58s

To cool the solution, a pump will circulate water at 5°C in a pipe around the bio reactor. Since the fridge is running with a power of 180W,
t2 = t1 * 2? → t2 = 1 min and t2 = 56s to lower the 5 liters by one degree.

Sonicator

The sonicator is a device that emits a sound wave whose frequency is between 20 kHz and 40 kHz. Its function here is to destroy bacteria without damaging proteins. This is made possible by emitting a wave which corresponds exactly to the natural frequency of the bacteria, in order to generate a resonance.

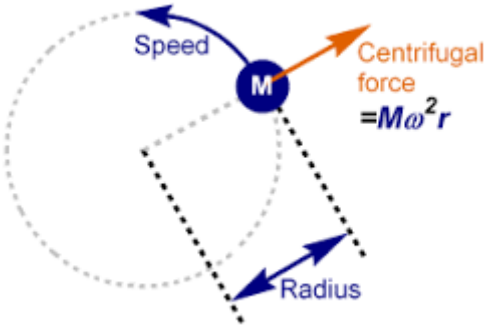
Centrifuge

Leaving a heterogeneous solution (2 different natures, for example) in a container for a relatively long time makes it possible to clearly separate the two solutions by gravity. This is necessary in our part; however the process needs to be speeded up. For that, we will use the centrifugal force which makes it possible to exert an effort like gravity, but with a much greater intensity. This force is calculated as follows:

$$F = MRW^2$$

W: rotational speed in radian / second

R: distance between the axis of rotation and the center of inertia of the solution



This formula shows that multiplying by 2 the radius of rotation, multiplies by 2 the centrifugal force, and multiplies by 2 the speed of rotation, multiplies by 4 the centrifugal force. Thus, we make the choice to set up a pump to reach 20000RPM is 2093rad/s. Knowing that the centrifuged solution is about 500ml and mainly consists of water, then about 0.5kg. One finding the container that the center of gravity position of the solution is about 3cm or 3E-2m, then F = 65797N

Columns

Abdou -> Make a circuit io
Kevin -> Make a 3d model

Add a 3D schematic of the Kevin Columns
Add an electronic schematic of the Abdou columns