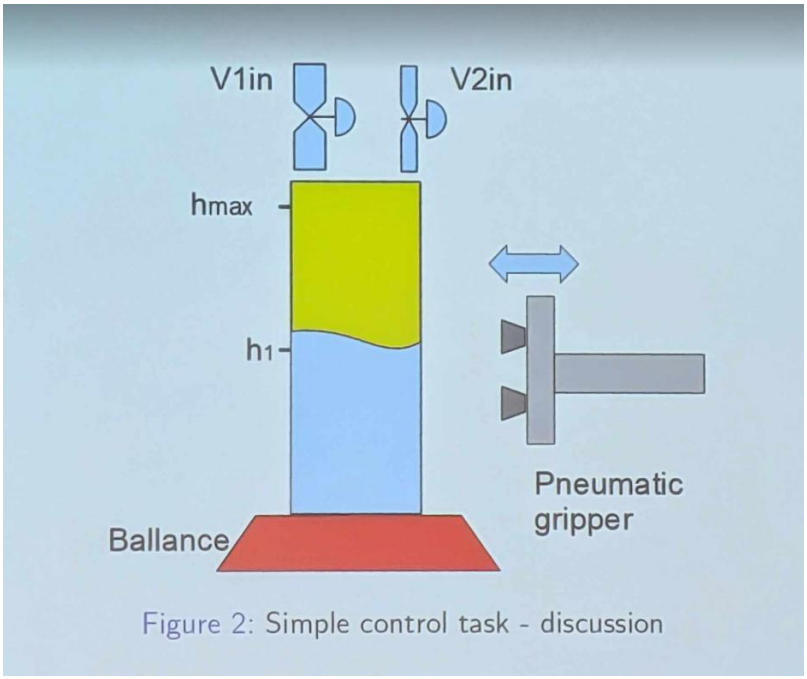
# Problem of filling and transporting a tank with fluids inside

## Introduction

The purpose of the exercise is to present the problems that occur while filling a tank with 2 different liquids and transporting this tank to a specific location. A diagram of the process can be seen below (Img.1).




Img.1 Diagram of the process

Two valves control the flow of liquids. It can be noted that pipes that provide fluids have different diameters. There are two sensors that measure the level of liquids after mixing. Then robotic arm must transport the tank from point A to point B.

## Valves

In this process different types of valves can be used, such as: electrical pneumatic or mechanical. Each of these types has advantages and disadvantages (Table 1).

Table 1 Comparison of valves

| Type | Pros | Cons | Is it suitable for the process? |
|---|---|---|---|
| Solenoid valve | Fast switching, easy control | May require a filter, operates in ON/OFF mode | Yes, if a simple control system is sufficient |
| Proportional | Allows precise flow regulation | Requires a more complex controller | Yes, if precise liquid flow is needed |

| | | | |
|---|---|---|---|
| Electric ball | Durable, resistant to contamination | Slower switching than solenoid | Yes, if high switching speed is not required |
| Pneumatic | Very fast operation, good for large flows | Requires compressed air supply | Yes, if a pneumatic system is available |

Also, in this process there is a need for control of flow of liquid in both pipes so mixing would be accurate. For this reason, flow sensors could be used. Depending on the type of fluid contact or contactless sensor can be applied. For example, if liquid in pipe is conductive, electromagnetic sensor is a perfect fit.

There are a lot of problems that can occur while fluid flows within valves. One of them is that liquids are not mixed evenly which is caused by different speeds of flow for both valves. There are some solutions for this problem such as: appropriate steering of the process using flow sensors and sequential opening and closing valves. Another thing is that pipes can have poor ventilation so the air will affect the process. Air vents or air babble sensors can be applied for this problem.

## Fluid level sensors

For this task a variety of different sensors could be used including contact (Table 2) and non-contact (Table 3).

Table 2 Contact level sensors

| Sensor | Working principle | Advantage | Disadvantage | Suitable for the system? |
|---|---|---|---|---|
| Float Sensor | A mechanical float changes position depending on the liquid level | Simple, inexpensive, reliable | Sensitive to contamination and foam | Yes, if the liquid is not viscous and the tank is stable |
| Reed Switch (Magnetic) | A magnet in the float activates a reed switch | No electronic components in liquid, pressure-resistant | May jam with viscous liquids | Yes, if the tank is closed |
| Electrode (Conductive) | Works by detecting the electrical conductivity of the liquid | Cheap, effective for conductive liquids | Does not work for non-conductive liquids, requires calibration | Yes, if the liquids are conductive |
| Hydrostatic | Measures the pressure exerted by the liquid column | Works with foamy and viscous liquids | Requires immersion in liquid | Yes, if the sensor can be installed at the bottom |

Table 3 Non-contact level sensors

| Sensor | Working principle | Advantage | Disadvantage | Suitable for the system? |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Capacitive | Detects changes in electrical capacitance near the liquid surface | Non-contact, works with conductive and non-conductive liquids | May require calibration, affected by tank wall thickness | Yes, if the tank is plastic or non-conductive |
| Ultrasonic | Emits sound waves and measures the reflection time from the liquid surface | Non-contact, high precision | Can have issues with foamy or turbulent liquids | Yes, if the liquid surface is stable (low foam, minimal vibrations) |
| Radar (FMCW) | Emits microwaves and measures reflection time | Highly accurate, works in harsh conditions | Expensive solution | Yes, if high precision is required |
| Optical (Infrared/LiDAR) | Detects the liquid level based on light reflection | Precise, works with various liquids | Can be affected by contamination | Yes, if the liquid is transparent and does not create deposits |

These sensors should have an impact on valves so liquid won't overflow or there would not be enough fluid in the tank.

## Robotic arm