# Automation of mega kitchens

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## 1 Introduction

The West looks to automate as its population is dwindling and getting skilled labor to run a factory or a production unit is difficult. And, if indeed, one can find such professionals, the cost of hiring such skilled labor would be exorbitant.

This is the reason that the West is going into automation. Many a time we have heard of a 1000 tons Production Unit, run by a skeleton staff of just 10 or 12 personnel! There are hotels in Europe, which are run by just a handful of people!

Whereas, in India, skilled labor is abundant, and on the rise! So, why will one think of automation, when we have such a huge bench strength of skilled labor in every field?

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And when the West brings its solutions, it will be basically based on reducing or even elimination manpower! One who goes to a Western country to get help to automate would be starting on the wrong foot because the basic reason for automation is wrong!

Automation in India should only be for the following reasons:

1. Accuracy
2. Speed of delivery
3. Ease of operations

and never for reducing manpower! In fact, we need a balanced approach to this problem.

Consider the following example:

The Owner of a sugar factory employing 40 skilled labor is planning to automate the production processes.

If he goes into 100% automation,

1. it will eliminate 90% of the workers
2. cost of automation would be prohibitively high
3. low quality sugar will be reduced to zero
4. quality of sugar will be very high

On the other hand, if he takes a balanced approach, he would go in for semi-automation, retaining most of the manual processes going only for automation of critical processes. In this case,

1. most of the labour will be retained
2. the initial cost of automation will be much lesser
3. low quality sugar will be drastically reduced
4. quality of sugar will be as high as for a fully automated plant

Automation in the hotel industry should also be based on this approach. For example, why will we go in for a super expensive robot bell-man, when we have quality bell-men in abundance in our country? Such blind automation does not take into account the best interests of the country.

Automation should be resorted to only if:

1. preparation time can be cut down
2. hygiene can be increased
3. quality of food can be increased
4. standardization (of, say, food production) can be achieved

and, again, in India, never to cut down on manpower!

The strength of our country is in the availability of skilled manpower, a fact which can be corroborated by the fact that our skilled personnel are much sought out, all over the world!

## 2 Reasons for automating a mega kitchen

Let us explore the reasons for automating a mega kitchen:

1. Production time can be cut down
2. The Plant can be run by semi-skilled professionals
3. Food quality can be increased
4. Hygiene can be increased

Time spent on cleaning the raw materials can be cut down. This will also ensure cleaner and more hygienic raw materials. Also time spent on moving material around should be cut down by using conveyors.

As the recipes are coded into the programmable logic controllers, the main chef need not be present during the production times. Anyone with appropriate training to handle the automated facility can handle the day to day production.

From the moment the raw materials are loaded into the hoppers, till the time that the finished products are loaded into trucks, they do not have any contact with human hands! Thus, a great degree of hygiene can be achieved.

Further, after completion of production, all the equipment used in the production area can be steam cleaned ensuring a high degree of cleanliness and hygiene.

Let us approach this subject from another angle.

We have a mid-day meal scheme for children in Government Schools. In a city or town, where there are more than 10 schools, we can put up a centrally located Automated Mega Kitchen for the entire town.

These mega kitchens can be run in tandem with the Disaster Management Department. In case of a flood, let us say, where a number of people have been uprooted from their homes, these kitchens can be of extreme importance as food can be produced in mass quantities to ease the suffering of flood affected people.

## 3 Basic features of an automated mega kitchen

1. Modular approach
2. Automated cleaning equipment
3. Conveyors for raw materials and finished products
4. Use of gravity for material flow
5. Hoppers with automated valves
6. Weight measurement devices
7. Automated Stirrers
8. Simple lifting trolleys
9. Packing machines
10. Boilers
11. 3D Crystal Heating Devices
12. Programmable Logic Controllers

**Modular Approach**

A modular approach would ensure smooth integration of additional units and thus, increase of capacities. Installation of additional capacities should not hinder the working of the existing units

**Automated cleaning equipment**

For purpose of maintaining hygiene, cleaning equipment like brushes will be operated with steam. There will be no human touch in all the food handling from the first hopper right down to the finished product conveyors

**Conveyors for raw material and finished products**

Conveyors will be needed to transport raw materials from the storage to the hoppers. Similarly, con veyors will be needed to handle the finished product from the production are to the dispatch section

**Use of gravity for material flow**

A 2-tier system will be designed to make use of gravity and thus avoiding expensive pumps to transport material to the hoppers and on to the production area. Also pumps require extensive maintenance and are prone to failures.

**Hoppers with automated valves**

This is a critical component as the system will take from the storage the exact amount of materials needed for production. This system will be used only for materials with mass volumes.

**Weight measurement devices**

Load cells will be used to weigh only main ingredients. This will not be done for all ingredients as we are not attempting 100% automation.

**Automated Stirrers**

Manual mixing and stirring will be totally eliminated. We can use pre-programmed timing for stirring as well as Bluetooth enabled stirring whenever the chef needs to achieve stirring. We can also easily program for different speeds of the motor for stirring different food products at different times during the cooking process.

**Simple Lifting Trolleys**

Manually lifting a 50 kg bag of rice or dal needs a back breaking effort. We will reduce this as much as possible by using simple hydraulic lifting trolleys.

**Packing Machines**

Packing machines are readily available in the market and if needed, will package the dal in 50- or 100-ml PE packets.

**Boilers**

Industrial boilers following IBR standards will be used in this project to cook the rice and the dal.

**3D Crystal Heating Devices**

At the time of writing this article, 3D Crystal Heating Devices have entered the Indian market. Though operating expenses are much lower in these devices, more research and performance analyses are needed to include them in our recommendation.

**Programmable Logic Controllers**

The entire operation will be controlled by programmable logic controllers. Writing the necessary software to run the plant is simple and can be modified at will.

## 4 Sizing of the vessels

For Dal:

For the production of dal for 20,000 people, we need 200 kgs of dal.

This works out to around 3000 litres of dal

Using 8 units, volume of each unit will be around 3000/8 = 375 litres per unit.

Allowing for overflow etc. we need 400 litres capacity per vessel.

For Rice:

For the production of rice for 20,000 people, we need 1000kgs of rice

Using 8 units, we get a capacity of 125 kgs per unit

This will work out to around 500 litres capacity per vessel

## 5 The layout of the facility

First let us take look at the building layout. (See Sketch - 2)

There have to be clear-cut ways for the incoming trucks and the outgoing trucks. The delivery bay and the loading bay will be positioned on opposite sides of the facility.

For sake of clarity, we are considering two separate buildings, one for dal and one for rice. In reality, both these buildings can be combined into one unit, depending on the area available.

The building itself will be at two levels (see Sketch – 3):

1. The first-floor level where the loading equipment are located
2. The ground floor level which will house the production area and the delivery bay.

The Ground Floor will also house the Control Room, the Loading Bay, the Office and the Boiler Room. The First Floor will house a storage area where enough raw materials for each day's production will be stored.

## 6 The automation sequence for cooking dal

Let us consider the process of cooking Dal, a prime menu item in most of these mega kitchens in India. Let us try and automate the process. This will give us a good idea of what the automation process entails.

The process flow chart is shown in Sketch – 1.

A complete drawing of the layout for processing Dal is shown in Sketch – 3.

The drawing of a single unit is shown in Sketch - 3a.

The First Floor Plan showing the loading utilities is shown in Sketch – 5.

**Preparations**

The raw material required for the day, that is dal, is pre-stored at the first-floor level. Transporting raw material from the ground floor to the first floor is done using a simple lift system.

First, we need to start the program. Then we will click on the Dal button and enter the amount of Dal to be cooked.

Depending on the amount of Dal needed, a light will come on, on the panel in front of each hopper. For example, if the cooking is only for 10,000 people, the light on the panel in front of hopper numbers 1 through 4 will turn on, indicating which of the hoppers will need to be loaded.

The program will calculate other details such as amount of oil and water needed for both cleaning the dal and cooking. The amount of Dal needed will be calculated and displayed on a panel in front of each hopper. Similarly, the amount of Oil needed will be calculated and displayed on each panel in front of each Hopper.

From the storage area, dal is loaded onto a hydraulic lifting trolley. (See Image – 4)) The top of the trolley is fitted with an SS tray onto which a 50 kg dal sack is emptied. This enables the Operator to manually inspect the dal for foreign substances. Then the trolley is pushed to the hoppers. Here the tray is tilted to load the cleaning vessel through its hopper.

If the quantity indicated is less than the standard 50 kgs, then the Operator will slit open the sack and weigh the exact amount needed in a weighing machine.

Simultaneously, the operator fills the oil container with the required amount of oil. Once this is done, the operator presses a button next to the hopper. This sends a signal to the Control Room. The Control Room then starts the cleaning process for that unit.

**Cleaning of the Dal**

The cleaning vessel has an inlet and an outlet pipe for water, both controlled by solenoid valves. The inlet valve opens and lets water in. When the pre-determined amount of water fills up the vessel, the PLC switches on the mechanical stirrers at pre-determined speeds for a pre-determined time. When the cleaning process is completed, the stirrers are stopped and the water outlet valve is opened.

**The cooking processes**

When the cleaning is complete, the PLC checks if the cooking unit is ready to start the cooking process. If yes, the solenoid valve controlling the material outlet is opened and the dal along with the water flows into the cooking unit. Then the PLC switches on the cooking unit and the cooking process begins. After a calculated amount of time, the heating elements begin to heat up the oil to the required temperature.

When the oil reaches the required temperature, the PLC will flash a light on the oil hopper to indicate that it is time to add the required ingredients into the oil vessel. The mechanical stirrer will keep the contents in a slow stir.

When the timer indicates that the cooking process is complete, the PLC will open the solenoid valve at the outlet of the oil vessel and the entire contents flow into the cooking vessel. After a calculated amount of time, the PLC will shut off the cooking unit and send a signal to the Control Room that the cooking process for that particular unit is complete.

The computer in the control room will indicate what process is going on in all of the 8 units.

**Packing**

There are several ways to pack up the finished product for transportation. We will look at a couple of alternatives:

Alternative I

Here, dal is poured into containers of desired volumes, easy for transportation. Let us say, we have 500 litres of dal prepared. This can fit into 20 containers of 25 litres capacity each. A conveyer belt will ease loading these containers into trucks.

Alternative II

In this alternative, dal is to be packed into 100 ml PE containers and then transported to different locations. There are automatic machines available readily in the market. One such machine is shown in Image - 6. As the machine is capable of packing around 1400 packets an hour, we will need 20,000 / (1400 x N) machines,

Where N = number of packing hours.

The outlet of the dal vessel is connected to a header pipe, which branches into these packing machines.

Caution

As the packing material is single layer PE film, we need to know what temperature of the dal is safe for packing. For example, if it safe to pack the dal at $50^0$ C, the program will not allow the outlet valve to open before the temperature falls to $50^0$.

Cleaning up

After cooking is complete in all the units of the process, the Control Room will start the cleaning process. The PLC opens the valve between the oil vessel and the dal cleaning vessel. Next, the PLC flashes a light on the oil hopper indicating that the Operator needs to add soap solution or soap powder to the oil hopper. Again, after adding the necessary cleaning material, the Operator presses a button. This will inform the Control Room that the unit is ready for cleaning.

The PLC will activate the stirrers to begin the cleaning process. Again, after cleaning the vessel, the outlet valve will be opened to drain out the water. This process may be repeated if necessary.

Then the same process will be repeated to clean the cooking units.

## 7 The automation sequence for cooking rice

A complete drawing of the layout for processing Rice is shown in Sketch – 4

A clearer drawing is shown in Sketch - 4a

The Ground Floor Plan showing the rice cookers and the boiler(s) are shown in Sketch - 5

A typical rice cooker is shown in Image - 2

Steam Cooking

Here, the use of induction heating is not considered, as we are going in for absorption method of cooking. This is because, after 60% of cooking is done, there is no more water to conduct the heat to the rice grains. This results in rice sticking to the surface of the vessel, especially at the bottom. So, whenever absorption method is chosen, it is imperative to go in for steam cooking as less rice sticks to the bottom of the vessel.

Steam cooking means procuring a steam boiler to generate the required amount of steam for cooking the rice. Industrial boilers have to follow stringent IBR standards and one of IBR requirement is to appoint an IBR certified person to oversee the boiler operations and maintenance.
So, as seen from sketch 6, we need to include a boiler room in the layout.

Processing rice

The loading and cleaning processes are similar to that of processing dal and so are not repeated here. Operations are simpler as there is no need to add oil and necessary additives.
The vessels will be double jacketed to allow steam to freely flow into the cooking chamber.
The cooking units have a vertical vessel, supported at the center, which will allow the entire vessel to tilt, so as to enable manually removing the rice into containers.

On Site Research

Rice, due to the presence of starch, rice is sticky by nature. This is the reason for draining the rice while bulk cooking. Unfortunately, the draining method removes much of the nutrients of the rice and so, we have resorted to cooking by absorption method only.

Stickiness can be reduced by:

1. selecting rice having less surface starch
2. adding a small quantity of salt, and
3. pre-soaking rice, which reduces the surface stickiness of the rice.

Some research is needed to make sure that the cooked rice does not stick to the vessels such as:

1. Ideal mix of water to rice
2. Exact time of cooking
3. Duration to pre-soak the rice

As the process is automated, it will be easy to perform and tabulate results for various mix ratios, timing etc.

## 8 The complete cycle

To reduce the capacity of the boiler, we suggest that first the dal is cooked and when that process is completed, the process for cooking rice is started. This will reduce the cost of the boiler by about half.
So, for a typical day, cooking of the dal starts at, say, 10 a.m. On completion of the cooking of the dal at, say 10.45 a.m., cooking of the rice begins.
Due to the plant being automated, these processes can easily be handled by the PLC, which will first process the dal by opening the steam valves for the dal cookers. On completion, the PLC will shut off steam to all the dal vessels. Then it will check if the vessels for the rice are ready. On receiving the green signal, the cooking of the rice will automatically begin. This is accomplished by the PLC by opening the steam valves for the rice cookers. Once cooking is completed, the PLC will shut off the steam valves.
Then the cleaning process will start once the vessels are emptied. This is expected to take about 30 minutes. The whole process will take around 2 hours and will be completed by 12 noon.

## 9 The Boiler

As per IBR (Indian Boiler Regulations), if the boiler size exceeds 22.5 litres, it must come under IBR. For a 1000 kg rice unit, we will need a 500 kg/hour boiler. This means we need to go in for IBR regulated boilers. (See Image – 3)
We also feel that instead of using 2 or more boilers, we need to use just one boiler to handle both the rice and the dal. The same boiler can also be used to produce steam for cooking vegetables and cleaning the large vessels.
To keep the boiler capacity low, we will first cook the dal and then we will start the process for the rice. This will reduce the capacity to just half of the total capacity needed.
Also, IBR demands that the Operator for the boiler should be IBR certified.

## 10 The PLC

There are several ways to get signals from equipment and send signals to valves / controllers to and from the PC.
The suggested schematics is shown in Image – 1.
As we have a number of solenoid valves, we need to have some electronic device to collect the individual cabling and route it to the PC by means of an Ethernet connection.
The manufacturer also supplies the subroutines that will enable the programmer to be able to collect information from the equipment and send control signals to the equipment especially the solenoid valves.
As these are digital I/O systems, all the signals will be either 5 – 10 volts or 4-20 mA.

## 11 Costing

- **CAPITAL COST**

| ITEM | COST |
|---|---|
| Building & Peripherals Cost | 65,00,000 |
| 8 Units Induction Units for Dal | 16,00,000 |
| 8 Units Rice Double Jacketed Vessels for Rice | 16,00,000 |
| Boiler & Piping | 10,00,000 |
| 16 Units Hoppers for Loading | 5,00,000 |
| Electronics (incl PLCs) | 5,00,000 |
| Automation Equipment | 10,00,000 |
| Loading Hydraulic Trolleys | 3,00,000 |
| TOTAL COST 130 LAKHS | |

RATIO OF AUTOMATION / TOTAL COST 12%

- **RUNNING COST**

| OPERATORS | Cost per month |
|---|---|
| Unit Head (1) | Rs 25,000 |
| Helpers (5) | Rs 75,000 |
| Computer Operators (1) | Rs 20,000 |
| Boiler Operator (1) | Rs 20,000 |
| Loaders & Assistants (5) | Rs 60,000 |
| ELECTRICITY | Rs 5,000 |

## 12 Conclusion

In this 1.3 billion people country, we are always going to keep finding ways and means to feed the masses. This is where mega kitchens will play a major role in the future.

Be it a mid-day meal scheme or feeding disaster affected people, mega kitchens will be only keep growing. It is a challenge to keep these facilities productive, hygienic, efficient and cost effective.

It is the hope of the authors that automated mega kitchens will come up all over the country in our constant efforts to feed our hungry populace.

### References


- An international survey of methods used for evaluation for the cooking and eating qualities of milled rice by by B O Juliano of the International Rice Research Institute, Philippines

- Effects of processing methods on physicochemical, functional and sensory properties of Ofada rice by Anuonye JC, Daramola OF, Chinma CE and Banso O of the Department of Food Science and Technology, Federal University of Technology, Minna, Niger State.

- Plastic Films in Food Packaging - Materials, Technology and Applications
  Edited by Sina Ebnesajjad of Flouroconsultants Group, LLC

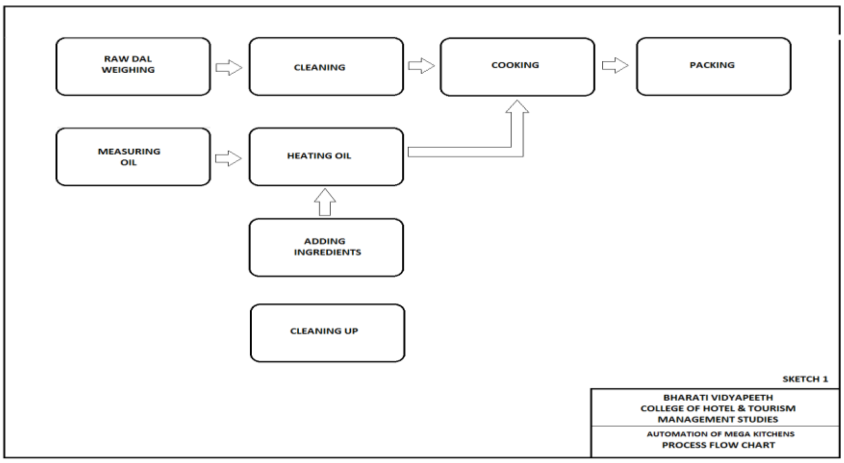
- Rice Starch Diversity: Effects on Structural, Morphological, Thermal, and Physicochemical Properties — A Review by Ali Abas Wani, Preeti Singh, Manzoor Ahmad Shah, Ute Schweiggert-Weisz, Khalid Gul and Idrees Ahmed Wani

- Rice: Chemistry and Technology Edited by Jinsong Bao

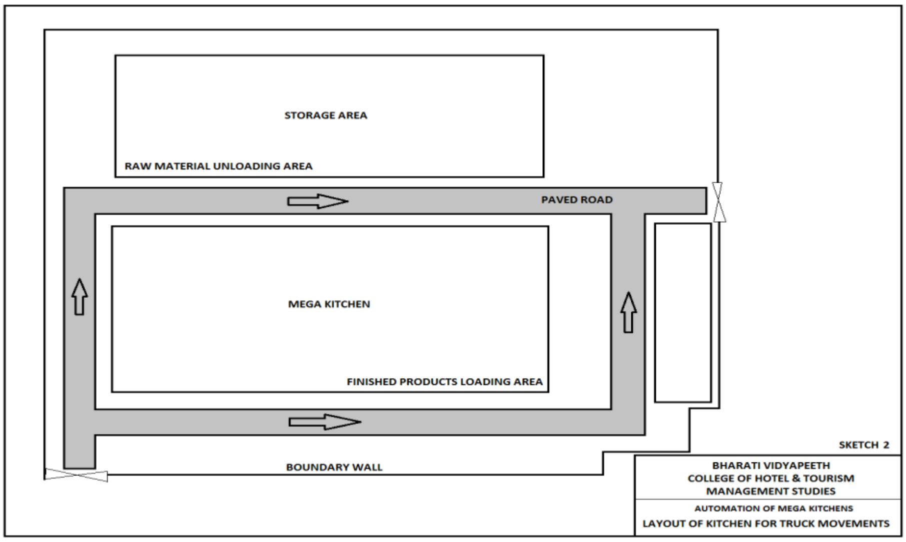
- Starch in Food: Structure, Function and Applications
  Edited by Ann-Charlotte Eliasson


**Sketches**

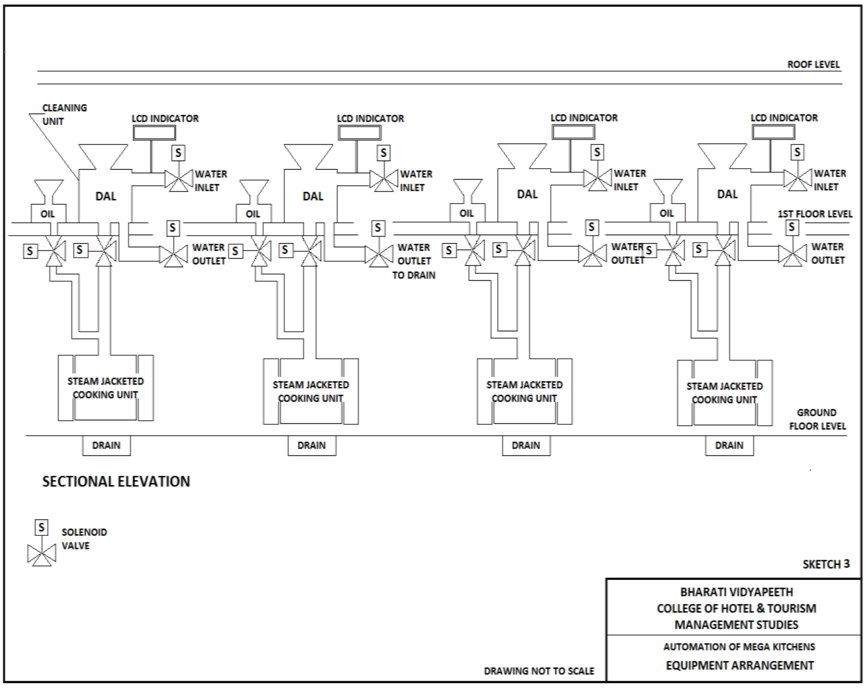
**Process flow chart**



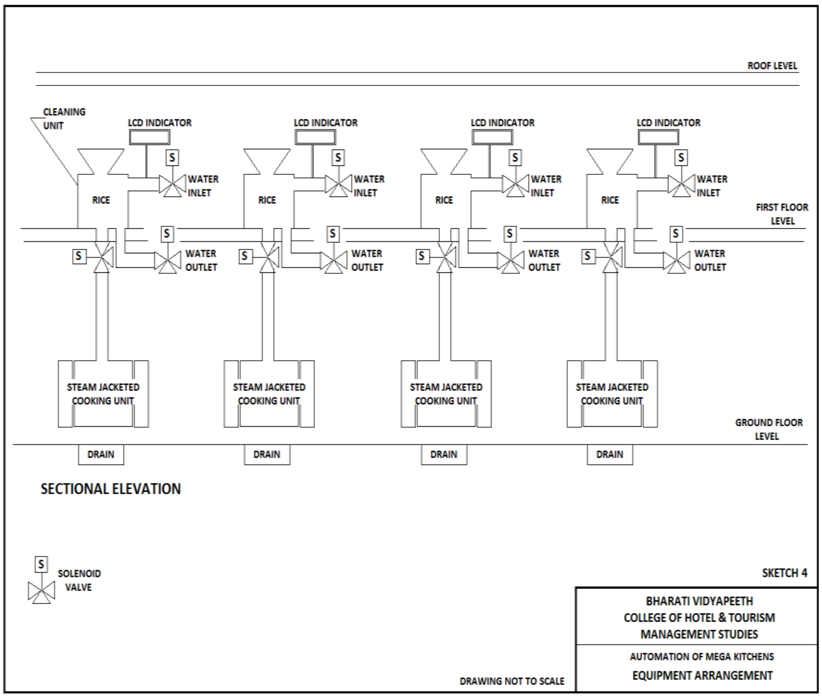
**Layout of mega kitchen for truck movements**



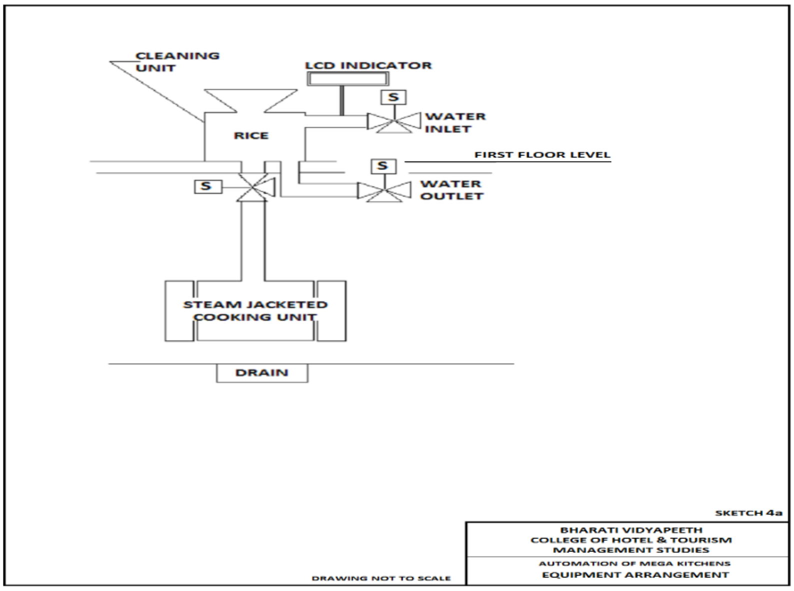

**Equipment arrangement for processing dal Single unit – dal processing**



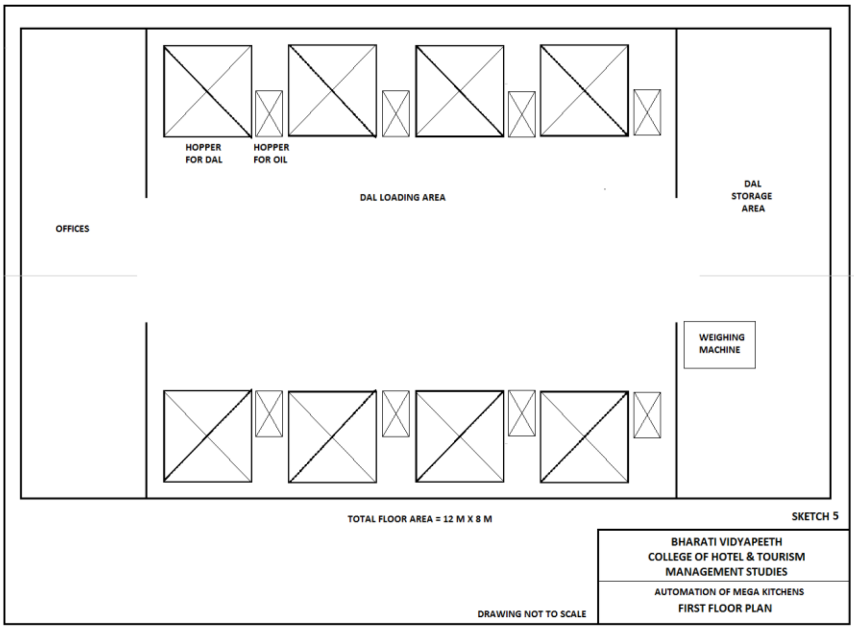
**Equipment arrangement for processing rice**



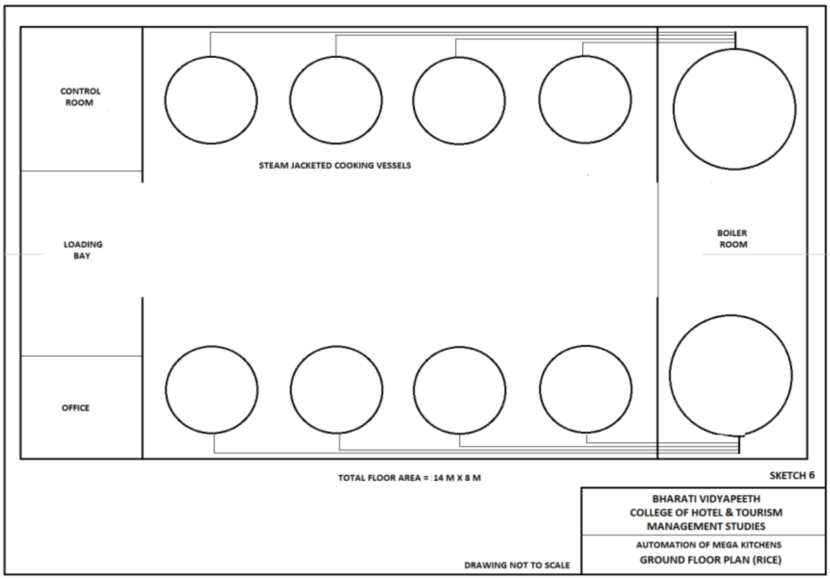

**Single unit – rice processing**



**First floor plan for processing dal**

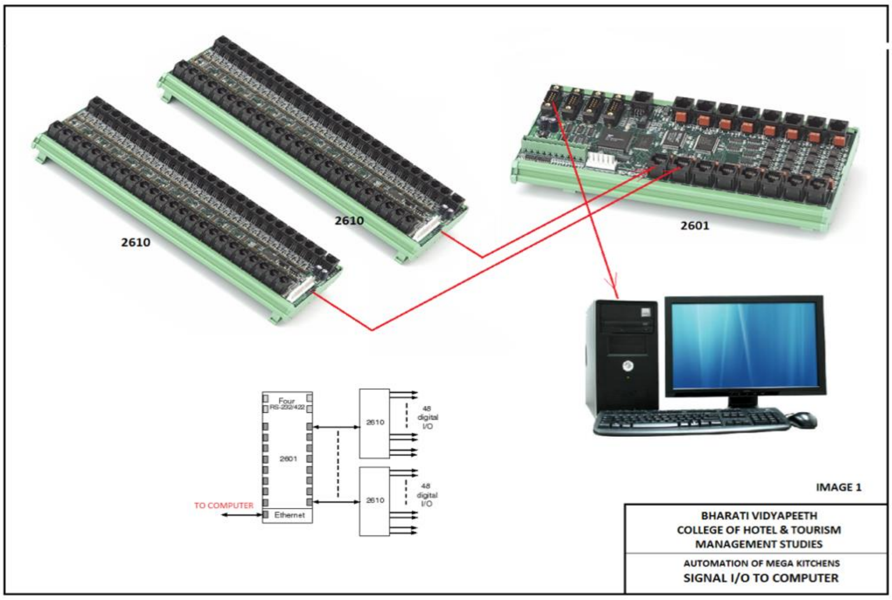



**Ground floor plan for processing rice**



**Equipment**

**Signal input / output to & from pc**

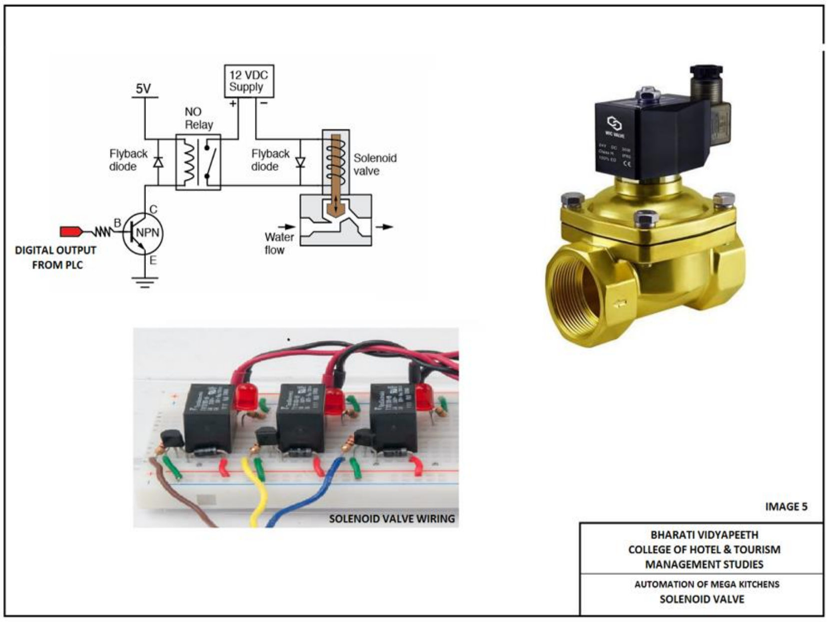



**Double jacketed steam-based rice cooker**

**Industrial boiler (for steam production)**


**Hydraulic lifting trolley**

**Lenoid valve**




**Automatic packing machines**