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Automatic Dough Draw Robot System Design

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Abstract

This robot system was designed to eliminate the human factor in the factories where bread production is provided and to enable the establishment of faster and sterile bread production lines. How the robot system works; doughs placed on bread baking boards machine. The automatic dough drawing robot takes these boards on to the machine. The doughs on the machine are drawn to the doughs for good cooking.

1. INTRODUCTION

Automatic dough drawing robot will enable the production of bread in series. Speed and time are the most important elements in bread production facilities. This robot system will increase the productivity in bread production. Bread consumption in our country is quite high compared to other countries. Robotic systems are essential to meet this need quickly. In many European countries, bread is produced with automatic systems. robotic systems are essential for production without human factor. Turkey is among the countries that consume more bread. Among the types of bread consumed, there is at most 250 gr bread. Human factor is in the foreground in these productions. Human factor will be eliminated with hhis machine system. Production will be made according to European standarts. 3- axis motion robot and image processing technology will be used in this robot system. The doughs on top of the machine will be rendered 3D by image processing. The coordinates of the doughs scanned in 3D will be determined. 3-axis robot will move according to the doughs whose coordinates are determined. The 3-axis robot will make the movement of the system according to the parabolic curve we have determined. Dough on the machine will be drawn on top. 3-axis robot system will make dough drawing process. As seen in Fig. 1.

Solak and Altınışık worked on image processing using clustering methods to identify and classify hazelnut fruit. In this study, images of hazelnuts were created by image processing and their shapes were also extracted. They also used the clustering method while performing these operations [1].

Eldem and Palalı, developed image processing techniques and face recognition system. In this study, face recognition was performed with image processing technique. Only the face detection process was performed in 2D [2].

Çankaya, Arslan and Ceylan, in this study, image processing is provided by following the neural networks on the photographed part. In the determination of the concrete strength, the phonograph of the

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cross-sectional surface of the existing concrete is taken and the value is determined on the phonograph. In other words, no direct image processing was performed in this study [3].

Çevik and Çakır, in this study, plates of vehicles were defined. Plate registration of the vehicles made by image processing method. İmage processing only as a picture made. The image was scanned and the text was determined. One size image scanning was applied [4].

Perihanoğlu, in this study, only details were extracted from the pictures. One-dimensional study was done on the scanned images. Matlab software and pictures are examined in electronic environment [5].

Gökçe, in this study, automatic storage process was performed. The positions of the parts in the warehouse are determined. The center mark to be recognized by the camera is affixed on the part. The parts are stocked after the positions are determined. One - dimensional image processing method [6].

2. AUTOMATIC DOUGH DRAW ROBOT SYSTEM DESIGN

The process of drawing the pulp is a very important part. For the dough to be cooked well, it must be scratched. The reason for drawing the dough is to cook the inside of the bread. The carbon dioxide gas comes out with the drawing of the dough. The dough is cooked in a better and larger way with the gas coming out. They are drawn to cook the whole dough. Dough drawing process is done with human. Worker draws on the doughs with the help of a knife. Speed is very important in the boot process. With human these speeds remain low. In this project, doughs are drawn with the robot system without human. this is done with the robot shown in the Fig. 1.

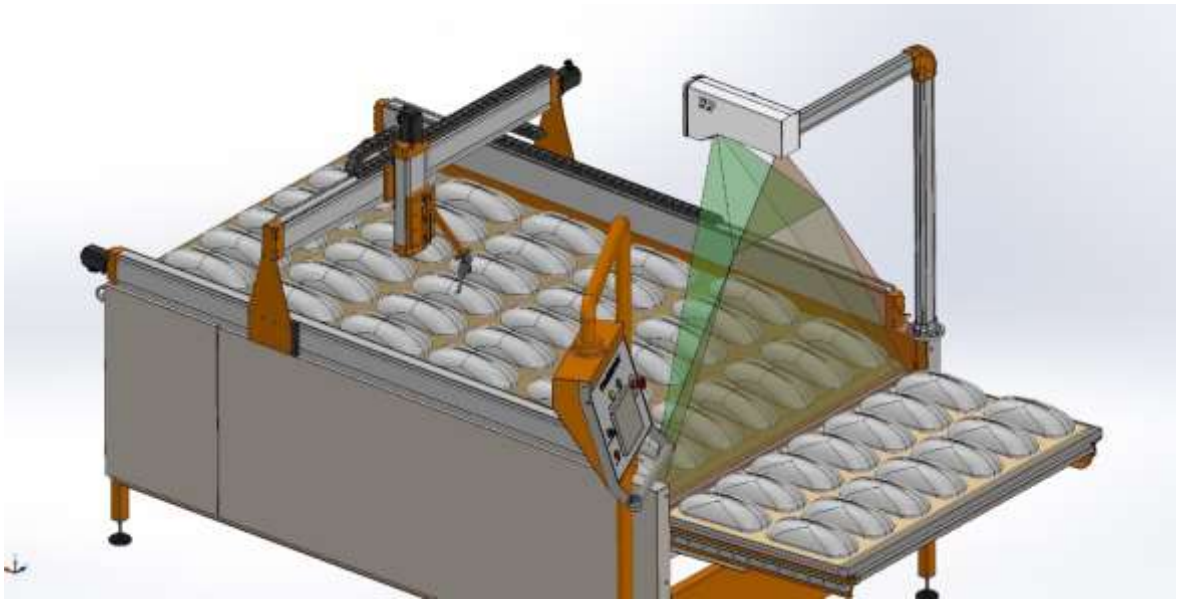

Figure 1. *Automatic Dough Draw Robot System Design*

2.1. Design Criteria

The most important part of the dimensioning of the robot system is the oven where the doughs will be cooked. Doughs are determined according to the oven size. İn Turkey production until dough bread are placed on board. The dimensions of these boards are 70x120 mm. 14 pieces of dough are stacked on one piece of wood. The design of the robot system is based on this 120 mm width. The depth of the robot system is determined according to the depth of the oven to bake bread. These ovens take 2 planks according to their size and max 5 planks. The working range capacity of the furnaces is such. These

parameters were taken into consideration when designing this robot system. As shown in Fig. 2, the doughs are transported onto the robot system. Robotic system length is determined according to oven size.

Figure 2. *Dough boot tip*

2.2. Automatic Dough Drawing Robot Working Principle

Automatic dough drawing robot system consists of 3 parts in itself. These parts;

1. Dough conveying belt system
2. Dough boot axial robot system
3. Control unit

In the operation of the robot system, as a result of these 3 parts working in conjugate with each other, it performs the process of drawing on the doughs.

2.2.1. Dough conveying belt system

The working principle of dough conveyor belt system is the same as conveyor belt systems. Dough from point a to point b transport. Dough is designed to get over the board. Boards with dimensions of 70x120 mm are placed in the machine. The robot system automatically takes the placed boards. The board remains at the bottom as a result of the import. The doughs are taken to the top of the tape. Dough removal process is made with a single axis mechanism. 0,75 kw 1400 rpm 3 phase electric motor is given to the system. This movement is drawn to the low speed by means of the reducer. The movement of the band on the robot system provides a drive shaft.

The drive shaft is covered with rubber. This shaft is rotated by means of a gear. The gear part takes its movement from the electric motor connected to the reducer. This band movement is provided by 3-phase 1,1 kw 1400 rpm electric motor. Roller bearings are used throughout this system. Axial movement of the table is made linear bearing. There are 2 sensors on the system, these sensors are the stop sensor and the deceleration sensor. 2 electric motors and 2 sensors are controlled by PLC. the detailed view of this system is shown in Fig. 3 below.

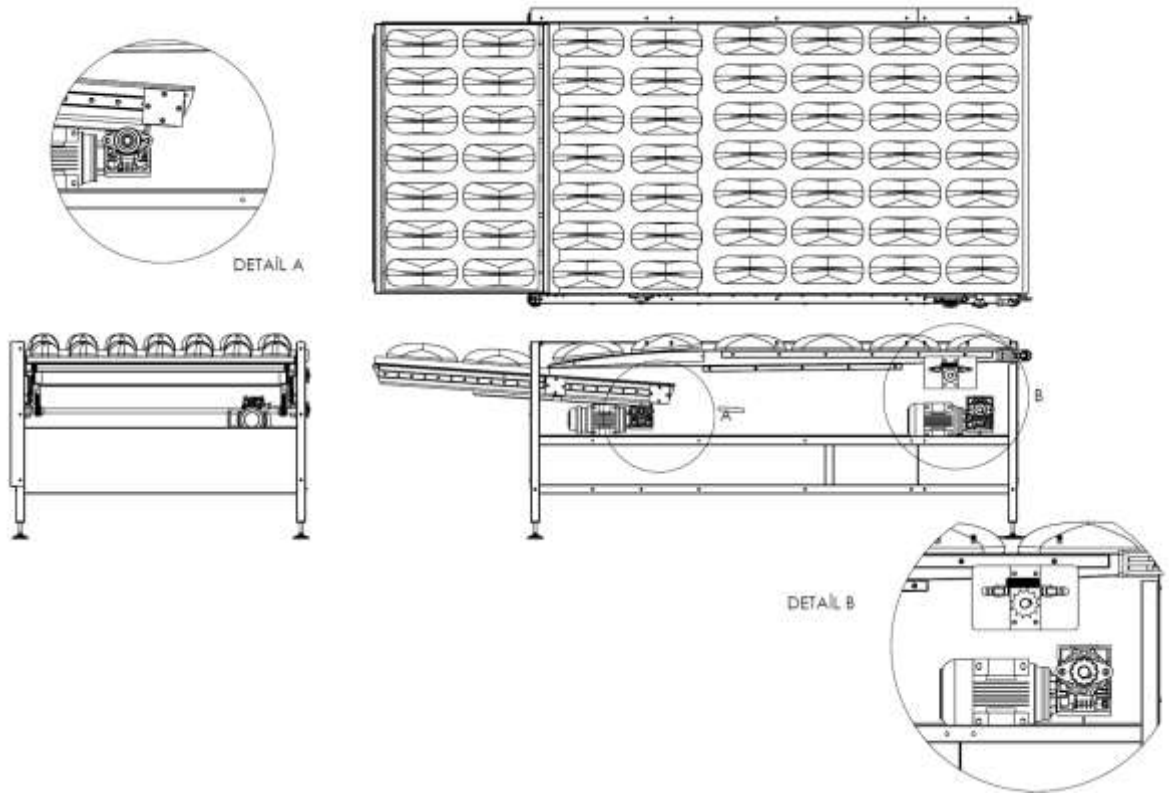

Figure 3. *Dough Conveying Belt System*

2.2.2 Dough boot axial robot system

The working principle of dough drawing axial robot system is to perform dough drawing by moving 3 axis. The design of this system is as shown in Fig. 4. These movements are to perform x and x ', y and y', z and z 'movements. The main purpose of these movements is to provide the cutter blade with access to all points of the dough conveyor belt system. The operation of the system; 3 servo motors are provided on the conjugate movement. The motion points of the servo motors move according to the technical data obtained from the image processing sensor which performs 3D field scanning. The doughs loaded on the dough conveyor belt are passed under the 3-D sensor and the positions of the doughs are determined. These positions are defined as x and y axis. According to these bread positions, 2 servo motors move to those points by positioning itself. The image processing sensor also measures the height at the same time and positions itself in the z axis according to the measured height value. These values are determined in the light of the parabolic movement of the dough is drawn on top. The movement elements in the system are coupled bearing elements in the squeezed profiles, in which the shaft and other pulley sets to be connected to the servo motor are ready.

The bearing elements which are ready for this three-way movement are preferred. Only the dough drawing knife and the degree of adjustment of this knife are mechanically designed. In this design, the maximum movement points of the system were determined and the knife clamping apparatus was designed by placing extra tolerances in this determination.

In the control of the system, PLC was also used, and the drives that enabled the servo motors to operate were preferred. These drives are determined by the motor power and the number of motor steps. Many

servo motors are operated as a team with drives. In our design, servo motor and driver are preferred as a team.

Figure 4. *Dough boot axial robot system*

2.2.3. Control unit

Automatic dough drawing robot system is controlled by PLC. The elements in which the control is provided in the system are given below.

- 1 piece three-phase 0,75 kW electric motor
- 0.55 kW three-phase electric motor
- 2 deceleration sensors
- 2 stop sensors
- 0.1 mm minimum pitch servo motor with 3 0.55 kW drives
- 1 SICK sensor with 3D scanning

The above parts need to be checked for the system to work. In the written program, the running speed of the motors is controlled and at the same time the reading sensitivity of the 3-D sensor can be adjusted. The mounting location and position of the control system in the automatic dough drawing robot are as shown in Fig. 5.

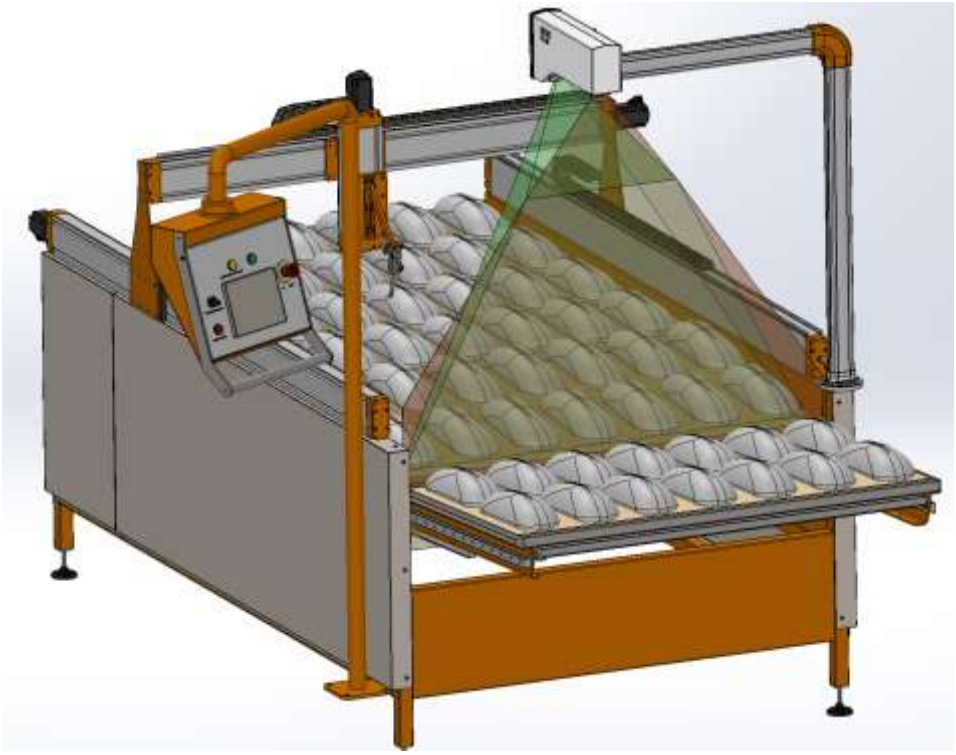

Figure 5. *Control Unit*

2.3. PLC and Image Processing

Automatic dough drawing robot can be provided by operating the PLC and image processing without any error in order to work as desired.

2.3.1. PLC

Automatic dough drawing robot system is controlled by PLC. Control of 2 three-phase electric motors, 3 servo motors and 1 deceleration and 1 stop sensor in the system are provided by gmt brand PLC. PLC system operates with 24 volt DC supply. 9-channel input 6-channel protected transistor output. 3 channels with 100 kHz 3 axis servo motor provides the opportunity to drive this system in our system of 3 servo motors is provided the opportunity to operate as a conjugate. The programming language of the PLC we use is the graphical ladder editor. In programming PLC, it is programmed with GMTSoft ladder editor software specially developed. Generally in the command system within the program; logic, mathematical, communication, fast counter and pulse outputs, time and counting relays are special purpose function blocks. In the PLC system, there is one main counter, in addition, expansion modules are used to increase and convert the inputs to the system. With this module, the desired inputs are transferred to the main PLC body [7].

The technical features of the PLC (Fig. 6) system to be used in automatic dough drawing robot system are given below.

• 24VDC supply
• 9 channels 24V DC PNP / NPN input
• 6 channel 24V DC 300mA short circuit protected transistor output
• 3 channels 100kHz with 3 axis servo / stepping possibility
• Modular structure, support up to 273 points with the possibility of connecting up to 16 expansion modules
• Network access via 100MB ethernet port
• MODBUS TCP Master / Slave support
• RS232 and RS485 communication ports

• MODBUS RTU protocol support
• Decimal operation support
• 12ns command processing speed
• DIN RAIL mounting
• 1 channel 0-10VDC / 0-20mADC selectable analog input (12 bit resolution)
• 1 channel 0-20mADC analog output (14 bit resolution)
• RTC (Real Time Clock) real time clock
• PLC internet connection service (WMI)
• E-mail sending function
• Possibility to connect 3 dual-phase (A, B, Z) encoders or 3 speed counters (50kHz)[8]

Figure 6. *GMT PLC*

2.3.2. Image processing

Automatic dough drawing robot is provided with the image processing sensor to identify the doughs in 3D. With this sensor, all details of the doughs are scanned in 3D. The system is moved according to the points obtained from this scan.

These sensors have emerged with industry 4.0 and have become the most frequently used tools in mass production. The characteristics of these sensors are given below.

• High speed and quality 3D measurement
• Provides reliable 3D control even in different colors, positions and heights of parts.
• Fast commissioning and control system thanks to intuitive user interface
• Integrated image analysis for fast parameterization.
• Fast instrument change thanks to guaranteed visibility and re-use of saved settings.
• Resistant to the harsh environment and harsh conditions of food processing
• Company calibrated data simplifies installation and saves time and expense
• High sensitivity to ambient light, accurate measurement and increased output in industrial environments.

• Industrial design with integrated laser light source guarantees trouble-free operation.
• High resolution 3D picture with density overlay.
• Material is not affected by the color and contrast
• Integrate with PLC systems
• Humidity, temperature, operating under severe conditions.
• 3D contours of moving parts
• Calibrated with software
• It works with laser triangulation method.
• Rugged IP67 metal housing with plastic glass.
• Usage areas; quality control of consumer goods: volume and thickness measurement, counting and positioning of objects, integrity check of boxes, content, completeness and void control, product sizing in food processing [9].

Sensor selection is based on the working area. According to this working area, the sensor system is positioned on the machine. If the sensor is not placed at the desired points, it cannot perform the reading process in a healthy way. The reading accuracy of the sensor is also determined by the location where it will be placed. For example Fig. 7 should be placed as is.

Figure 7. *Image processing sensor*

It is used in all areas where 3D scanning will be performed in Uygumala areas. Although it is often used in quality control units, it is also used in facilities established for full automation. It is used in 3-dimensional dimensioning of dough in food sector, detecting surface defects and counting pieces. The scanning of a 3 dimensional dough made by this sensor is shown in Fig. 8.

Figure 8. *Image processing sensor applications*

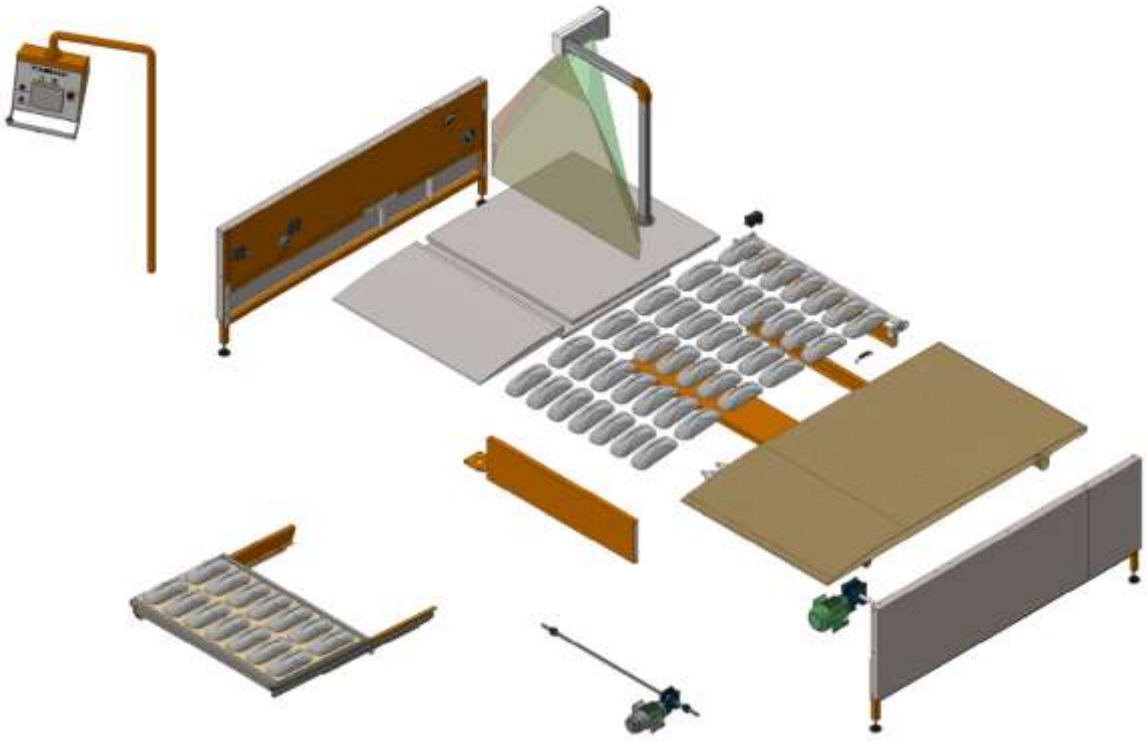

Figure 9. *Dough conveyor belt assembly parts*

The assembly elements and parts of the automatic dough drawing robot system are as in Fig. 9.

3. CONCLUSIONS AND RECOMMENDATIONS

Automatic dough drawing robot system in our research about any patent, utility model, name right, etc. studies have not been encountered. Automatic dough will be a robotic system boots made in Turkey and the world for the first time. So far the studies have been quite limited and the reason for this is limited by the human factor. The fact that they do these operations with the personnel in the production facilities is not a situation that affects their production and the fact that they cannot get the required efficiency from the mechanical systems made so far is the factor. Fixed mechanical systems which make line drawing process on doughs are made because these systems do not work efficiently because the dough is not fixed. Due to the different reactions during the fermentation process (deformation of the dough, differences in the amount of swelling, different physical dimensions of each dough, etc.), a system operating at full efficiency could not be constructed. Turkey is also not included in the product range of companies operating in this sector. The companies that make production abroad do not make this system because of different bread consumption and consumption types. In the automatic dough drawing robot system, the dough will work with full efficiency no matter which shape it enters. The working principle of the robot system is that it will scan the shape of the dough and perform the movements that we have determined through that shape.

Many methods will be applied in the application of automatic dough drawing robot;

• Field scanning
• Image processing
• Data transfer
• Value creation through data
• Ensuring system movement according to the result obtained by image processing
• Electric motor, servo motor, 3D sensor, deceleration sensor, stop sensor, etc. it will allow a plurality of parts to be operated concomitantly.

Fully automatic bread production facilities will be established with automatic dough drawing robot. It will enable mass production in bread production and facilitate product production under sterile conditions.

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CONFLICT OF INTEREST

Automatic dough drawing robot project is a project that belongs entirely to us. It is not related to a different institution or person. No conflict of interest was declared by the authors.

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