DESIGN A PROCESSOR FOR CONTROLLING MIXING PROCESS (CMP)

EEX7436

Processor Design

Assignment 01

by

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Submitted to

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at

Colombo Regional Center

on

02/08/2021

1 Analyze the problem, identify the requirement of CMP and write a short description of the working procedure of the CMP. Indicate the internal functionality of your processor.

<u>Analyze the Problem</u>

Mixing is defined as the reduction of inhomogeneity in order to achieve a desired process result. The inhomogeneity can be concentration, phase or temperature. Also, secondary effects such as mass transfer, reaction, and phase properties are usually critical objectives[1]. Mixing operations are necessary step for wide range of industries such as fine chemical, agrichemical, pharmaceuticals, petrochemicals, Biotechnology, polymer processing, paint and automotive, food, cosmetics, pulp and paper, mineral processing and drinking water. In all of these industries, the mixing problem mainly focuses on two factors, known as key variables in mixing.

- Time available to accomplish mixing (The time scale)
- Required scale of homogeneity (The length scale)

Both factors are different in each industry as well as each consumer product. For example, in food industry the time of mixing is depends on the recipe of the food and petroleum and pharmaceutical industries uses some catalyst to reduce the mixing time. Homogeneity is also very dependent on the industry for example in food industry some mixers use to just mix some ingredients without any chemical reactions. But in pharmaceuticals industry homogeneity is critical aspect which consider concentration variation, temperature variations and other filed specific factors also.

To do the mixing operations, process or chemical engineers use mixing machines. There are wide range of mixing machines are available in market that made to do specific things. From the traditional stirred tanks, baffling, the full range of impellers, and other tanks, pipeline mixers, High viscosity mixers, double motion mixers are uses in different industries with suitable changes as suitable to the requirements. But in controlling viewpoint, all these mixers have common attributes such as vessel controlling, sensor measuring, motor controlling (expect in static mixers). Mixing operation is vary with the type of ingredient that intent to mixing. For example, solid-solid, solid-liquid, liquid-liquid, high-viscosity liquid mixing and gas mixing required deferent types of controlling methods. Also, for the evaluate mixing process, process engineers are using field specific theories like Residence time distribution theory. Mean value and variance of some measurement is also used in most of theories as well as directly evaluate the mixing process. For obtain the data for calculations, sensors are using. Most of the cases use a array of sensors instead of use one sensor. For example, Figure 1 shows the Strain gauges mounted on the mixer shaft are a popular and reliable method of measuring torque.

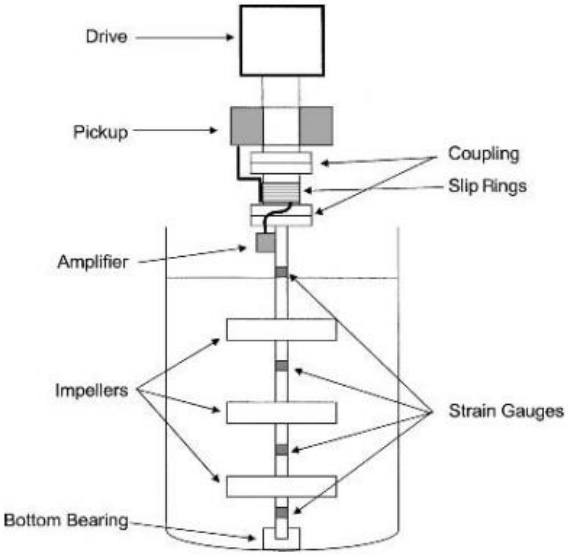


Figure 1: A example for the use of array of sensors within mixers. Strain gauges mounted on the mixer shaft are a popular and reliable method of measuring torque. source [1]

There are wide range of sensors are used to evaluate the mixer such as Platinum electrode conductivity probe or optical probs for measuring solid concentration, strain gauges for measure mass or torques, thermocouples use for temperature measurements and tachometers uses to measure the actual shaft speed. For control and read each type of sensors, needs to adepts their own drivers and required to convert as suitable to the controller.

Expect of the static mixers, all mixers are uses motors to create a motion. There are various types of motors (actuators) used, Electric motors, air motors and Hydraulic Motors. Although theoretically, all the speeds are possible with in motors, practically gain some of difficulties to operate motors with all speeds. Usually, mixer speeds can vary from 3600 rpm (High-Shear Mixers) to 30 rpm. Mixing speed is a critical factor to be ensure the quality of mixer and the time scale of mixer. Also, sometimes users are required to measure the consume power of mixer. Below text is summarized common attributes used in most mixers as well as most industries.

Common attributes used in most of mixers as well as most of industries:

1. Most industries do their mixing operations with sequential step by step process. Each step is defined with its own attributes such as mixing speeds, mixing time, required temperature scales, pressures requirements, and so on.

2. Most industries and mixers are designed with a combination of sub mixing units, that includes dedicated motors (or actuators), Dedicated array of sensors and input vassals. Some industry mixing operations are required to circulation also such as in pharmaceuticals, Fermentation and Cell Culture Industries.

3. Mean value and variance of some measurement is also used in most of theories as well as directly evaluate the mixing process.

4. Speed controlling, in and out vassal controlling, pressure controlling, PH controlling, and temperature controlling can be seen in many industries.

5. Measure the array of sensor values for concentration, temperature, speeds, pressure, pH rates and weights are common in many industries.

6. Also required to additional procedures for the stop all operations in safely when occurs an emergence. Cleaning of mixers are also required routing operation in many industries.

Addition to these common attributes, some industries required specialized operation to done the mixing. Below text summarizes the few special requirements for selected industries.

Mixing in the Fine Chemicals and Pharmaceutical Industries: Required to control overmixing and particle crystallization. Also, needs to control the temperature difference within the mixer and ensure that a uniform distribution of heat. For the crystallizations, gas-liquid reactions and some mixing operations are required to control the angle of impellers also. Figure 2 shows the common impellers angles.

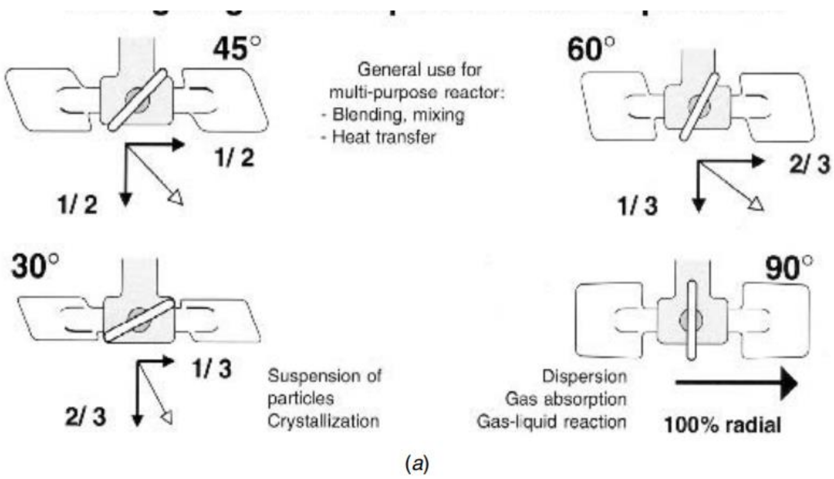


Figure 2: Common impellers angles

Fermentation and Cell Culture Industries: Cell culturing industry required much more controlled environment while the mixing when compared to other industries such as food. The maximum productivity, product concentration, and quality achievable depends primarily on bulk mixing and oxygen mass transfer, which in turn are governed by process operation, impeller type, and fluid properties. The viscosity of the broth will influence the bulk mixing, air dispersion, and power draw by the agitator. Therefore, proper torque measurement, speed and viscosity measurements are required. The dissolved oxygen can be fluctuated with a fixed frequency in a square- or sine-wave fashion by either varying the inlet gas composition or the fermenter head pressure to alter the liquid-phase dissolved oxygen concentration. Therefore, proper gas inlet or pressure controlling mechanism is required and control should be able to be controlling the gas by predefined ways.

Fluid Mixing Technology in the Petroleum Industry: Mixing applications in petroleum industry may be somewhat limited compared to chemical, pharmaceutical, and food manufacturing. In addition, refinery streams are less complex than specialty and fine chemicals in terms of fluid physical properties and process conditions. However, due to large volumes of petroleum streams to be mixed, mixing technology plays an important role in enhancing productivity and profitability. The refining processes involving mixing operations include making emulsion products for oil drilling, absorption of CO_2 from natural gas, crude oil–water homogenization for custody transfer, sludge suspension in crude oil storage tanks, desalting of crude oil, alkylation, caustic–oil contacting for neutralization, pH control, and more.

Mixing in the Pulp and Paper Industry: The pulp and paper industry comprises companies that use wood as raw material and produce pulp, paper, paperboard, and other cellulose-based products[2]. The most common chemical pulping process is the kraft process. Here, wood chips are treated to remove the lignin that binds the cellulose fiber to the wood matrix.

Highly Viscous Fluids, Polymers, and Pastes: Many industrially important products, such as pastes, putties, chewing gum, soap, grease, solid propellant, and some foods, fall into this category. Viscous mixing involves many applications in processes wherein the viscosity is sufficiently high (greater than 10 Pa s-1). Mixing highly viscous fluids required to draw much attention to the heat transfer, speeds and power built-up. Slow impeller speeds to limit heat buildup. These mixing industries required negative speeds also because of stop the fluid speeds. Figure 3 illustrates the requirement of negative speeds and the requirement of controlling the power and speeds of impellers in high-viscous fluids mixing.

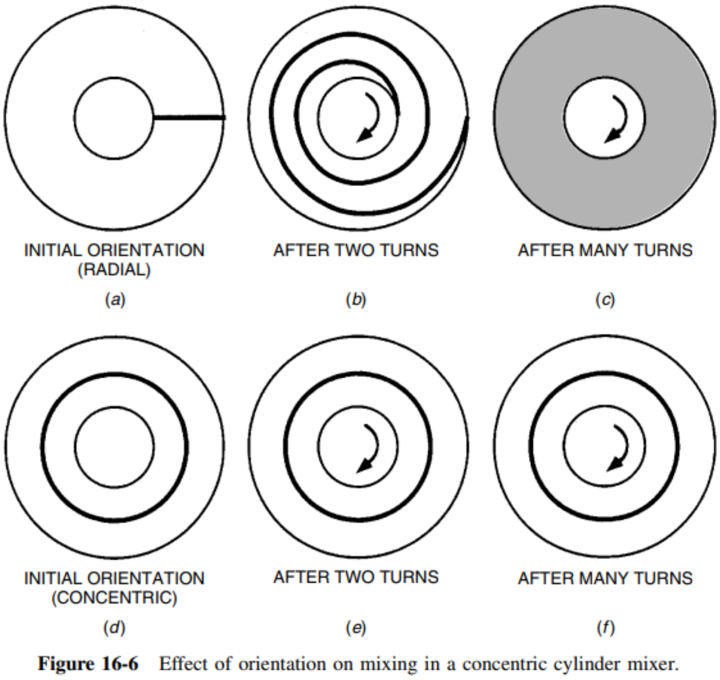


Figure 3: Requirement of negative speeds and the requirement of controlling the power and speeds of impellers in high-viscous fluids mixing.

Requirement of CMP

1. It may be able to design an algorithm to make mixing operations step by step.
2. Each step or profile could be able to design or edit separately and independently.
3. Could be able to make motors and sensor groups as can control as once. This makes easier the process engineer job.
4. After doing the initial configurations, process engineers can control the mixing operations as steps. Also, could be able to evaluate the mixing process by using sensor values.
5. For the Diagnostic proposal, each operation, input and output could be controlled separately.
6. When wanted, additional functionalities that are required to various industries could be able to design using basic logic functions.

Working procedure of the CMP

For use the CMP, the programmer must follow two necessary steps according to their mixing operations.

- Configuration Phase
- Mixing and monitoring phase

During configuration phase, programmer should make the steps (known as profiles) according to the mixing operations. Each profile must include the considered motors, initial speeds of motors, required temperature sensors, required pressure sensors, required concentration sensors. Also, the timing information's and general-purpose input output functions are also required to define. After done the configuration phase, mixing and monitoring phase must program. Here the sequence of steps (profiles) and the required calculations can be performed with CMP.

Internal functionality of processor

Followings are the assumed available resources of CMP,

Number of motors: 32

Number of vessels: 32

Number of temperature sensors: 32

Number of pressure sensors: 32

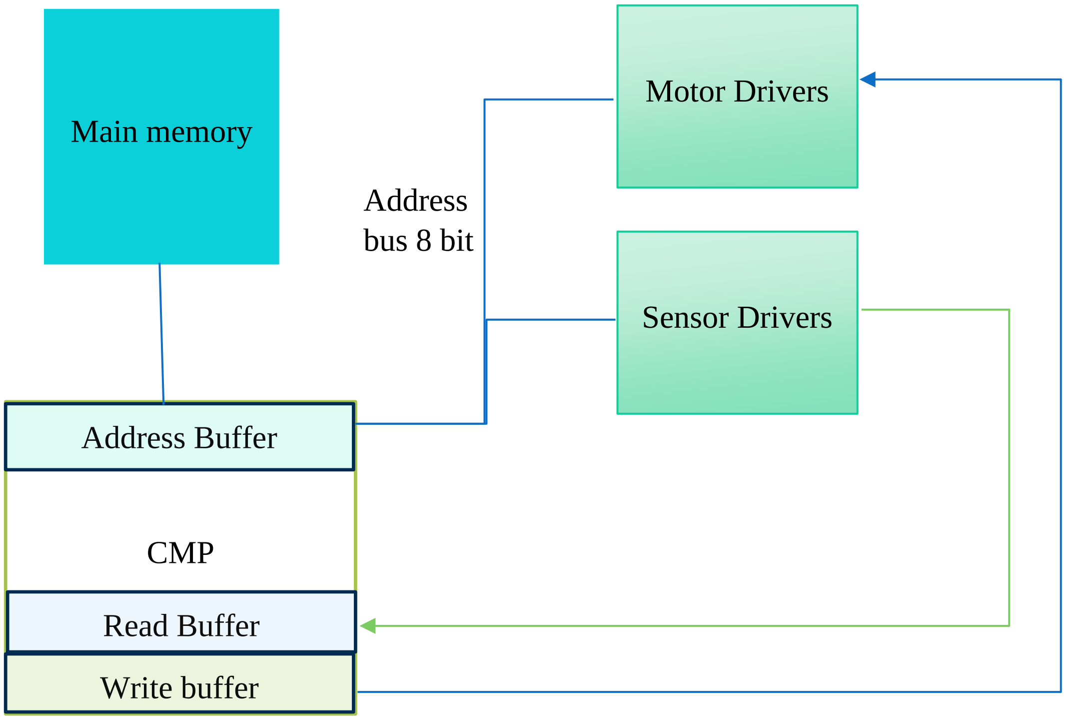
Number of concentration sensors: 32

Number of general proposed motors: 64

Number of general proposed sensors: 32

The processor could control the motors (actuators) and vessels or inlets separately. sensor values could be read. The processor could hold the configurations according to the profiles that make the programmer. For understanding the instructions, fetch, decode and execution of instruction could be performed. By reading the array of sensor values, mean and variance could be calculated. For increase the flexibility, some arithmetic calculations, and logic operations could do. Timing operations can be performed also. Speeds and sensor reading are 8-bit values and assume 8 bit resolution if enough to operate mixing operations with acceptable error.

2 Show how the CMP can be used in a mixing machine.



Mixing machines has many motors, sensors. CMP uses to controlling and monitoring each device. Each sensor and motors have to connect appropriately with CMP through a suitable driver. Each device can select using addresses and after selecting the device, write or read operation can be performed. Read and write buffers are used to store the motor data (such as speeds, directions) and read the sensor data until CMP use it. With proper interfacing, CMP can control all devices in mixing machine effectively.

Initially programmer should create the steps of mixing process. Each steps includes the required motors, sensors and calculations. The CMP can have maximum of 16 steps (Including cleaning) within a mixing operation. These operations may include read sensor values, do some calculations on them (like finding mean), and control the motors according to the results. 8-bit address bus is used to select a particular motor or a sensor. First bit of address bus is deciding the type of device, 1-Motor, 0-Sensor. Address buffer is used to hold the address while the operation is done.

3 Accordingly, identify the necessary instructions and design an ISA for this processor.

Programing can be divided into two main phases. Configuration phase and mixing & monitoring phase. During configuration phase, programmer can create profiles which follow below format.

Profile template:

1. Profile number
2. Profile motors
3. Profile temperature sensors
4. Profile pressure sensors
5. Profile concentration sensors
6. Profile vessels
7. General proposed outputs
8. General proposed in outs
9. Speeds of each motor (in rpm)
10. Values of each general proposed outputs

After creating profiles, programmer can write for the logic of each step of mixing. During third mixing and monitoring phase, programmer can obtain sensor values, calculate mean and decide the next phase.

ISA for CMP

1. **Configuration Instructions**

1.1 Addmotor Profile_number Motor_Number

Add a motors to a given profile

1.2 Addmotorall Profile_number

Add all enabled motors to a profile

1.3 Addtempsen Profile_number Temperature_sensor_number

Add a Temperature sensor to a profile

1.4 Addpressen Profile_number pressure_sensor_number

Add a Pressure sensor to a profile

1.5 Addconsen Profile_number concentration_sensor_number

Add a concentration sensor to a profile

1.6 Addvassl Profile_number vassel_number

Add a vessel to a profile

1.7 Addvasslall Profile_number

Add all enabled vessels to a profile

1.8 Addgenout Profile_number GPO_number

Add a general output to a profile

1.9 AddgenIn Profile_number GPI_Number

Add a general input to a profile

1.10 Setmotorspeedall profile_number speed

Set the speeds of all motors included in a profile

1.11 Setgpoall profile_number value

Set the speeds of all general outputs included in a profile

1.12 Setmotorspeed profile_number motor_number speed

Set a motor speeds of a motor of a profile

1.13 SetGPOval profile_number GPO_number value

Set a value of a General porpose output of a motor of a profile

1.14 Setvesselsvalue profile_number vassle_number value

Set a value of a vessel of a profile

1.15 Setvesselsvalueall profile_number value

Set a value for all vessels in a profile

2. Mixing and Monitoring Instructions

2.1 FindMean profile_number A

Here A : 0 – Temperature sensors

1 – Pressure sensors

2 – concentration sensors

3 – GPI values

* Store the results in mean register

Finding the mean of a sensor values included in a profile

2.2 start profile_number

Start a profile outputs with configured values

2.3 stop profile_number

Stop all operations of a profile

2.4 SIGmean #immediate_value profile_number, address

Start given profile if greater than the mean register value than given value. Else jump to given address

2.5 STPIGmean #immediate_value profile_number, address

Stop given profile if greater than the mean register value than given value. Else jump to given address

2.6 SILmean #immediate_value profile_number, address

Start given profile if Less than the mean register value than given value. Else jump to given address

2.7 STPILmean #immediate_value profile_number, address

Stop given profile if Less than the mean register value than given value. Else jump to given address

2.8 wait #immediate_value

wait given number of milliseconds without fetching next instruction.

2.9. compareG B, # immediate_value,Jump_Address

Jump to the address if B>immediate value.

B: 1 – Temperature mean register value

2- Pressure mean register value

3 – concentration mean register value

4 – GPI mean register value

3.0 JUMP address

jump to given address.

3. Diagnosis and cleaning

3.1 clean

This instruction starts the profile 16.

3.2 set address value

set value manually to each input or output. This helpful for diagnosis the mixers.

4 Using your ISA, write a program to do different mixing operations. You can use your own examples for this.

Example for industrial cake batter mixing procedure:

Mainly, the cake mixing can divide into 7 steps.

1. Preparation of ingredients: Add all the ingredients and measure them according to the recipe. Typically flour, sugar, eggs, butter, baking powders, flavorings, and milk or water.
2. Dry Ingredient Mixing: Strat the mixer at low speed and gradually add the dry ingredients such as flour, sugar, baking powders to the mixer. Mix until dry ingredients mixed properly.
3. Adding Butter and Other Fat: Add the softened butter or other fats to the mixing bowl. Mix at a low speed until the butter is incorporated into the dry ingredients.
4. Adding Wet Ingredients: Gradually add the wet ingredients such as eggs, milk, and flavors. Mixer running at low speed.
5. Mixing: Increase the mixer speed to medium and continue mixing until the batter is smooth and well combined.
6. Final Mixing: Once the batter is smooth and well mixed, continue mixing for a short period at a higher speed to ensure uniform concentration.
7. Evaluation: Evaluate the batter for its consistency and texture.

For the done mixing procedure, This Hypothetical mixer is used which have 5 Motors to mix, has 10 concentrations sensors, and has 10 vessels for control each ingredient. To measure the batter concentration, calculate the mean value of all 10 sensor values.

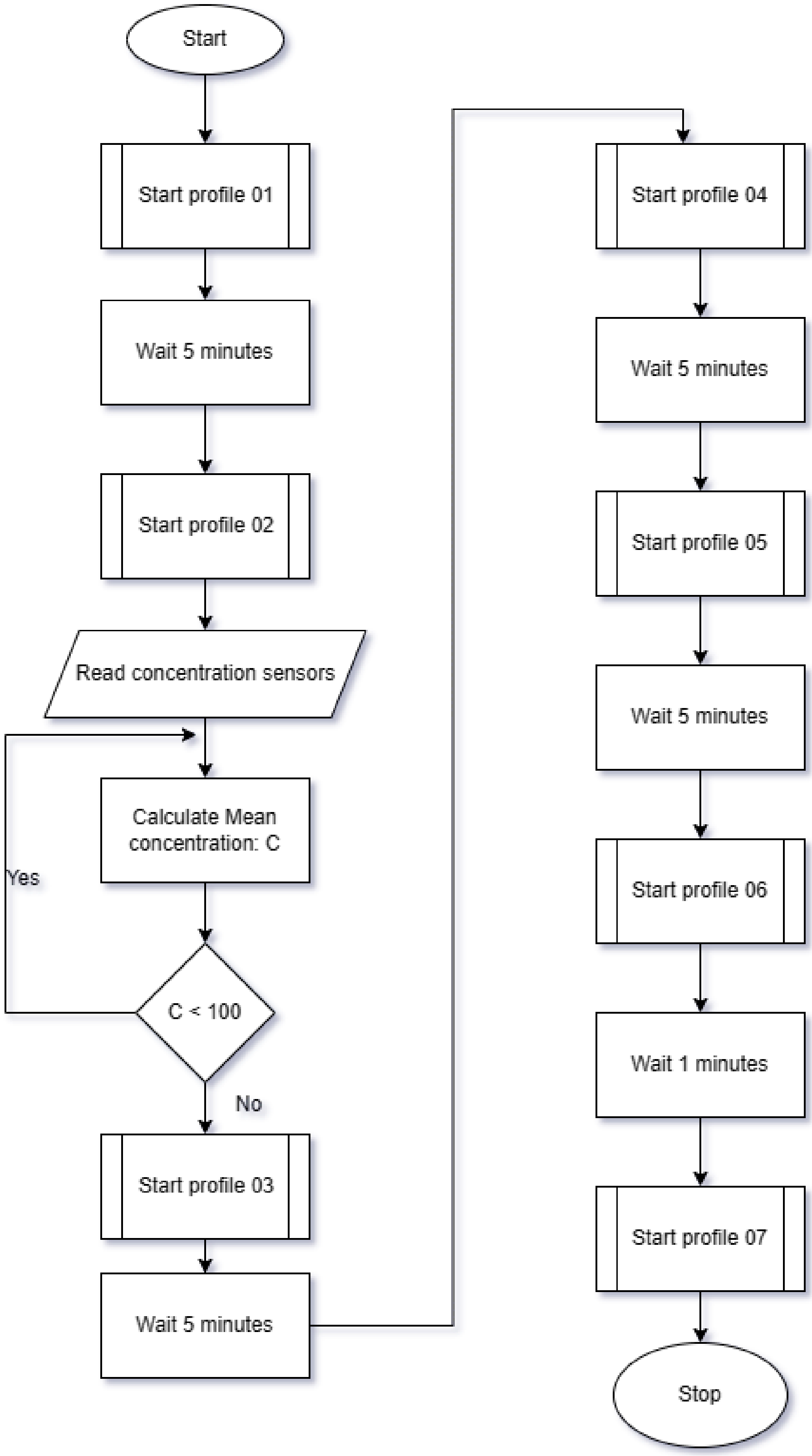
Vassel number	Ingredient
01	flour
02	sugar
03	eggs
04	butter
05	baking powders
06	flavorings
07	milk
08	water
09	softened butter
10	other fats

Create a program: Step 01: Identify the profiles.

For each step has a dedicated profile as following,

Profile Number: 01 Profile motors: - Profile concentration sensors: - Profile vessels: all vessels Vessels open value: 50% all Speeds of each motor (in rpm): -	Profile Number: 02 Profile motors: all motors Profile concentration sensors: all sensors Profile vessels: all Vessels open value: all closed Speeds of each motor (in rpm): 50 each
Profile Number: 03 Profile motors: all Profile concentration sensors:- Profile vessels: 9,10 Vessels open value: 50% all Speeds of each motor (in rpm): 50 each	Profile Number: 04 Profile motors:all Profile concentration sensors: - Profile vessels: 3,6,7 Vessels open value: 50% all Speeds of each motor (in rpm): 50 each
Profile Number: 05 Profile motors: all Profile concentration sensors: all Profile vessels: - Vessels open value: - Speeds of each motor (in rpm):200 each	Profile Number: 06 Profile motors: all Profile concentration sensors: - Profile vessels: - Vessels open value: - Speeds of each motor (in rpm): 250
Profile Number: 07 Profile motors: - Profile concentration sensors: all Profile vessels: - Vessels open value: - Speeds of each motor (in rpm): -	

Create a program: Step 02: Draw a Flow chart considering the steps.



Create a program: Step 03: Configure Profiles

```
--Profile 01
Addvesslall 1 -- Adding vessels to profile 01
Setvesselvalveall 1,50 -- Set vessle open at 50%


--Profile 02
-- Add Concentration sensors to profile 02
Addmotorall 2 -- Adding Motors to profile 2
Addconsen 2,1
Addconsen 2,2
Addconsen 2,3
Addconsen 2,4
Addconsen 2,5
Setmotorspeedall 2 50 -- Set all motor speeds as 50 rpm

--Profile 03
Addmotorall 3 -- Adding Motors to profile 3
Addvassl 3,9     -- adding 9 and 10 vassels
Addvassl 3,10
Setvesselsvalueall 3,50 -- Set vassels value as 50%
Setmotorspeedall 3,50 -- Set motor speeds as 50 rpm

--Profile 04
Addmotorall 4 -- Adding Motors to profile 4
Addvassl 4,3
Addvassl 4,6
Addvassl 4,7 --Adding vessels 3,6 and 7
Setvesselsvalueall 4,50 -- Set vessels value as 50%
Setmotorspeedall 4,50 -- Set motor speeds as 50 rpm

--Profile 05
Addmotorall 5 -- Adding Motors to profile 5
Addconsen 5,1 --Adding Concentration sensors
Addconsen 5,2
Addconsen 5,3
Addconsen 5,4
Addconsen 5,5
Setmotorspeedall 5,200 -- Set motor speeds as 200 rpm

--Profile 06
Addmotorall 6 -- Adding Motors to profile 6
Setmotorspeedall 6,250 -- Set motor speeds as 250 rpm



--Profile 07
Addconsen 7,1 --Adding Concentration sensors
Addconsen 7,2
Addconsen 7,3
Addconsen 7,4
Addconsen 7,5
```

Create a program: Step 04: Crate a program for Mixing and monitoring phase.

```
start 1 --Start Step 01
_wait 300000 --Wait 5 min
stop 1 --Stop Step 01
Start2: start 2 --Start Step 02
compre: FindMean 2,2 --Read Concentration sensors
        STPIGmean 100,2,compre -- Stop step2 if mean >100.
Wait until
        SIGmean 100,3,start2 -- Start step3 if mean >100. Else
jump to start2

_wait 300000 --Wait 5 min
stop 3 --Stop Step 03
start 4 --Start step 4
_wait 300000 --Wait 5 min
stop 4 --Stop Step 04
start 5 --Start step 5
_wait 300000 --Wait 5 min
stop 5 --Stop Step 05
start 6 --Start step 6
_wait 60000 --Wait 1 min
stop 6 --Stop Step 06
start 7 --Start step 7

compre2: FindMean 7,2 --Read Concentration sensors
        compareG 3, 120,Jump_Address, success –Check
Concentration
        JuMP undermix


success: set 11111111,1 -- Tell about success mixing
JuMP success

undermix: set 11111111,0 ---- Tell about fail mixing
JUMP undermix
```