



Novel solicitations of computer in food processing industry: A critical review

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Abstract

Computer Aided Design (CAD) has turned into an essential tool for solving engineering challenges in the various industries. To minimize wastage and increase output the food processing industries should use this tool to a greater extent. In food processing industry the two important places in which Computer Aids are required are Procedure management and mechanization and Manufacture scheduling. Currently CAD is used for many operations in food industry like packaging design, process flow sheeting, additive manufacturing, plant designing, food process modeling, and etc. The emergence of new technology affected on the main constituents of industry firstly, the diminution of power consumption, secondly carbon foot prints and thirdly the enhancement of food security and safety. CAD systems have huge potential to develop extra smart and eco-friendly products. Growth in more user's friendly specifically CAD application is principal to overcome the present gap between food production business and modeling in research. These efficient computerized ways demonstrate capable perspectives to help rising next generation feasible technology, customized to the novel necessities for the upcoming society and are likely to play more significant role in food research and development.

Keywords: computer aided design, modeling, automation, 2 dimensional, 3 dimensional

Introduction

The Computer aided design CAD systems are used to create, analyze and modify the design. A computer contains both hardware and software to perform specialized design operation. The software consists of computer program that apply computer graphics on system (Groover and Zimmers 1983). The properties of food such as physical, chemical, nutritional, sensory, and thermodynamics plays significant role in food manufacturing and processing. The knowledge of food properties is essential to get mechanical understanding of changes occurring during food processing. In process of designing and operating the processing equipment's the calculable information regarding food properties is required. Foods, due to their biological character and unpredictability, differ in the significance of their characteristics. The alteration in characteristics offers challenge for their assessment and utilization in food handling application. Often a high intensity of accuracy in measurement of characteristics is not possible as the measurement technique may itself cause changes to the product, resulting in difference in the obtained values (Singh and Medina 2012).

The need of the hour in food processing industry today, to have the efficient processes to manufacture product with similar and superior quality using low capital in raw matter and lesser energy consumption. In designing of any process or food in a food industry, it is important to consider the boundaries of technology because food are from biological source and they contain properties of unbalanced

multifaceted mixtures which requires to be studied at every step of the designing, imitation may not give a total representation of working process (Petersen and Drown 1985).

2. Computational fluid dynamics

Computational fluid dynamics (CFD) is powerful tool used in the food industry showed in table 1. It makes use of the powerful computers and applied mathematics for the modeling of situations of flow. From the late 1960's the use of the CFD has been increasing in all fields of the fluid dynamics (Parviz and John, 1997) [1]. CFD has the capability to foresee the process or the performance of the new designs prior to they going to be manufactured (Schaldach *et al.*, 2000) [3]. The process engineers, researchers and the equipment developers are more and more using the CFD to examine the performance of equipment and the flow, for example spray dryers, stirred tanks, baking oven, heat exchangers and much other equipment. In only the recent period the CFD program has been used in the food industry (Scott, 1994) [4]. The expansion of novel technologies and the food processing practices has been enhanced since the demand of consumers for the superior quality and convenient meals has been rising over the last some years. The use of the CFD in food technology provides the better understanding of the complicated physical mechanisms that governs the physical, rheological and the thermal characteristics of the food commodity. The fast growth has been taken place in food

manufacturing industry since last few years the reason behind this is the CFD tools.

Table 1: Applications of computer in food industry

Application	Description	Software's	Reference
Computational fluid dynamics (CFD) Computer vision Technology Food Packaging	It makes use of the powerful computers and applied mathematics for the modeling of situations of flow. The information about an object automatically collected and examined from a detected image. Packaging is significant operation for food to produce, distribute and sell to the consumer. There are many systems available in the market.	CFX MATLAB V5R18, 2012	(Parviz and John, 1997) (Francis, 1975) Marjudi <i>et al.</i> (2011)
Additive Manufacturing	It is a group of technologies characterized by a layer upon layer production directly from Computer Aided Design data.	Food Jet, Food Form 3D,	Pinna <i>et al</i> (2016)
Design of food process and food processing plant	Process design means design of food process, process flow sheeting, and design of processing and control equipment.	Aspen Plus	Saravacos <i>et al.</i> (2002)
Food process Flow sheeting	It is used in modeling of the steady state functions of processing and to calculate the design which develop product using least amount of energy and material	PACER	Petersen and Drown,(1985)
Measurement of Physical attribute of agricultural products	The detailed description of the irregular product geometric surface form/shape is significant for any related analyses used in both product quality evaluation and design of agricultural machinery systems.	3D parametric solid modeling	Celik <i>et al.</i> (2016)
Automation for a food industry	Automation in food industry in the form of computer-aided analysis and control engineering methods that facilitate sustainable development in the food Industry.	Aspen Suite	Papadopoulos <i>et al.</i> , (2013)
Nutritional Food Labeling Food safety detection technology	The role of nutritional food labeling is to provide the information that consumer need to maintain health and avoid risk of bad effects	Win Diets	Wise <i>et al.</i> , (2009) Dianxin <i>et al.</i> , (2014)

2.1 Applications of CFD

2.1.1 CFD in Drying

Drying is an ordinary food processing operation. The drying rate is depends on rate flow of the air velocity. Therefore, there is huge importance to identify the air velocity and air flow in the drying chamber for the appropriate drying operation. It is very difficult to find out the air flow and the air velocity during the operation of the drying, because various sensors needed to be placed in drying chamber at various directions of the air flow and location. So there are several problems in modeling the difficult conditions, particularly the instability of gas (Oakley, 1994)^[5].

To resolve this issue CFD has been used. Mathioulakis *et al.* (1998)^[6] utilized CFD in industrial batch type dryer to simulate the air movement. Drying tests of the various fruits were tested and the solutions shown that the amount of fruit dryness is rely on its location in dryer. To find out air velocity and the pressure profile by the application of CFD in dryer shown that the major reason of the deviation in moisture contents and drying rates was the lack of uniform speed of the air inside dryer.

2.1.2 CFD in Sterilization

It is known that product superiority, safety, prices are the focus areas of the consumer for food product. Thus, there is huge demand to improve the quality and assure the security of food delivery. To store and to preserve the food there is need of the sterilization technique. CFD be able incorporate to study together flow pattern and temperature sharing of food within procedure of sterilization so as to enhance the superiority of food products. Thermal processing is the most essential method of sterilization that consequences microbial inactivation however, in the meantime, loss in quality and flavor improvement. Extreme heating will influence the quality and nutritive characteristics of food. However, with the help of the CFD, optimization in thermal processing can be achieved (Datta and Teixeira, 1987)^[7].

The study has not been done on the sterilization of the food packets because in some recent years only, the food pouches have been introduced. The utilization of the CFD was done for the velocity profile, shape of sluggish heating zone and fleeting temperature of carrot soup inside pouches (Abdul *et al.*, 2001)^[2].

2.2 Commercial CFD codes

In some recent years the improvement of the CFD code has been in continuous progress. In various research areas the codes of the CFD are now able to handle the high intensity of the complications, this make it attractive to utilize in industries (Spalding, 1999a, b).

2.2.1 CFX

CFX is the branch of the AEA technology which is engineering software. There are many types of the CFX software. CFX-4, CFX-5 is used for the general functions, CFX-TASCFLOW is used for mechanical engineering design and study and CFX-PROMIXUS is used for mixer design. As we see in the food processing area the CFD has been used at high level like thermal food processing (Verboven *et al.*, 1997). In air blast chilling also process CFX software has been used. CFX-4 provides the potent tools like automated geometry forming tools, computer aided design access tools.

2.2.2 FLUENT

It is the world's biggest supplier of the commercial CFD software. FLUENT software is used in food industry for the improvement of the air flow conditioning in the processing of chilling and storage of the meat.

2.2.3 PHOENICS

PHOENICS is universal CFD software package. It can be used and run on each and every hardware platform. It can run on single processor to multi-processor super computers.

In 1, 2 and 3-dimensional geometry, steady flow and unsteady flow, it helps to resolve the equations like momentum, energy conservation. In PHOENIX there are some specific tools like for ventilation and heating FLAIR is used as tool, for chemical vapor deposition PHOENIX CVD is used as a tool.

2.2.4 STAR CD

This code is a commercial code of the CFD which resolves the various complications in the industry. STAR CD is used in industry to find out the heat transfer and flow distribution of the heat exchangers (Sorensen *et al.*, 2001).

3. Computer Vision System

Now a day's consumers are more aware about the quality and viability of food products. The mechanization in processing has stimulated the growth of testing tools in production line. The development in sensor technology has led to creation of the novel techniques of measurement of products, thus allowing permanent supervising throughout the process, with the implementation of visual inspection systems. Presently in some food processing industries, the assessment of the quality is done manually by skilled inspectors, which is costlier, labor consuming and wearisome because of its subjective character (Francis, 1975).

Due to the augmented demand of objectivity, efficiency it is needed to introduce the computer-oriented image processing system. The complicated size, shape, texture and color characteristics of food material can be measured easily by use of this technology.

3.1 Computer vision system

In a computer vision system, the information about an object automatically collected and examined from a detected image. Therefore the image is the heart of the computer vision system. Now a day's for assurance of the quality of food computer vision system is increasingly utilized in a food processing industries. In food industry and the research this system has many applications like quality assessment, control of robot, color measurement, grading, fault finding.

3.2 Image Processing

Basically, image is the group of the square components or pixels organized into rows and columns. Pixels are the main constituents of images. Brightness rate and location these two forms of information are generally present in each pixel. The image processing method has a very important part in a quality assessment of the food, in addition to get rid of the subjectivity of manual assessment and upholding the precision. In food quality assessment to expand an automatic system image processing system usually joined with instrumental and mechanical devices to reduce the human interference in process. In computer vision system image processing system is an integral part which manages the working of the machines (Li, Q. Z., 2002).

3.3 Matlab Tools

The numerical computing setting and the 4th generation programming language is known as MATLAB. It is made by Math Works. MATLAB let matrix manipulations, machinations of functions and data, interfacing with

programs written in other languages, application of algorithms and formation of user interfaces with C, C++, Java, and Fortran. In research and industry nearly about 1 million peoples had used MATLAB in year 2004 (Richard G., 2002)^[2].

3.4 Computer Vision Setup

This system mainly contains three parts as given below:

3.4.1 Lighting system

3.4.2 Digital Camera and image acquisition

3.4.3 Image processing

3.4.1 Lighting system

Two analogous lamps are used to light up the sample of which the image has to take. The temperature of the color light is nearly about 6500° K and rendering index of color i.e. (Ra) is about 95%. The lamps are placed like that it will make 45° angles with sample and 35 cm distance above the sample.

3.4.2 Digital camera and image acquisition

In this stage different devices are used to capture the images of sample like cameras, videos, scanner etc. Firstly, the real image is to be captured and after that it is converted into the digital form using above devices. The images capture in camera is to be processed in computer. The camera used should be present above the background and the distance is to be 30 cm. For the incidence of color the 45° angle was settled between lighting resource and camera lens (Francis and Clydesdale, 1975).

To keep away from reflection and external source of light the color digital camera and the light source were enclosed with black color cloth. The black background was used to capture the images. The images were stored in JPEG format. Finally the captured images were sent to PC for the image processing.

3.4.3 Image Processing

For the processing of the image MATLAB 6.5 software was used. With the help of software preprocessing, segmentation and color analysis were done. Preprocessing stage consists of image enhancement and the highlighting the features of object and to eliminate the noise. The segmentation procedure is depends on the resemblance of color of every pixel and its adjacent pixel. The alliance within section of image as well object fluctuating inwards scene was influenced by attributes of extraction (Gonzalez RC., 2009). After this stage in color analysis the reorganization and interpretation of the image were done.

3.5 Application in Baking

To monitor the baking products inside oven the image processing system was used. The baking process on industrial scale is a time and temperature-controlled process. The proper monitoring is required to maintain the even quality of the product. The digital image processing system was used to capture the actual images inside the oven. The final goal was to maintain the quality, avoid quality deterioration and color dispersion resulting in optical online process observing system showed in figure 1,2,5 (Paquet, D.O. 2011).

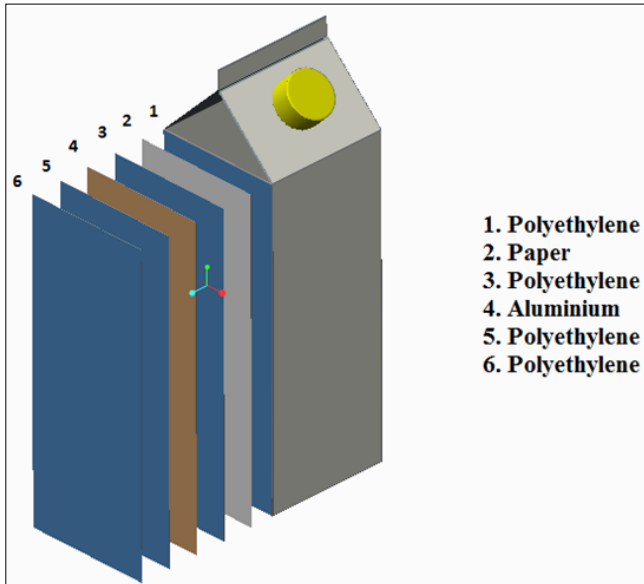


Fig 1: Packaging design created in CAD software

3.6 Application in Fruits

In recent periods the necessity of the sorting of fruit for eating has grown extremely. The factor used in sorting operation is appearance of fruit. Appearance is an attribute which is used in judging the quality whereas it contains measurement like shape, size, texture, color, brightness. On categorization and sorting of fruits numerous researches has

been developed. In marketing and sales of fruits the exterior quality plays significant role. To meet the consumer requirements the computer vision system is incorporated in assessment and grading of fruits, showed in figure 6 and 3 (Brosnan and Sun, 2014)^[8]

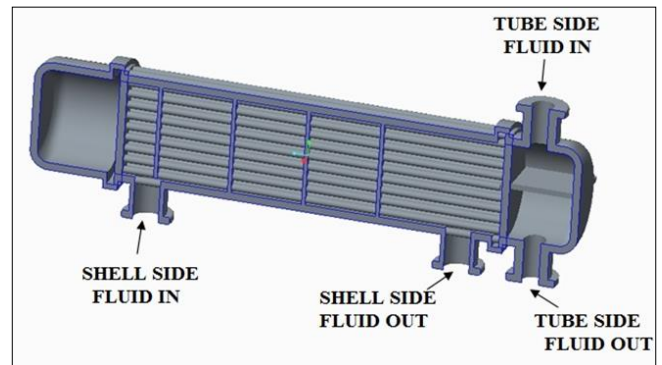
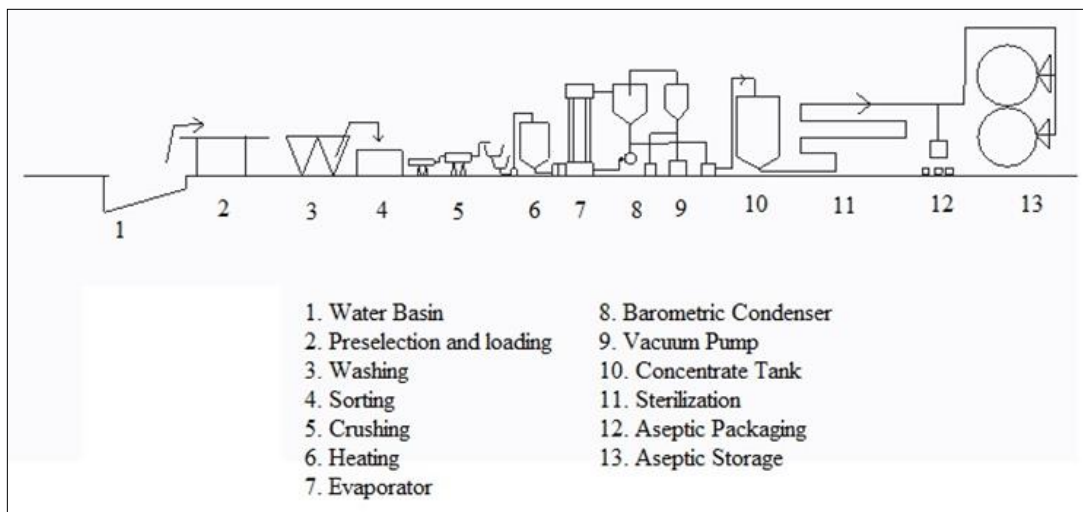


Fig 2: design of heat exchanger in CAD



Fig 3: Measurement planes of geometric features of the Pecan fruit



Source: Saravacas et al., 2002

Fig 4: Process flow sheet of tomato paste plant

4. Food Safety

The development of science and technology computer technology played significant role in different manufacturing industries. In food industry food safety is the most significant issue. The computer technology helps to resolve this problem. Presently at broad level various international systems are used for food security in food industry like GMP (Good manufacturing practices), HACCP (Hazard analysis and critical control point), ISO 9000 and GHP (Good hygiene practices). We judge the food safety by the use of limited standards. Before it is not possible to judge rapidly but now with use of computer technology the judging gets simpler.

4.1 Food safety detection technology

4.1.1 Chromatography

This is a widely used technique of separation and examination in various fields of biochemistry, organic chemistry and chemistry. This is the If you want to control our food security; you must strengthen the application of information technology. The chromatography is a method of separation and analysis, which is widely used in the field of chemistry, organic chemistry and biochemistry. Chromatography is the use of the principle of different matters that have selective distribution in different phases; the different matters in the mixture will move at different speed following a stationary phase, finally we can achieve the separation effect. Chromatography technology has many

advantages, such as high separation efficiency, wide application range, fast analysis speed, less sample consumption and high sensitivity and so on.

4.1.2 Mass Spectrometry

Mass spectrometry (MS) is a detection method by using the electric and magnetic fields to separate the moving ions (electrically charged atoms, molecules or molecular fragments, molecular ions, isotopic ions, fragment ions, rearrangement ions, multi-charge ions, meta-stable ions, Negative ions and ions produced by ions and molecule's interactions) according to their ratio of mass and charge. As long as the accurate quality is measured, the composition of ionic compounds can be determined the test depends entirely on the application of computer information technology.

4.1.3 Atomic Absorption method.

When the radiation goes through free atomic vapor, and the frequency of incident radiation is equal to the sum of needed energy frequency of the electrons in atoms jumping from the ground state to the higher energy state (under normal circumstances is the first excited state), atom will absorb energy from the radiation field and resonance absorption will be produced, electron from the ground state jumps to the excited state, accompanied by the absorption spectra of the atom. Atomic absorption method is through this principle to detect the metal elements in food, and detection equipment is also dependent on computer information technology.

4.2 Food safety traceability system

As per UN Codex Alimentarius Commission food traceability refers to the ability to trace the any given stage of food production, processing and circulation and As per the European Commission food traceability refers to the possibility of finding and following the trace of food, feed, animal used for food production or for possible material used in food or feed in the whole production, processing and sales process (Hui and Yufa, 2005)^[9].

In recognition of individual or group of manufactured goods it is required to have simple detection, easy compilation, low price and easy to recognize information into the database. Computer technology has four aspects in traceability like GSI system, traceability information database, RFID technology and bar code technology.

4.2.1 Global Identification System (GSI)

GSI a is open standard system service which help in logistic supply chain, whose foundation is in code of trade, logistics Unit, product classification, service relationship, trade, electronic data interchange, global data Synchronization, assets. International Article Numbering Association helps managing and formulation of GSI. In different areas like logistics, e-commerce, e-government, trade, medical, building material, textile, food and others this system is widely used. In all over world nearly about 145 countries and 1000 enterprises and companies are using this system (Dianxin *et al.*, 2014)^[10]

4.2.2 Traceability Information Database

Traceability information database is the key technology of the food safety traceability. Information technology is the base of the traceability system and it must be depend on it.

The unique recognition on outer surface of packaging the packaging material is depends on the database. To get the related product data the unique recognition is the way to go into the database. The database system is basically divided into two systems firstly the single data system and secondly the multi data system. In single database system in food supply chain the provider of logistics and enterprises uses central database. By giving the input of code of product to database the information about the product can be achieved. The track rapidity is very much faster and transparency in system also gets improves. In multi data system the main disadvantage is each enterprise has to set up their own database. This system have low transparency rate because of that it creates problems in traceability and security regarding food safety (Chai *et al.*, 2009)^[11].

4.2.3 Radio-frequency identification (RFID)

To transmit data RFID technology makes use of radio-frequency electromagnetic fields. It is non-contact wireless technology. The tags are connected to object to automatically track and identify particular object. The tags connected to object have electronically saved data. There are some tags which can accessed from few meters by the use of magnetic field. The tags which are works on battery can be accessed from nearly about hundred meters. RFID tag contains 1 dimensional and 2-dimensional bar codes. In various industries these tags has been used. The major advantage of this technology over barcode is it can read 100 tags at a time but barcode can be read only one at time (Vedpal, 2016)^[12].

4.2.4 Barcode Technology

The optical machine-readable illustration of data associated to object for which is attached. Basically, barcodes are represented by parallel lines differentiating in spacing and width is called as one-dimensional barcodes. Later they represented by different forms like dots, rectangles, hexagons etc. are two-dimensional type barcodes. Barcodes are basically scanned by the device called barcode scanner or reader. Barcode scanner is an electronic device which contains light source, lens and light sensors. This scanner is connected to computer which access the data scanned by the barcode (Vedpal, 2016)^[12].

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