

## **ADVANCED PROCESS CONTROL IN FOOD INDUSTRY**

## Table of Contents

Introduction.....	2
Overall Process Description.....	2
Process Flow Diagram (PFD) .....	4
Detailed Process description for Section 3 .....	7
Process Control Philosophy .....	10
Piping and Instrumentation Diagram .....	12
A HAZOP on the P&ID.....	13
Conclusion .....	15
References.....	16

## **INTRODUCTION**

The food industry is one of the most profitable industries in the world. In this global competitive scenario, it is difficult for the organizations to survive without proper use of effective and efficient process control techniques to increase yield, minimize the cost of production, and improve quality of food. The food industry found a new path of progress with modern control strategies like model-based control and artificial neural networks, and their utilization have opened a new gateway to the food-related industry. Food processes are found to be nonlinear and depict various dynamic processes consisting of different raw materials and various condition of processing. The classical control approaches have proved to be highly expensive, and modern food processing techniques are cost-effective. The report aims to present the entire control processing techniques of the food industry. The report further aims to give a process flow diagram for a piece of machine or equipment. The report aims to describe the flow diagram functional system and reveals the process control philosophy. The analysis of the piping and instrument diagram will be made in the report. HAZOP on the P&ID will be conducted.

## **OVERALL PROCESS DESCRIPTION**

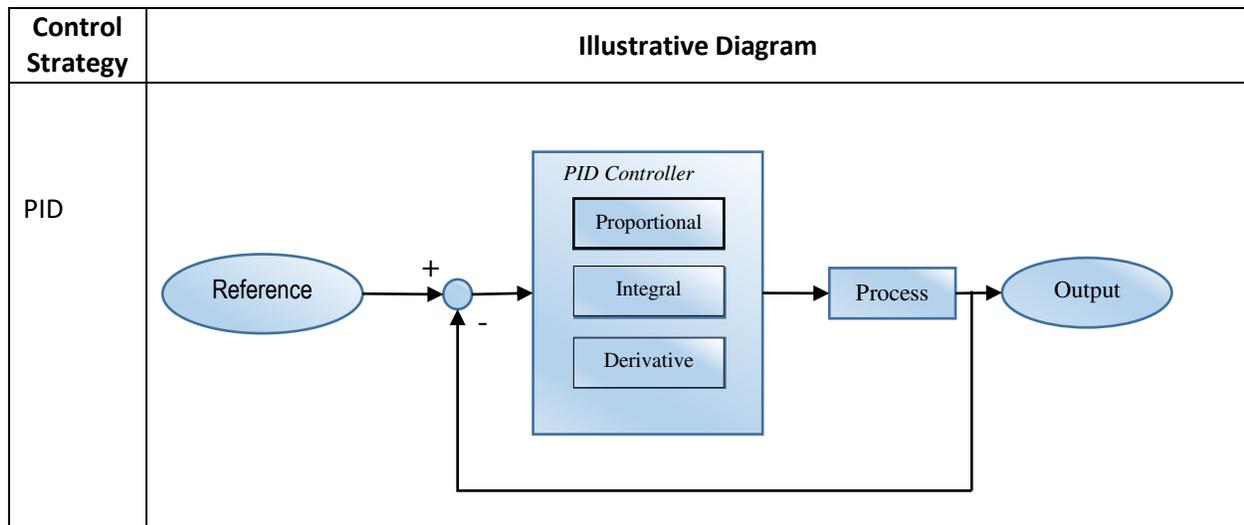
Inside a food process control, it is required to establish the relationship between raw materials, end, end product outcomes and products setting. The traditional control strategy is still being used, and proportional integrative derivative represents the classical food processing control technique (Moscicki &van 2011). The technique is applied for low ordered, linear dynamics. There are advanced techniques that contribute the food processing techniques such as neuro-fuzzy control, expert system and hybrid control system. These can bring the advantage of different food processes(Moscicki &van 2011). There are many food processing control techniques like nonlinear process control, model predictive control, batch process control and finally, design and control integration. The linear characteristics actively led to effective food processing control. There are many food processing control systems which are to be

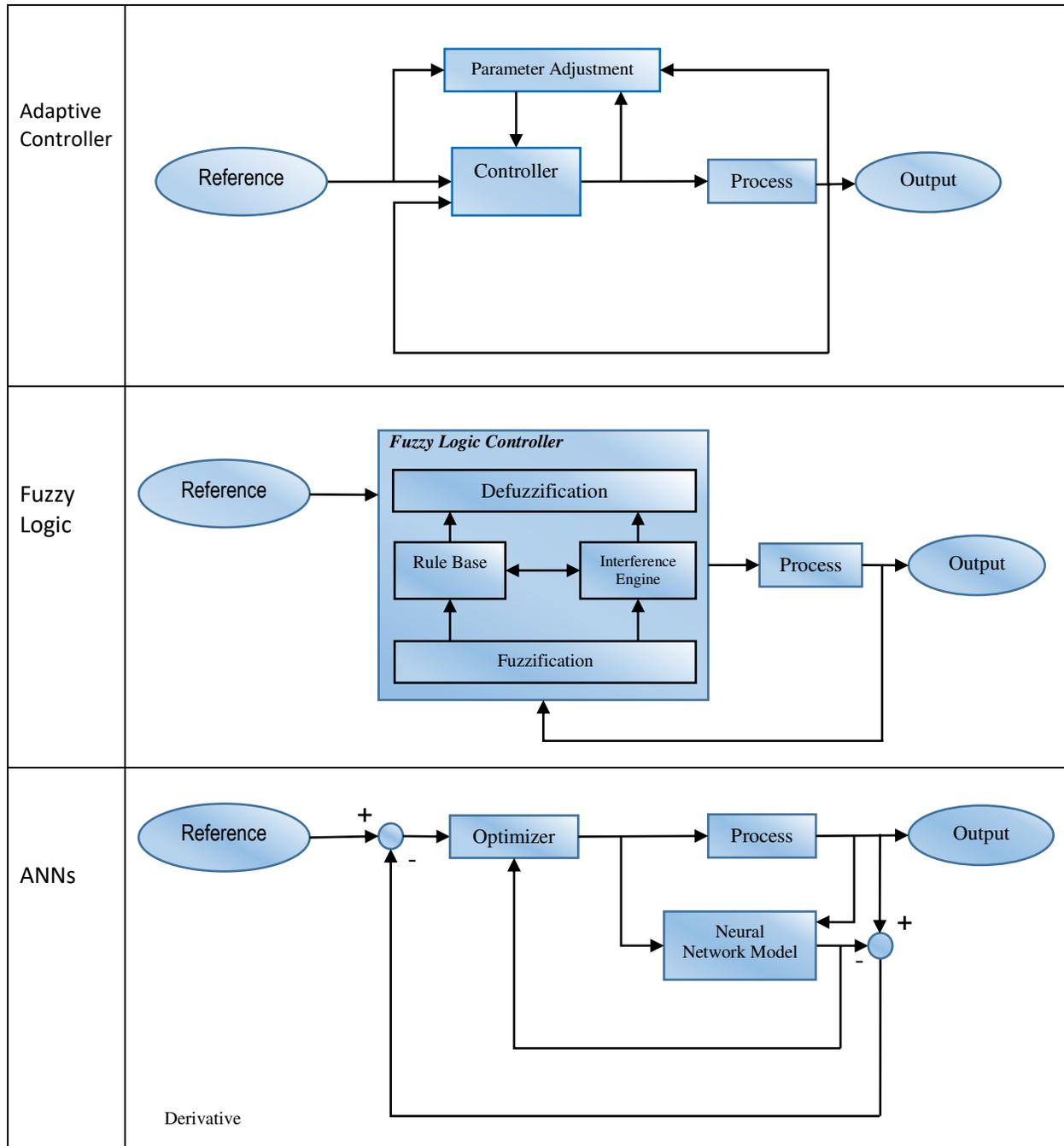
discussed here, and its application would be made in the baking process control (Moscicki & van 2011). One of the most effective techniques of food, processing control is adaptive control strategy. It has the capability to adjust automatically for changes in the process by regulation of setting. It can be divided into two types, namely STC (self-tuning controllers) and MRAC (model reference adaptive controller (Kondakci & Zhou, 2017). Parameter estimator is accountable for applying the output and input process for predicting the parameter process online (Kondakci & Zhou, 2017). The change is made in the process to adjust its setting. Intelligent Controllers is yet another food processing control technique is used for the higher-order dynamic processes. Failure detection, process history and heuristic are generally utilized to settle the parameters controller (Kondakci & Zhou, 2017). The fuzzy controller is here a rule-based technique or approach which employs logical connectives like IF (condition) and then (termination). Biological processes generally follow a nonlinear pattern. Hence, it can be considered as one of the best food processing control method (Kondakci & Zhou, 2017).

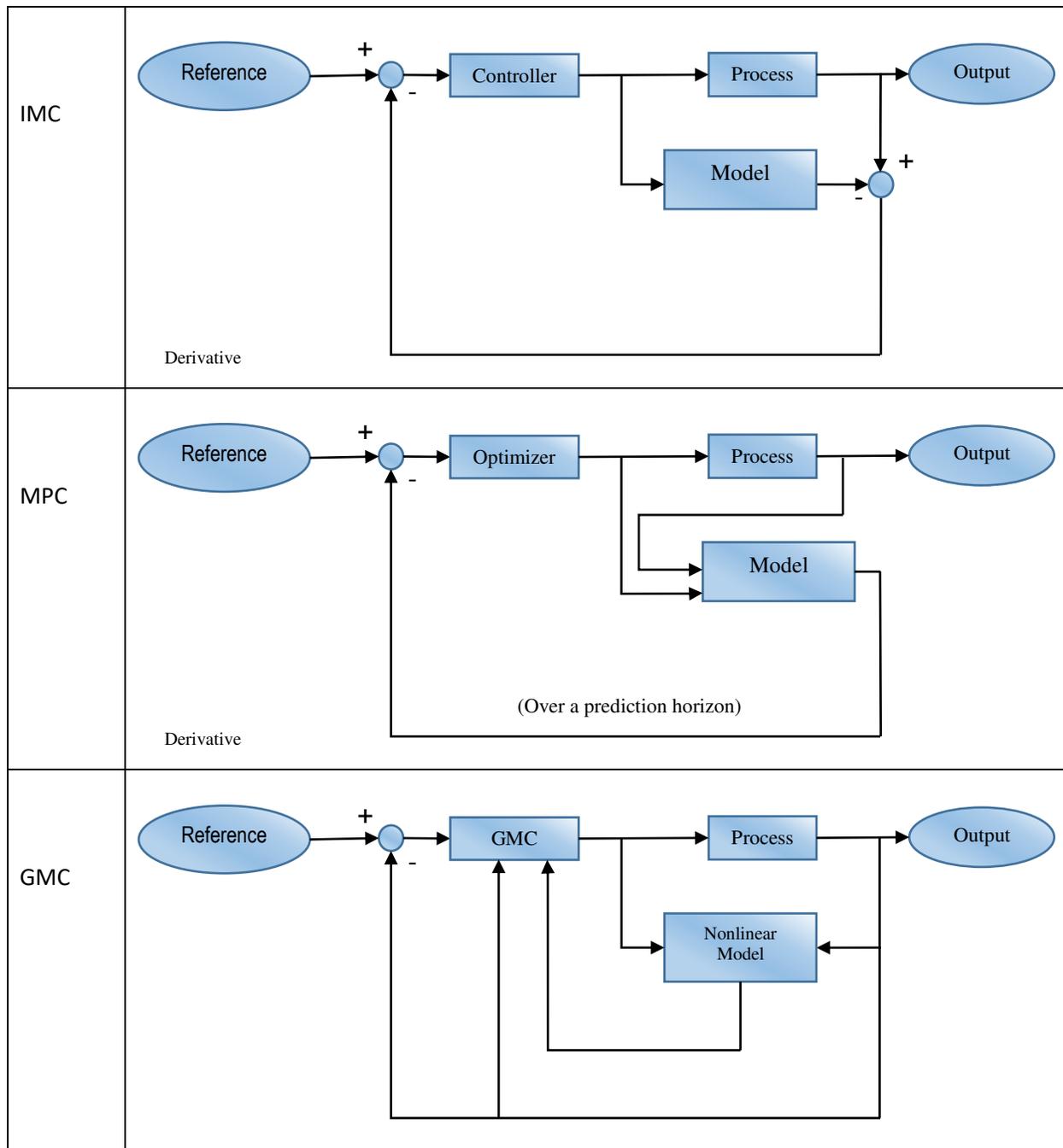
Neural Networks (Artificial) is one of the best food processing control method. It is a dynamic system which is comprised of an easy version of neural networks of biology within the brain. It uses output-input data for recognizing and the patterns for controlling process. It requires having computational power for the inception period of the food processing (Kondakci & Zhou, 2017). The model-based control technique is yet another technique which is empirical or analytical in nature. A method needs to be simple, precise, applicable, and stable for the purpose of controlling online in this technique it is the IMC and MPC which are applied to find the effect of the method. IMC lays stress on the inversion model and process forward. These are employed in the main components in closed-loop feedback. MPC formula employs a linearized model for getting the response for the controlled processes. Data acquisition and supervisory control technique are one of the best and effective control techniques of food processing which is employed to keep control over the food processing. It attempts to collect data of the processing network and uses the actions to control the various parts of the network process. It includes some advanced control system as well as PID.

In Baking system, baking food processing system involves the mass and heat transfer which brings about changes in the physical and chemical dough properties. It is a dynamic process. The bondage between baking parameters and dough leads to a change in the quality of the food baked. Application of appropriate strategy helps in producing quality food. The above mentioned fuzzy food processing control method finds s relevance in the baking food processing control system. It was an older method used in cooking processing of bread extrusion. The advancement and modification have been brought in the technique with the incorporation of the object-oriented small talk/v programming environment, which was implemented to make a fuzzy expert system. The control system was supported by the Federal Research Centre in Detmold in Germany. The model-based control system is also applied in the cooking extruders and baking oven. It is a complex and time-consuming but effective method.

### PROCESS FLOW DIAGRAM (PFD)







(Source: Kondakci & Zhou (2017))

### **DETAILED PROCESS DESCRIPTION FOR SECTION 3**

The entire process of manufacture, as well as the processing of industry, is a lengthy as well as difficult. It is time-consuming and requires the effort of a huge number of workers as well as advanced technology and machines. The control process system helps to this entire process. The process is made faster and errors free, and it becomes easier to handle and maintain the procedure. The control process, as shown in the above diagram, helps to deal with this issue better and makes the entire process faster and better. In this section, we will discuss in details the diagram and its application. For bioprocesses and food, modelling can be referred to as time-consuming, difficult, and complex. With the help of the internal process model, MPC performs better in the optimization of action controlling where single output can be achieved through a single input (Kouvaritakis et al., 2016). The advancement of the model is better than the food extrusion cooker associated with PI control. DTPC (dual-target-predictive-control) is further predictive multivariable control strategy to allow output and input variables for monitoring which serves a better purpose for food extrusion control.

SME (Specific Mechanical Energy) depends on screw speed to obtain the production of flatbread with the help of extrusion cooker with the help of twin-screw (Hoogeboom et al., 2016). In order to address start up modelling for the process of food extrusion, the neural network model is developed. However, to justify the model devices for measuring moisture which can be helpful for distribution centres, residence time, colour and flavour sensors need to be associated with the referred model. Further, the advancement can even be achieved through fuzzy control system as it is potential enough to make a balance between torque and speed. Sound recording system installations can even an advancement for the process. In order to

evaluate certain things like pressure, temperature, expansion rate and moisture content, acoustic data are a better approach to address. It can be referred to as an assisting process control tool for the in-line process. The systems can be helpful for utilizing mechanic and torque energy to adjust pump speed and liquid speed. SCADA is a better system which can be implemented to have a satisfactory result. A methodology can be developed to improve the baking quality where fuzzy control helps to proceed with a smooth flow in the process. Fuzzy logic is used by the control system. The entire process shows that it has an effective controller of the time so that the workers will be able to set the time and manage the entire process within the stipulated time. Specific mechanical energy, along with control torque, is applied in the system to ensure that the system is working well and meeting the required criteria of the baking bread process. The closed-loop control helps in keeping the good quality of the biscuit and the bread, and this helps to maintain the best quality of bread and deliver the same to the customers.

Application of food processing control method has another effective technique which is used in the baking industry. A method is developed for the banking industry, which is a closed-loop control method that controls the biscuit quality at the time of baking. It used fuzzy sets for sustaining a smooth control. It helps in the smooth flow of the process. The fuzzy logic used by the control system. The system supports fuzzy logic which helps in sensory diagnosis, evaluation and decision. In the baking industry, a two-dimensional fluid computational method is used for the process control design that will support the bread-baking oven in the baking industry. A new integrated system called feedback control system was developed, and feedback was received on the preheating step of the oven in the CFD model (Vyzikas et al., 2017). It was studied on the basis of simulated process control results. With the optical system, the digital processing control system can be used for controlling and monitoring a baking process. In order to calculate the

colour saturation and lightness of the products of the bakery, the baking process, which is based on a neural network model, is identified.

Thereby it is a much-clarified concept that baking application has a different advanced system for process control as per the discussion. In a summarized part it can be stated that mechanical energy is the main base for the application of flatbread through the adjustment of screw speed which helps in the improvement of the process by accessing certain factors like neural networks, fuzzy logic and control approaches based on the model. In order to offer insight for biscuit and bread baking process support application for the operators to make a decision, image processing and preheating steps are mandatory and significant. All the stated factors are important to improve the quality of the product through control strategies depending on the several models and implementing neural networks.

The highest energy-demanding procedure is drying having its most use in the food industry consuming biotechnology, agriculture everything (Andres et al., 2015). The preliminary target of the process is to reduce the moisture content from a product by utilizing thermal energy, which is much helpful to prepare the desired characteristics of the referred product.

Considering the varied range of dry food, it is quite impossible to project a single system or controller type to grasp all types of product. Thereby different MPC (Model Predictive Control) strategies need to attend (Grune et al., 2017). The optimal controller is effective to reduce 18% time for drying where fuel consumption can be decreased by 6.4%. Summing up all these reflects that the total cost of production decrease by 1.3%, which is much appreciable. Using MPC is even beneficial to reduce the energy cost up to 1.2%.the online control system can even be obtained for drying process which facilitates stability and high accuracy to get the

overview of moisture content for the product. Recently LV-MPC (Latent Variable Model Predictive Control) is being investigated to analyze the temperature of the control process (Sæmundsson et al., 2018).

## **PROCESS CONTROL PHILOSOPHY**

Food process controls have several legit objectives and help the food process control industry. Its focuses on several aspects like the safety of the food, quality of the food and also maintaining a robust system of control. This helps in maintaining a healthy atmosphere of a food processing unit in the industry. Recently various advance process and the methods of control have added to extra benefits of the food processing unit (Pinto, Giordano & Giordano, 2009). The bread baking machines not only ease the process of formation of the bread, but it also assists in the process of making the entire food system contamination-free and free from any disease-causing germs. The benefits that the process control philosophy imparts are highly recognised by the people and also appreciated. It improves the product quality of the material like the lightness of the bread, colour of the bread; the amount of browning can also be done correctly and desired way. In addition, it has got various other sensory attributes attached to its benefits (Petre, Şendrescu & Selişteanu, 2011). This is done by employing neural networks and control strategies that are based on the model of the products. The most important fact about the process control system is the reduction or complete elimination in the process of contamination of the baking process of bread. It reduces the risk of germs and other mishandling of the process of baking and assists in the production of quality products in the market. The process control system helps to deliver and produce quality products in the market along with reducing the chances of contamination of the bread and the baking process of the bread. Also, in the control system, the

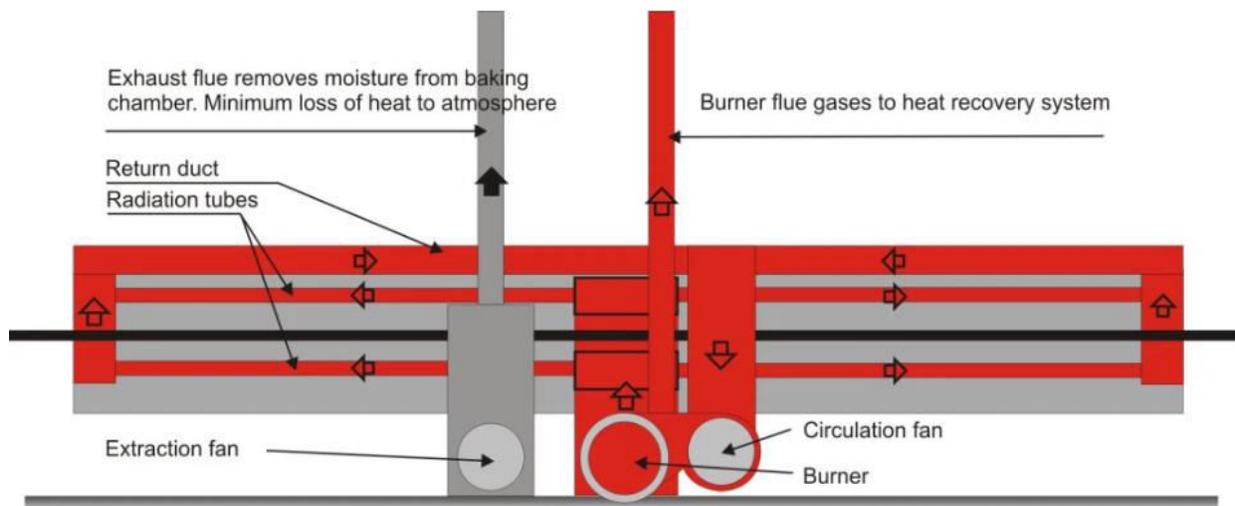
process of baking can be controlled in a desired manner. The amount of brown texture, stiffness of the bread as well as the softness of the bread can be controlled in the best manner by using the process control system.

Any food industry has a number of ethics and philosophies attached to the business strategy that any given food industry must adhere to in order to get the best results from the industry. This will also ensure that the industry will acquire a better position in the market and also acquire the trust and the satisfaction of the customers. The first and foremost ethics that is attached to this industry is to maintain the best quality of food and also to supply the same in the market. The process control system helps to achieve this and also maintain the sustainability of the business. It also helps in the process of enhancing the brand image and the brand value of the food processing unit. In the season where the work pressure is very high, and the people need to work harder to meet the demands and the needs of the huge number of customers in the business. This will be made simpler and easier by the process control system of the bread baking industry. It will help the baking bread unit to produce a huge number of products in a limited time period and also to deliver the same in the given time period. The ethics and the philosophy attached to food industry generally describe the process of food, processing, manufacturing and delivering the same in an honest and unethical manner (Paquet *et al.*, 2012). This helps the company to attain the required reputation in the market and provide the best kind of products in the market. It helps in maintaining the sustainability of the company in the market and so on. The process control system, as mentioned, elaborated and depicted in the above diagram shows that the control process is formed with an advanced technological process and techniques. This modern technique, as depicted in the diagram, helps to keep the food free from contamination and also free from the germs and poor materials. It ensures that the bread is baked with the best

quality of materials that is available in the market. In the era of new technological and social changes, it has also increased the demands of the people from food processing and units. A critical analysis of the ethical concerns about the food processing units mention that have emerged, raising public awareness and calling attention to ethical issues with respect to food.

These areas increase the scope and create greater awareness of the people regarding the ethics and the philosophy of the people. However, the philosophy related to the food process control and the advanced technology associated with it is subject to constant debate, and the dimensions are changed with each passing. The basic and the primary philosophy that is attached to the above process control diagram is to provide the best quality of food that is free from contamination.

## PIPING AND INSTRUMENTATION DIAGRAM



Piping and Instrument Diagram

Source: ("Baking by Infrared Radiation", 2019)

## A HAZOP ON THE P&ID

Guiding Word	Deviation	Causes	Result	Actions to be taken
More	The pressure increase in the oven (Guiochet, 2016)	Failure in compressor control	High-pressure oppression of tank	Automatic emergency shutting down triggering
Not	Stop of the flow in the compressor	Closing of the control valve	Increase the pressure caused in the compressor	Equipping with the relief fo pressure valve in the compressor
Less	Less time for oven heating (Guiochet, 2016)	Malfunction in the valve opening	Initial concentration inconsistency (Guiochet, 2016)	Check-up and periodic maintenance on the valves
As well as	Highly increased level of temperature reaction	Fail of the oven in hot stream valve (Guiochet, 2016)	Destruction of the instrument in the valve as well as reactor, transmitter and sensor.  Yielding of product is not at the good quality	Fail close and fail open valve system is to be equipped with the reactor system.
Part of	Low heat value is	Failure of	heat value	Utilization of

	found in the record (part of)	thermometer meter	deviation in reaction. It may cause an inessential heat controller for the system.	enough sensitive heat or utilize the current technology in ph meter.
More	More coil is going in the Oven	The oven will be more heated	The oven will be overheated	To be used fail closed or fail open valve

In the piping and instrument of the oven, one of the hazards is identified here is heat. If the compressor or oven is overheated, it will damage the oven valve, and it may also set fire in the factory (Chong et al., 2019). The threats of the oven are heat cramps, heat stress, heat exhaustion, and heat stroke, loss of consciousness of worker, stress on legs, feet and back. It is necessary to identify the insulating material for reducing heat radiation (Chong et al., 2019). It is important to note that thermometer does not indicate the proper heat. It is important to cook only when there is a cooler part of the day (Chong et al., 2019). It is important to adjust the burners to make a clean-burning for reducing carbon monoxide formation. There is a requirement of a monitor to continue to check the co2 level. The fan is to be used only when the temperature is less than 35C (Chong et al., 2019). There is a constant requirement to check the pipeline pressure due to heat. The overheating or increased pressure in the pipeline of the oven may lead to the failure of the oven (Chong et al., 2019). It is necessary to wear tight-fitting sleeves while working with the oven (Schulze et al., 2019). The pressure of the pipeline of the oven is to be checked and analysed regularly to stay out of danger of reaction or bursting of the oven. There needs to be a system that can make the system shut down when the temperature rose considerably.

## CONCLUSION

It can be said that advance food processing control techniques are effective techniques to be utilized to achieve industrial products. The most effective food processing technique is a fuzzy logic controller technique which is highly advanced food control processing system. It can be employed in the food processing control system with effectiveness. Besides the fuzzy logic control method, there are several methods which are being used in the food processing industry that help in the development of the food processing industry. The study has analysed the risk of the pipeline of the oven. The hazards found in the pipeline system of the oven may cause great danger. There are automated systems that can control the hazards and risk associated with the internal system of the oven technology in the

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