بسم الله الرحمن الرحيم

Palestine Polytechnic University

College of Engineering

Electrical Engineering Department

Graduation Project

"Potato Sorting Machine Based on LabVIEW with Image Processing strategy"

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الإهداء

إلى المعلم الأول إلى القدوة الأولى والأخيرة إلى الحبيب المصطفى، إليك يا من علمتنا بأن سمو الأمة يغدو على كاهل الشباب المتعلم، وأن كل شيء سواه يدبها في وحل الجهل والظلمات.

إلى أمي، أمي التي ابتدأت حياتي بها، وابتدأ إنجازي بها، ويخفي الله في علم غيبه مما عملته لي أكثر بكثير مما أعلمه، فلا يوجد كلمة شكر توفيها حقها، ولا يوجد جهد يقارن بجهدها، إليك يا من كنتِ دائما العصا التي يتوكأ قلبي عليها، وكنتِ السند الثابت الذي لم يتزحزح رغم ميل الدنيا كلها، فلا نجاح سوى النجاح الذي تنعكس فرحته في عينيك أنتِ، ولا إنجاز سوى الإنجاز الذي يبتدئ باسمك أنتِ.

إلى أول من همس لقلبي الله أكبر، إلى من حمل راية الإسلام منذ اللحظة الأولى فأضاء بها سبيلي وخطواتي، إلى أبي الحبيب.

إلى بوصلة العلم والقلب. إلى الأقصى الحبيب، إليك يا مبتدأ الطريق وإكليل نهايته، إليك نهدي هذا الجهد الضئيل. فماذا يملك الذي هو أدنى للذي هو أجل وأعلى سوى الضئيل الضئيل؟ لعل ما في القلب يغفر لقلة ما بأيدينا.

إلى نهر العلم اللامتناهي، إلى الذي صبر على تعليمنا طوال السنين الماضية. إلى البروفيسور سمير خضر.

إلى من كانوا سند القلب ومأمنه، إلى من اختارهم الله ليشد بهم عضدي، فكانوا خير مؤنس وخير رفيق، إلى إخوتي وأخواتي.

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إلى روح زميلنا الحاضر الغائب فينا، إلى نبضنا ومهجة فؤادنا إياد غيث _ رحمه الله _ وإلى طلاب تخصصنا وزملائنا وأصدقائنا وكل من شذا بعطره نحونا وجاورنا بلطفه وصبره وحلمه في مشوارنا.

إلى من كانوا قناديلنا عندما كانت تعتم الدنيا وتظلم الطريق. إلى من تقاسمنا وإياهم أوجاع الحياة الجامعية والابتلاءات التي يمن الله علينا بها عندما نبذل أنفسنا في سبيل الحق. إلى فرسان الكتلة الإسلامية.

إلى كل من علمنا حرفاً فأصبح سنا برقه يضيء الطريق أمامنا.

Table of contents:

Table of Figure Contents:

Tables contents:

Abstract:

This project aims at providing the local market with fully automated sorting machines capable to sort different sizes of vegetables and fruits. The proposed technology compares the object size with already installed image by using image camera integrated LabVIEW platform. As a result of the applied technology and control strategy the system is characterized with high production rate, acceptable accuracy and reduce time consumption which in turn avoid the probability of human errors and inaccuracy. A complete mechanical, electrical and control design were established for prototyping system by the LabVIEW Compact Rio controller.

When there are enough budget and investment, the designed porotype module can be scaled to a real size vegetable sorting system that can be sold for the local Palestinian agricultural market.

الملخص:

ماكينة تصنيف البطاطا حسب الحجم:

الهدف الرئيسي من هذا المشروع هو تطوير وتصميم نظام جديد ومتطور لتصنيف الخضراوات. وهذا يخدم القطاع الزراعي الفلسطيني. يهدف هذا المشروع إلى تزويد السوق المحلية بالات فرز مؤتمتة بالكامل قادره على فرز احجام مختلفة من الخضروات. التكنولوجيا المقترحة هي لمقارنة حجم العينة ومقارنتها مع الصورة المثبتة بالفعل باستخدام كاميرا مرتبطة مع منصة LabVIEW.، يتميز النظام بارتفاع معدل الإنتاج، والاستهلاك الدقيق والمخفض للوقت والذي بدوره يتجنب احتمال حدوث أخطاء بشريه وعدم وجود دقه عالية، في التصاميم الميكانيكية والكهربائية والتحكم الكامل للنظام والنماذج حيث يتم استخدام وحده تحكم ريو الخاصة بـ.LabVIEW .

وعندما يتم دعم المشروع بتمويل كامل، يمكن أن يتم تطوير المشروع كآلة إنتاجية للخضراوات ليتم بيعها في السوق الفلسطيني.

1

Chapter 1: Introduction

- **Overview**
- **Challenges**
- **Estimated budget**
- **Time schedule**

1.1 Overview:

The agricultural sector is an important driver in the Palestinian economy since it creates new jobs opportunities in the local Palestinian market. As of 2010, this sector was employed by 11.5% of the Palestinian labor force. The value of Palestinian agricultural production was estimated at $1,295 million for the year 2011 (70% in the West Bank, and 30% in the Gaza Strip). In regards agricultural trade, the value of agricultural exports grew by 32% from 2011 to reach $56.7 million in the year 2013, contributing to 6.3% of the total value of Palestinian exports19. In addition, agriculture plays a major role in the conservation of the environment, and supplies other sectors with inputs. [1]

According of the study that the Ministry of Palestinian Agriculture made, the results indicate from figure (1.1) that the average number of workers in a farm in west bank is 11.3%, 69% of them are male and 31% are female, Furthermore, the 75% are paid workers (formal), while the rest are unpaid (informal) since many of them are family members and owners of farms.

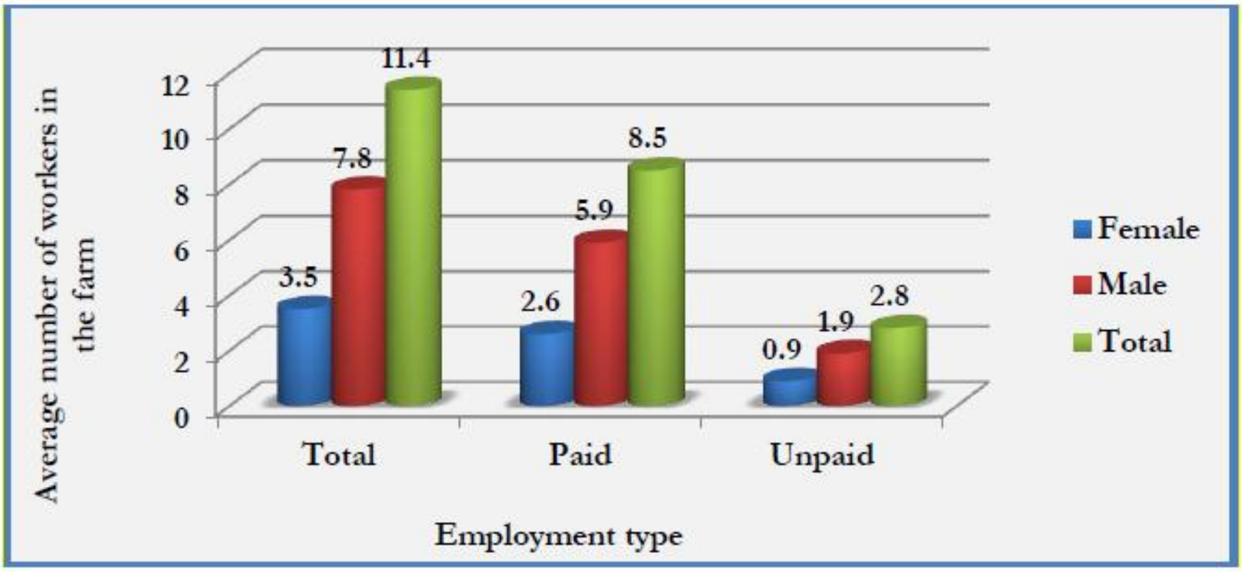


Figure 1. 1 average number of paid and unpaid workers in farms by gender

The best average income earned by Palestinian's farmer from Potato crop is the best income among the other crops. It was found that the estimated average income earned by Potato farmer's household from agriculture is 3,474 NIS. It was also noticed that the least income is earned by olive farmers, where their estimated average income per household per month reached only is 965 NIS as shown in figure1.2.

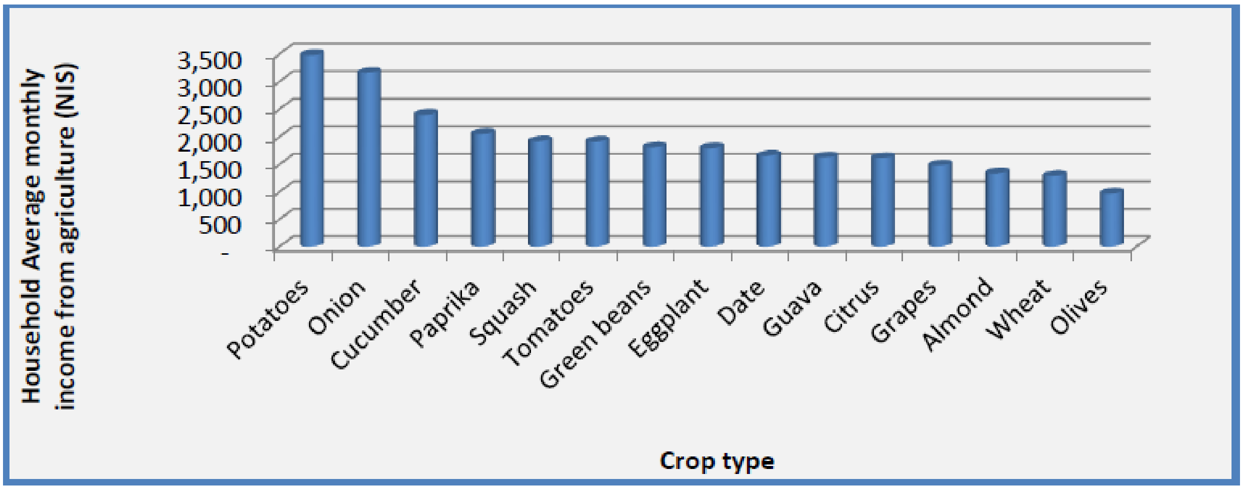


Figure 1. 2 Household average monthly income earned from working in agriculture by crop (NIS).

According to the Ministry of Agriculture, 10,835 dunum of agricultural land has been utilized for the cultivation of potatoes in the West Bank in the year 2012/2013. Accordingly, potatoes constitute 1.3% of total agricultural land cultivated in the West Bank. Furthermore, the project survey results indicate that the annual total production of potatoes is estimated at 37,552 tons in the West Bank, representing 7% of total production of all surveyed crops. Tubas governorate is the highest producer of potatoes, constituting 43% of total production, followed by Jenin governorate (27%), and Nablus governorate (25%).

As the research applied on Potatoes crops, the statistics shows that by the year 2009 the following numbers were taken as illustrated in table1.1. [2]

Table 1.1 Statistical Data for Potatoes in 2009 .

	Daily		(2-5)times every week		Once a week		Less than once a week
Frequency of Purchased	0.7		13.7		82.8		26.8
Purchased quantity each time	West Bank		Gaza Strip				
	5.6 kg		3.8kg				
Packaged vs. Non Packaged preferred.	Without Packaging		With Packaging				
	89.7		9.3				
Size Preferred	Large		Middle		Small		
	24.3		63.6		11.9		
Colors Preferred	Green	Red	Carrots	Yellow	White	Black	Other
	1.6	2	0.3	43	35.6	0.3	17.2

1.2 Challenges:

Figure 1.3 illustrates the challenges facing the agriculture sector in Palestine, where it is clearly shown that there is a need of huge efforts to overcome most of challenging obstacles such as using new technologies, financial support, water efficiency use…. etc.

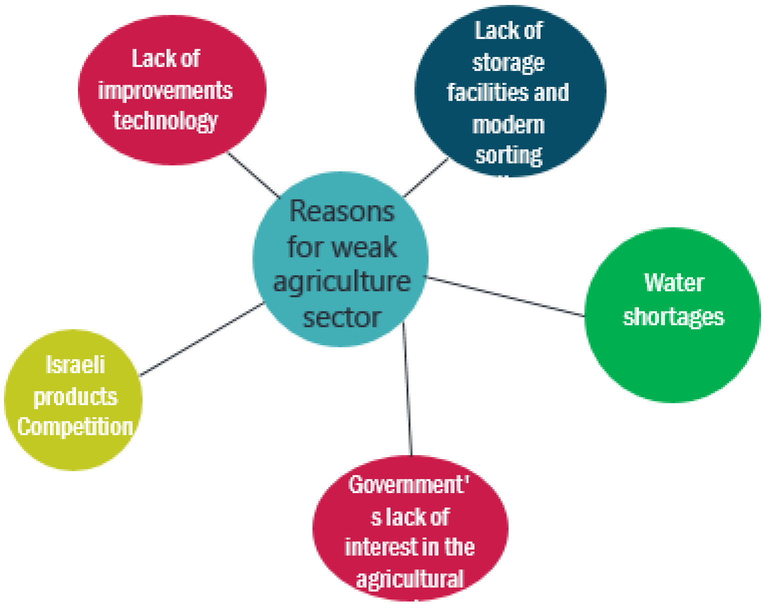


Figure 1. 3 challenge facing agriculture sector in Palestine.

The global cultivation of potatoes faces many challenges; the main key obstacles are [3]:

- Production initiatives:

Average yields remain far too low for small-scale potato producers to produce marketable surpluses. Thus, sufficient quantities of quality seed are essential to meet the needs of potato growers, processors and traders. For farmers to capitalize on the potential gains from using quality seed will require improvements in technology, irrigation, fertilizer use, storage facilities, transport and infrastructure.

- Producer groups:

With few buyers relative to sellers, the farm gate price of potato is often based on very limited negotiation. Smallholder farmers often do not have the market savvy or access to market information needed to negotiate appropriate prices with buyers. Unfair pricing as a result of uneven bargaining power can lead to producers failing to respond to market incentives, and can stifle farmers' drives to invest in increased productivity. This makes the formation of producer groups to share expertise and to strengthen bargaining power within the chain essential.

- Public and private support:

Agriculture policies and resources have traditionally focused on cash crops for export and on cereals, leaving potato and other root crops at the periphery. Readdressing this imbalance – with policy-makers providing more support – and seeking substantial levels of public and private investment is critical if the potato sector is to thrive. Such investment would include breeding programmers, infrastructural improvements and commercialization initiatives that are all geared towards strengthening the value chain.

When consumers can rely on a broad base of staples in their national food baskets, external changes in commodity prices do not have such impact on the food security in either cereal importing or exporting countries.

The sorting of different kinds over wide area has proven to be an important part in every sector. So as to accomplish the work of sorting, manual efforts were put in. Earlier, the manual involvement has been commonly imparted for the sorting process from small-scale industries to comparatively high-level large-scale industries. But, due to increase in competition in the global market, the so-called big companies and industries started seeking for better technologies that would reduce human effort and hence the consequent errors which in turn would help them increase their productivity and meet the increasing demand. This further would help them take a huge profit in return and thus the growth of that firm gets kick-started. As a result, the advent of automation in sorting sector has become a boon for such industrial sector. In large-scale industries and multi-national companies, the manual sorting is very less or nearly nil. This has further improved the product quality and reliability as a whole. [4]

1.3 Budget:

Table 1.2 Projec's budget.

Tools and devices	Items	Item price($)	Total price($)
motor and gear	1	280	280
conveyor	1	300	300
Sensors	3	30	90
manufacture		300	300
cylinders	2	50	100
compressor ,valves		250	250
VFD OMRON		300	300
camera		300	300
Arduino(MEGA)		35	35
ACCESSORIES		400	400
		Total:	2305 $

1.4 Time Schedule

table 1.3 time schedule.

Date	15.1. -14.2.2019				15.2. -17.3.2019				17.3.-17.4. 2019				17.4. -15.5.2019				
Task																	
1.identification of project idea																	
2-Drafting a Preliminary Project Proposal																	
3.introduction chapter (1).																	
4.mechanical design.																	
5.electrical design																	
6.software programming																	
7.controling and interfacing design																	
8.reporting, documentation and financial model																	

2

Chapter 2: System theory

- **Overview**
- **Image acquisition**
- **Image analysis and decision**
- **Driver**
- **Block diagram**
- **Flowchart of proposed machine.**

2.1 Overview:

Due to the increasing demand of potatoes and production increase as well, new technologies have to be used for sorting operations that leads to:

- Keep up with product demand.
- Less cost.
- More safety and avoiding the human flaws.
- Precisely system.
- Increase competition.

Potatoes sorting machine with LabVIEW vision module is the practically proposed solution for fast and accurate Potatoes sorting.

The proposed functional block diagram of the sorting machine is shown on figure (2.1):

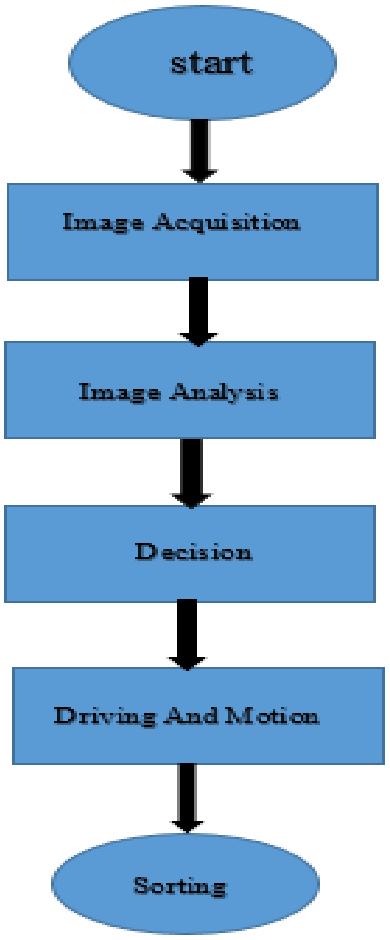


Figure 2. 1 Functional block diagram of proposed solution.

2.2 Image acquisition:

As a result of development of imaging technology, cameras have used to meet needs of some applications. Using the best camera in industrial application is important to perform best quality and lowest cost. This section offers industrial cameras (figure 2.2) properties and the selection of right camera for a certain application.

Figure 2.2 Image of industrial cameras .

2.3 Cameras on focus:

Generally, cameras are divided in two main types: analog and digital cameras. Analog cameras transmit a continuously variable electronic signal in real-time. The frequency and amplitude of this signal is then interpreted by an analog output device as video information. Both the quality of the analog video signal and the way in which it is interpreted affect the resulting video images. Also, this method of data transmission has both pros and cons. Typically, analog cameras are less expensive and less complicated than their digital counterparts, making them cost-effective and simple solutions for common video applications.

Figure 2.3 Image of Analog machine vision camera (232S).

Digital cameras (figure 2.4), transmit binary data (a stream of ones and zeroes) in the form of an electronic signal. Although the voltage corresponding to the light intensity for a given pixel is continuous, the analog-to-digital conversion process discretizes this and assigns a grayscale value between 0 (black) and 2^{N-1}, where N is the number of bits of the encoding. An output device then converts the binary data into video information. Of importance are two key differences unique to digital and not analog cameras types:

1. The digital video signal is exactly the same when it leaves the camera as when it reaches an output device.
2. The video signal can only be interpreted in one way.

These differences eliminate errors in both transmissions of the signal and interpretation by an output device due to the display. Compared to analog counterparts, digital cameras typically offer higher resolution, higher frame rates, less noise, and more features. Unfortunately, these advantages come with costs - digital cameras are generally more expensive than analog ones. Furthermore, feature-packed cameras may involve more complicated setup, even for video systems that require only basic capabilities. Digital cameras are also limited to shorter cable lengths in most cases.

Figure 2.4 image of TAG-5 digital camera.

The table"2.1" summarize the difference between digital and analog cameras.

Table 2.1 comparison between analog and digital cameras.

Analog Cameras	**Digital Camera**
Vertical resolution is limited by the bandwidth of the analog signal	Vertical resolution is not limited, offer high resolution in both horizontal and vertical directions
Standard –sized sensors	With no bandwidth limit, offer large numbers of pixels and sensors, resulting in high resolution.
Computers and capture boards can be used for digitalizing, but are not necessary to display.	Computers and capture board (in some case) required to display signal
Analog printing and recording easily incorporated into system	Signal can be compressed so user can transmit in low bandwidth.
Signal is susceptible to noise and interference which causes loss in quality.	Output signal is digital, little signal loss occurs during signal processing.
Limited frame rates.	High frame rates and fast shutters

2.3.1 Camera Formats:

Camera formats can be divided into interlaced, progressive, area, and line scan. To easily compare, it is best to group them into interlaced vs. progressive and area vs. line. Conventional CCD cameras use interlaced scanning across the sensor. The sensor is divided into two fields: the odd field (rows 1, 3, 5..., etc.) and the even field (rows 2, 4, 6..., etc.). These fields are then integrated to produce a full frame. For example, with a frame rate of 30 frames per second (fps), each field takes 1/60 of a second to read. For most applications, interlaced scanning does not cause a problem. However, some trouble can develop in high-speed applications because by the time the second field is scanned, the object has already moved. This causes ghosting or blurring effects in the resulting image (Pictures 2.4A– 2.4B). In Picture 2.4A, notice how TECHSPEC® Man appears skewed when taking his picture with an interlaced scanning sensor.

In contrast, progressive scanning solves the high-speed issue by scanning the lines sequentially (rows 1, 2, 3, 4..., etc.). Unfortunately, the output for progressive scanning has not been standardized so care should be taken when choosing hardware. Some progressive scan cameras offer an analog output signal, but few monitors are able to display the image. For this reason, capture boards are recommended to digitize the analog image for display.

Figure 2.5 High-Speed Movement Using an Interlaced Scanning Sensor.

Figure 2.6 High-Speed Movement Using a Progressive Scanning Sensor.

In area scan cameras, an imaging lens focuses the object to be imaged onto the sensor array, and the image is sampled at the pixel level for reconstruction (*Figure2.5*). This is convenient if the image is not moving quickly or if the object is not extremely large. Familiar digital point-and-shoot cameras are examples of area scan devices. With line scan cameras, the pixels are arranged in a linear fashion, which allows for very long arrays (*Figure2.6*). Long arrays are ideal because the amount of information to be read-out per exposure decreases substantially and the speed of the readout increases by the absence of column shift registers or multiplexers; in other words, as the object moves past the camera, the image is taken line by line and reconstructed with software.

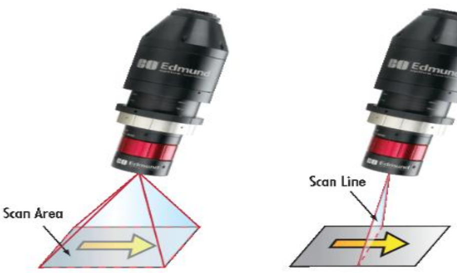


Figure 2.7 Illustration of Area Scanning Technique (left) Illustration of Line Scanning Technique (right).

Table (2.2) offers short comparison between area scan cameras and line scan cameras:

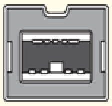
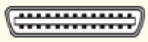
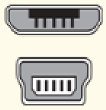
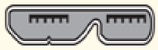
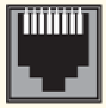
Table 2. 2 comparison between area scan cameras and line scan cameras.

Area Scan Cameras	**Line Scan Cameras**
4:3 (H:V) Ratio (Typical)	Linear Sensor
Large Sensors	Larger Sensors
High-Speed Applications	High-Speed Applications
Fast Shutter Times	Constructs Image One Line at a Time
Lower Cost than Line Scan	Object Passes in Motion Under Sensor
Wider Range of Applications than Line Scan	Ideal for Capturing Wide Objects
Easy Setup	Special Alignment and Timing Required; Complex Integration but Simple Illumination

2.3.2 Digital Camera Interfaces:

There are several most techniques for cameras interfaces that used with image processing applications. capture boards, FireWire, Camera Link®, GigE, and USB, (Following table). As with many of the criteria for camera selection, there is no single best option interfaces, but rather one must select the most appropriate devices for the application at hand.

Table 2. 3 Type of several Camera Interfaces.

Digital Signal Options	**FireWire 1394.b**	**Camera Link®**	**USB 2.0**	**USB 3.0**	**GigE**
					
Data Transfer Rate:	800 Mb/s	3.6 Gb/s (full configuration)	480 Mb/s	5Gb/s	1000 Mb/s
Max Cable Length:	100m (with GOF cable)	10m	5m	3m (recommended)	100m
# Devices:	up to 63	1	up to 127	up to 127	Unlimited
Connector:	9pin-9pin	26pin	USB	USB	RJ45/Cat5e or 6
Capture Board:	Optional	Required	Optional	Optional	Not Required
Power:	Optional	Required	Optional	Optional	Required (Optional with PoE)

2.3.3 Camera selection:

Before determine the type of camera that appropriate with vision application, it should to answer many key questions:

- How to choose a machine vision camera?

Standards machines visions cameras are four types:

1. Visible
2. Near (NIR)
3. Short wave infrared.
4. Long wave infrared.

- Which interfaces type matching with vision application?

- What is The resolution of camera?

In engineering application, the low resolution camera is preferred because it meet the needing of solution the engineering problem.

Image acquisition is going to be performed using LabVIEW IMAQ software which enable you to acquire images from cameras. [5]

2.4 Image analysis and decision:

2.4.1 LabVIEW OVERVIEW:

- The name LabVIEW is a shortened form of its description: Laboratory Virtual Instrument Engineering Workbench.

- LabVIEW is a visual programming language: it is a system-design platform and development environment that was aimed at enabling all forms of system to be developed.

- LabVIEW was developed by National Instruments as a workbench for controlling test instrumentation. However, its applications have spread well beyond just test instrumentation to the whole field of system design and operation.

- LabVIEW uses a graphic interface that enables different elements to be joined together to provide the required flow.

- LabVIEW is essentially the user interface for G. However, as the software has developed, the term LabVIEW is now synonymous with the G language. LabVIEW also provides a host of other facilities including debugging, automated multithreading, application user interface, hardware management and interface for system design.

- LabVIEW runs on Windows, OS X (Apple) and Linux platforms, making it suitable for most computing systems.

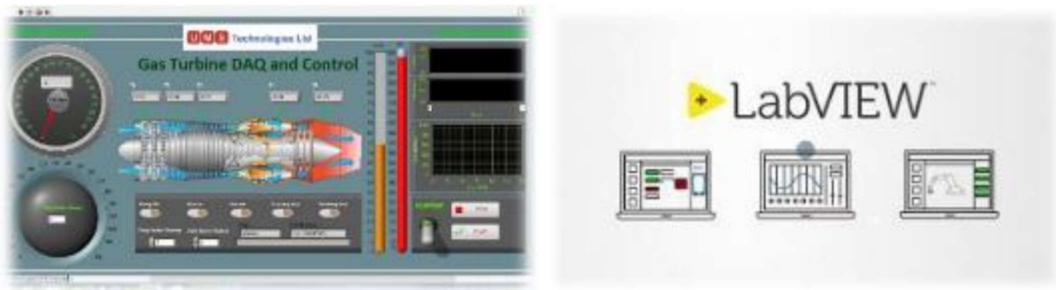


Figure 2.8 labview platform

2.4.2 LabVIEW key concepts:

LabVIEW Environment: The LabVIEW environment consists of LabVIEW VI manager (project explorer), the programming tools, debugging features, templates and ready built sample examples, and an easy interface to the hardware drivers.

LabVIEW VIs: The LabVIEW VI is a “Virtual Instrument” that enables a user interface to be built and it contains the programming code

LabVIEW G programming: this is the graphical programming language where the functional algorithms are built using “drag and drop” techniques.

LabVIEW dataflow: this is the core concept that determines the running order for the programme.

2.4.3 LabVIEW advantages:

1. Graphical interface is flexible and simple to use.
2. LabVIEW provides a universal platform for numerous applications in diverse fields.
3. LabVIEW can be used with 3rd party hardware: it can be interfaced with C/C++, VB.
4. Easy to interface to many hardware items like data acquisition and test equipment products.

Figure 2.9 image of LabVIEW Environment.

2.4.4 LabVIEW Based Vision:

LabVIEW Vision enables you to read or create image files and provides means for managing those files using built-in functions (Vis) for analyzing image files. Following picture shows the Low-level Based Vision Tools.

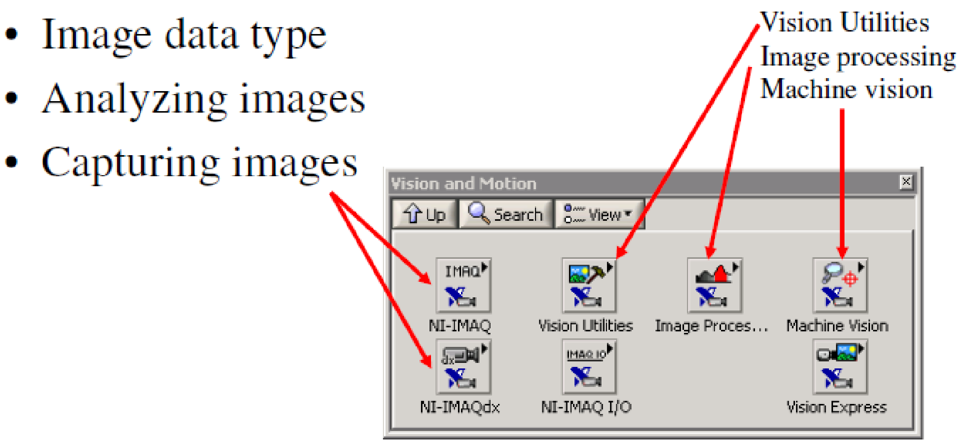


Figure 2. 10 LabVIEW Vision Utilities.

Example:

The following Block Diagram opens an existing image file, reads the file and then display it. [5]

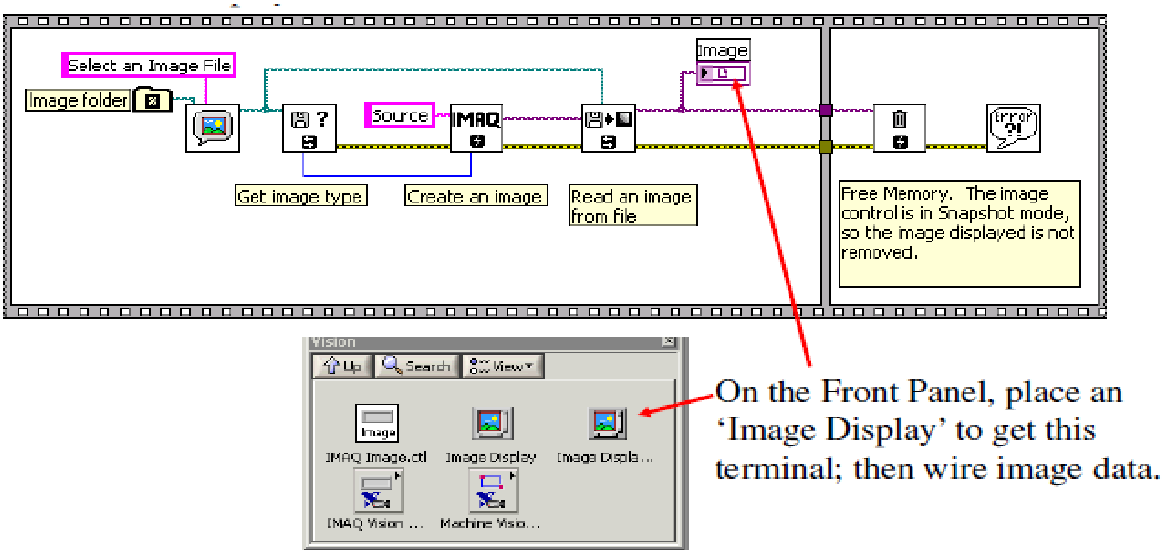


Figure 2.11 opens, reads and display an image file example.

2.5 Driver "Arduino":

- What is the Arduino?

Open Source electronic prototyping platform based on flexible easy to use hardware and software.

Figure 2.12 image of Arduino

- What can Arduino do?

1. 3D printer.
2. Puff the Magic Dragon Robot
3. Laser Harp and led cubes.
4. Environmental monitoring such as the work of a system to monitor temperature and humidity remotely.

2.5.1 Arduino parts:

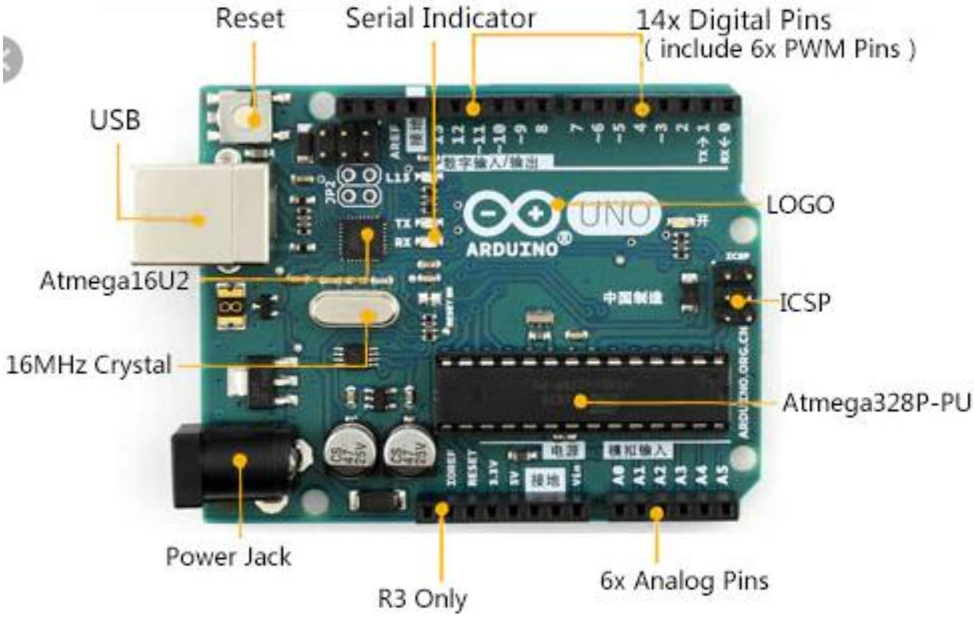


Figure 2. 13 Arduino Parts

2.5.2 Raspberry pi VS. Arduino:

Table 2.4 Raspberry pi VS. Arduino. [6]

	Raspberry pi	Arduino
price	Start from 25$	Start from 24$
version	Model B	R3
SOC card	ARM11	ATMega 328
Speed	700-1000 MHZ	16-20 MHZ
RAM	512 MB	2 KB
ROM	External card	32 KB
Operating voltage	5 Volt	5-17 Volt
Run high video(1080P)	yes	No
Min current of operation	320 to 480 mA	Up to 42mA
Number of Digital Ports	8	14
Number of Analog Ports	No	6-10 bit
PWM Ports	1	6
I2c ports	1	2
SPI ports	1	1
UART ports	1	1
USB ports	2	Non
Run more than one program.	yes	No
Ethernet port	10/100	Non
Screen links ports	HDMI, RCA Video (analog)	non
Voice port	HDMI, Analog	non
Programming language	All language of Linux	Arduino C Embedded C Scratch

2.5.3 LabVIEW with Arduino:

Arduino is a powerful electronics prototyping platform used by millions of people around the world to build amazing projects. Using Arduino, it is possible to easily connect sensors and physical objects to a microcontroller, without being an expert in electronics. However, using Arduino still requires us to know how to write code in C/C++, which is not easy for everyone. This is where LabVIEW comes into play. LabVIEW is software used by many professionals and universities around the world, mainly to automate measurements without having to write a single line of code. [7]

2.6 Block diagram:

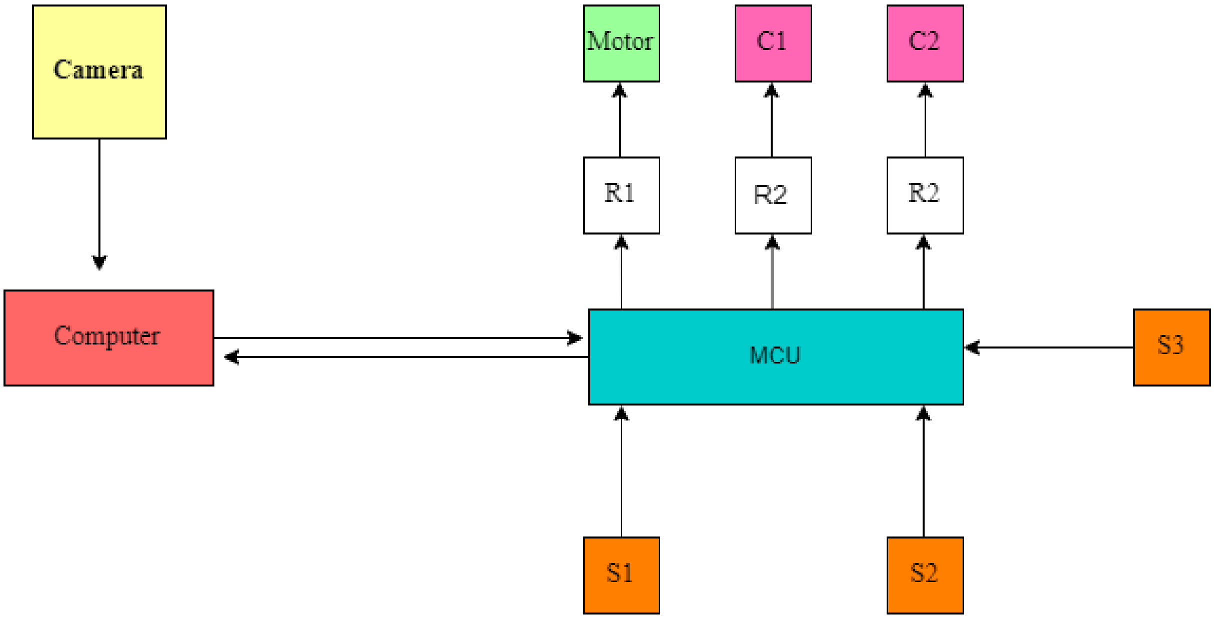


Figure 2.14 Block Diagram of proposed machine.

Where,

- **C1**: solenoid of valve for cylinder 1 (24 volt).
- **C1**: solenoid of valve for cylinder 2 (24 volt).
- **R1**: Relay signal to Run the conveyor (motor).
- **R2**: Relay signal to activate C1.
- **R3**: Relay signal to activate C2.
- **S1**: sensor to detect that the item near to cylinder 1.
- **S2**: sensor to detect that the item near to cylinder 2.
- **S3**: sensor to activate Image Acquisition.

2.7 Flowchart of proposed machine:

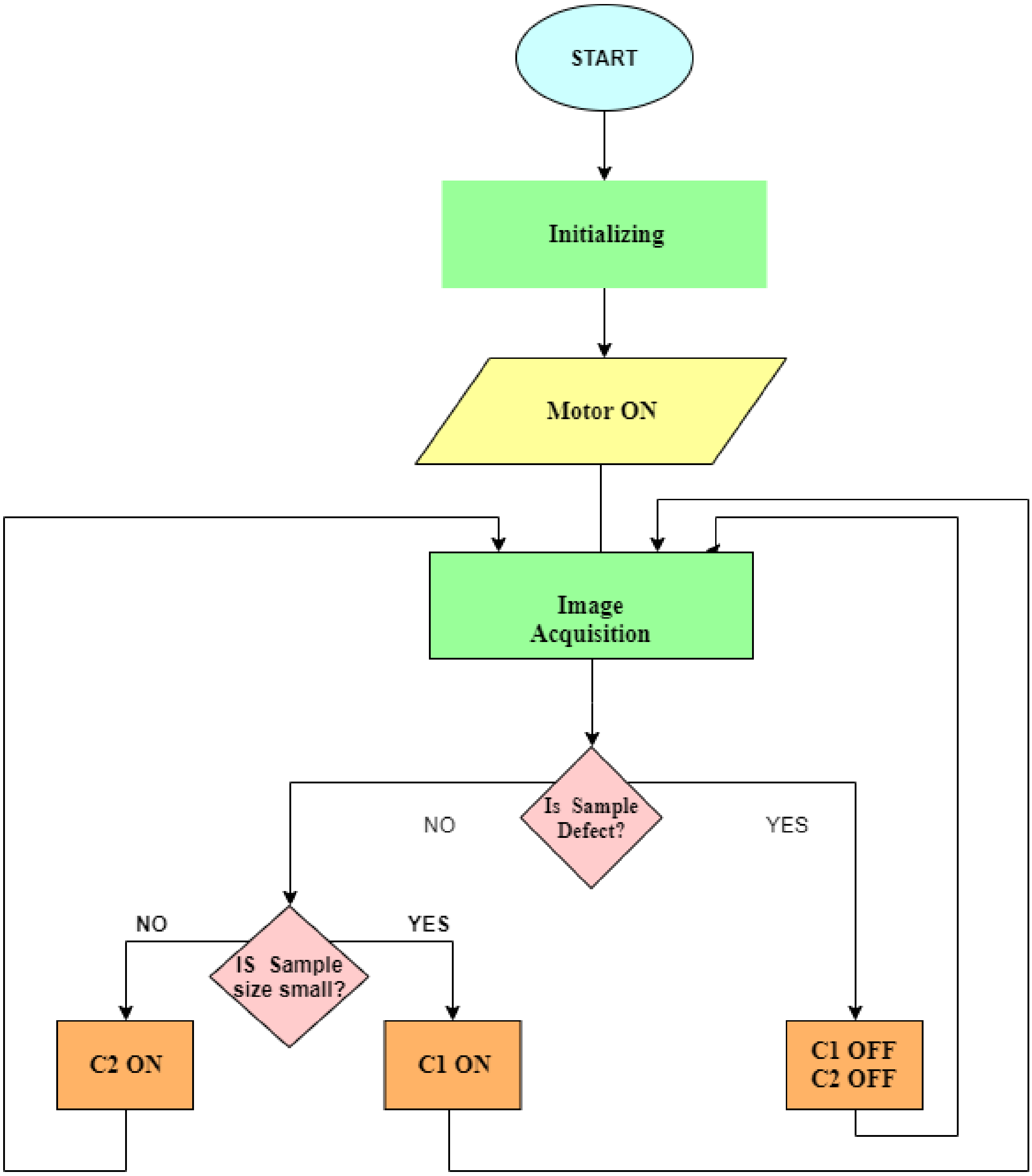


Figure 2. 15 flowchart of machine.

3

CHAPTER 3: Design and Implementation

- **Mechanical design**
- **Electrical design**
- **Pneumatic design**
- **Programming design**

3.1 Mechanical Design:

Figure 3.1 shows the mechanical proposed design of the machine, this for 180° implementation. This design has three stages: Acquisition image, processing and sorting.

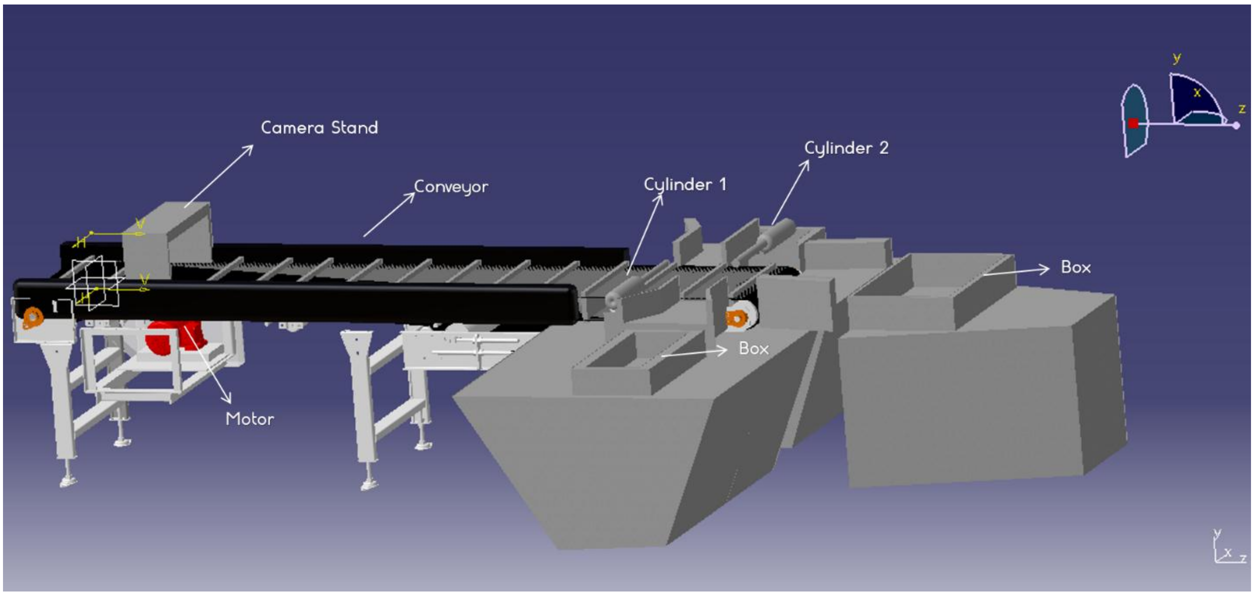


Figure 3.1 Mechanical Design

The top section area of the mechanism and dimensions shown in the following figures:

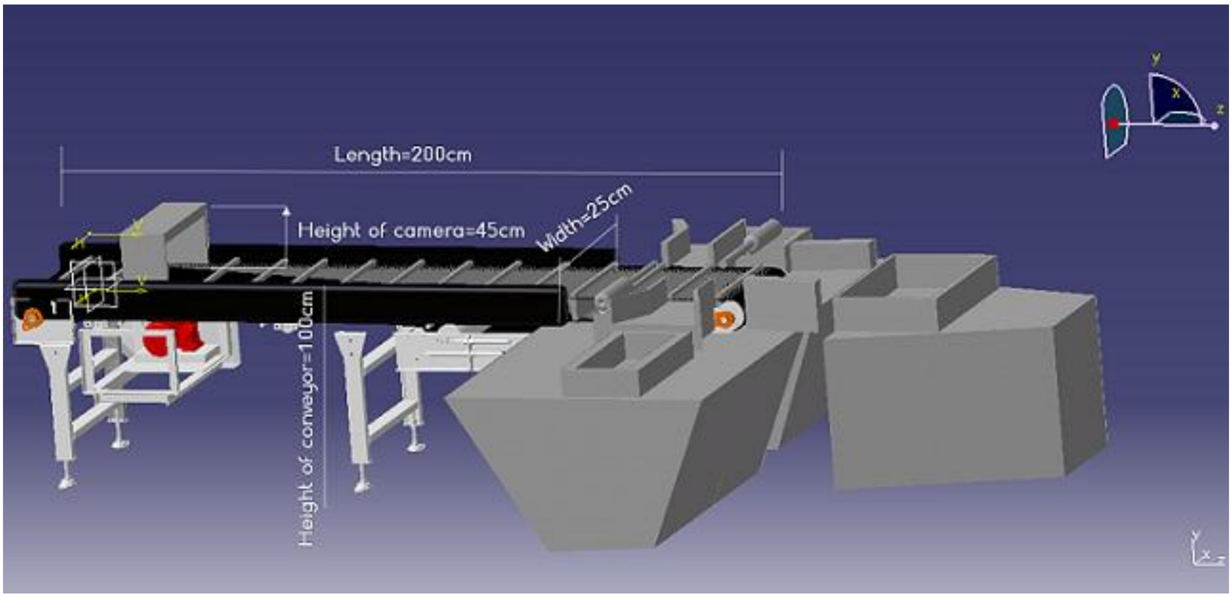


Figure 3.2 : dimensions of the mechanical design

Figure 3.3 shows the top sectional area of the proposed machine design:

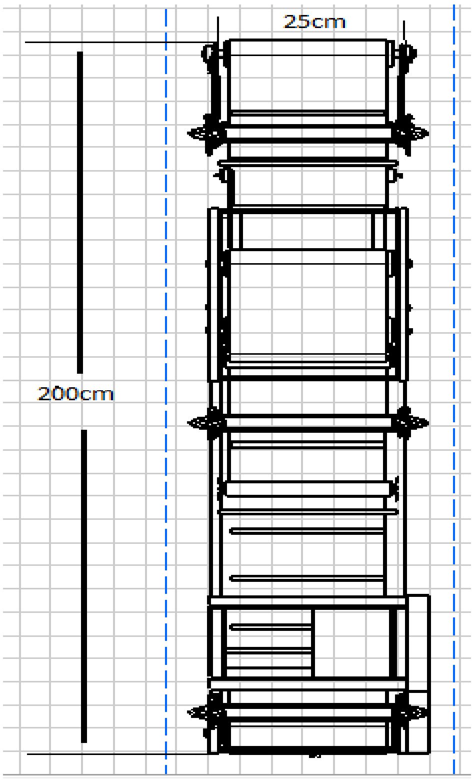


Figure 3.4 Top Section area

3.1.1 Parts of the mechanical system:

1. Cylinders.

Figure 3.5 shows the pneumatic cylinder that will used to separate the pieces through sorting operation.

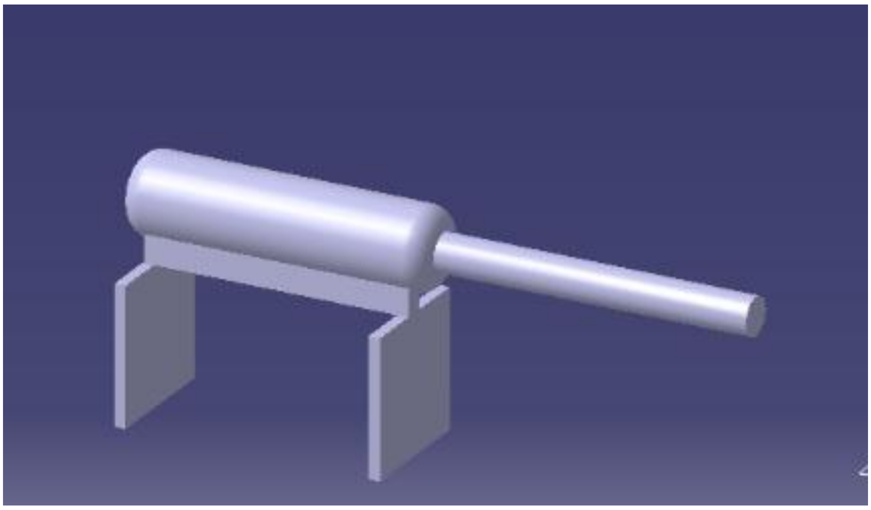


Figure 3.6: Cylinder.

2. Conveyor.

the pieces need to be moved from acquisition area o sorting area, this can be performed by using the conveyor. See *Figure 3.7.*

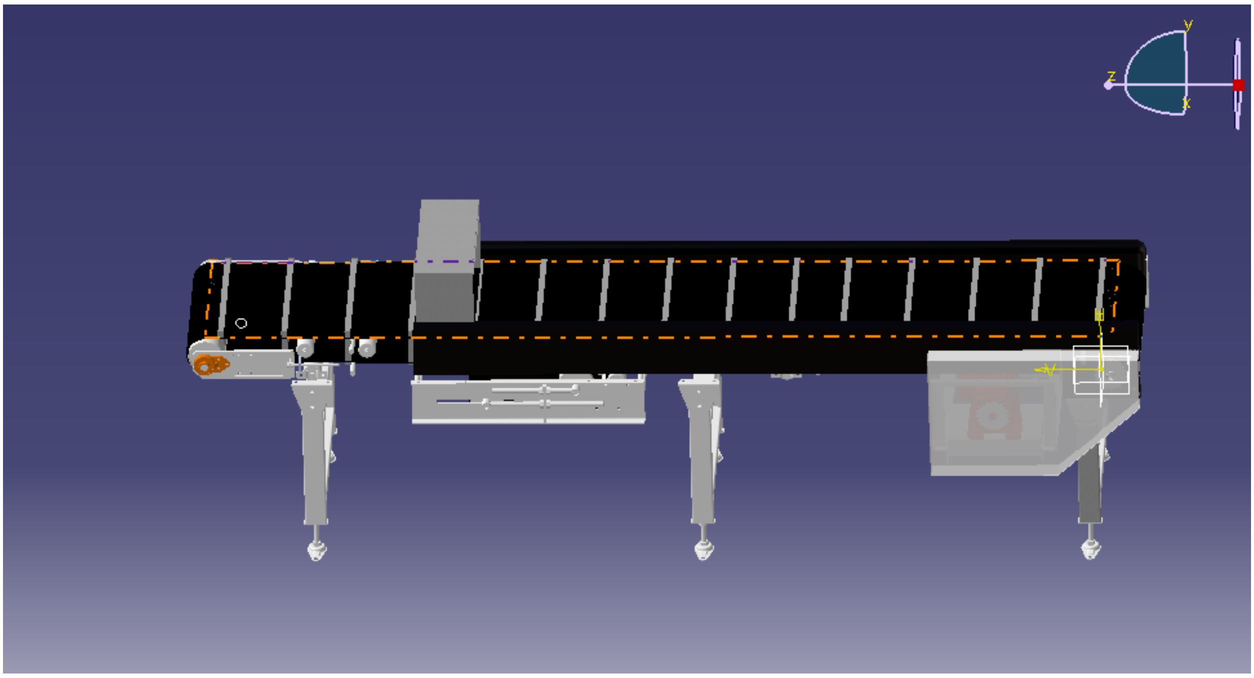


Figure 3.8 Conveyor.

3. Motor:

the conveyor need the electromechanical machine to drive it. It is squired cage Induction motor machine. See *Figure 3.9.*

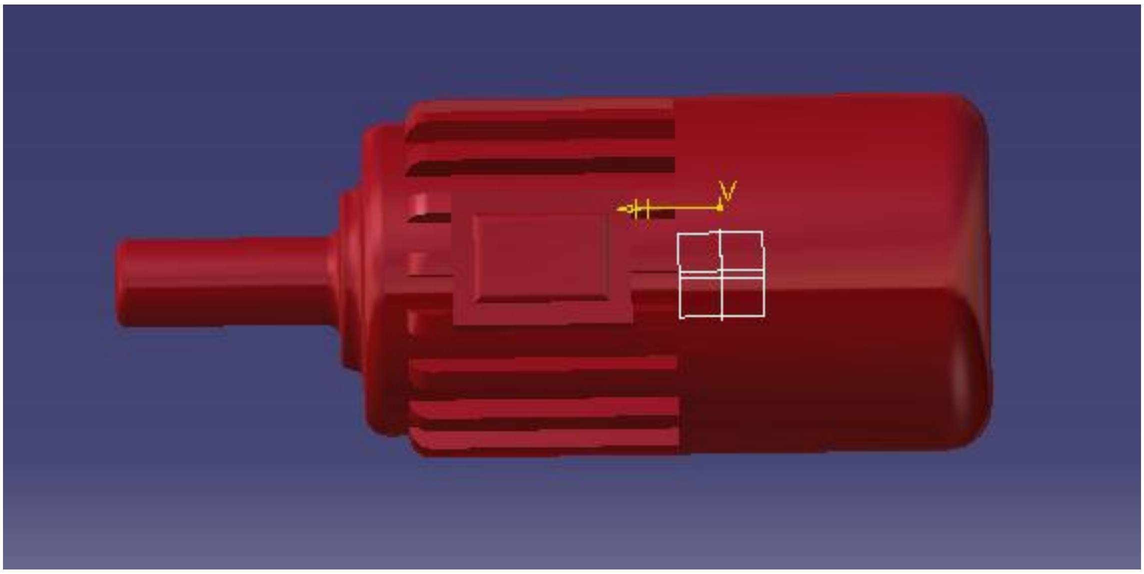


Figure 3.10: Motor of Conveyor.

3.2 Electrical Design:

This section offers the complete electrical design and components of the Machine, suggestion design of the electronic and electric layout circuits, protection components and Main Control Board.

Machine electrical design depends on that the Arduino drives a five signals outputs and two inputs signals, the first one for enabling conveyer's motor and the rest is for driving the 5/2 Directional Control Valves Electrically operated. The inputs signals for IR sensor to determine which cylinder operated.

The Electronic Driving Circuit is shown on figure (3.5):

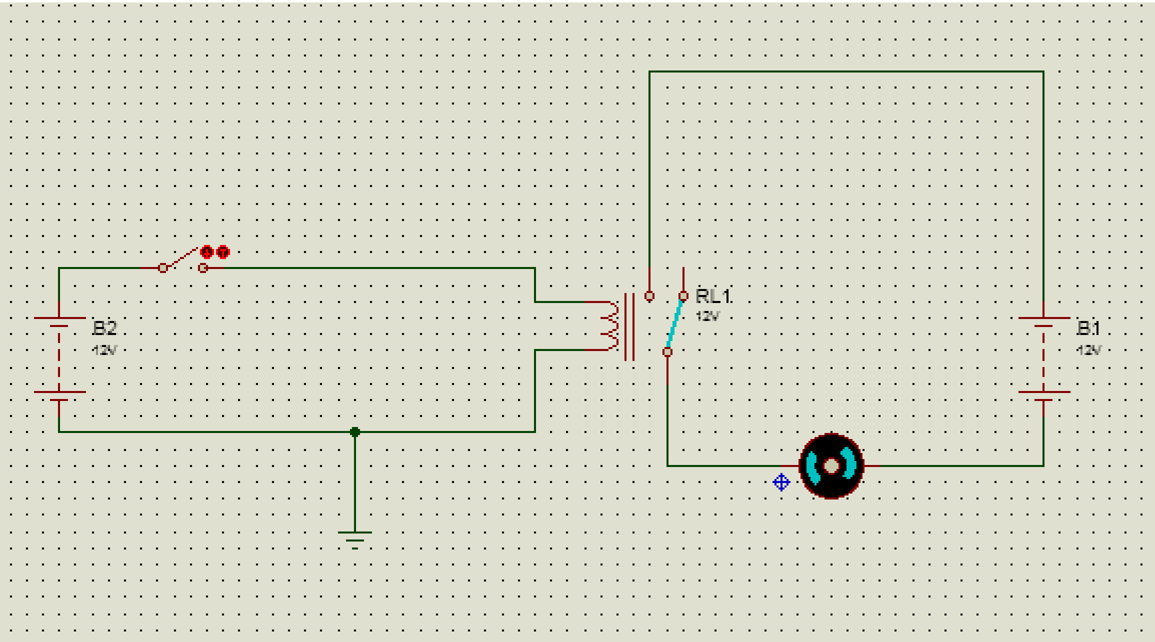


Figure 3. 11 Layout of electronic driving circuit.

Signals: the activated signals come from LabVIEW Front Panel through Arduino Driver and control with other parts of machine.

Transistors: to supply the coil of the relay with appropriate current.

Relays: Enable to control of low voltages with high voltages loads. Using of relays because the Machine's Design based on single phase induction motor.

Freewheeling diodes: allow discharging the reverse inductor current and protect the transistor from damaged due to energy stored inside the coils of valves.

3.2.1 Motor sizing calculations:

The motor is the most important components in machine, so, the following procedure should be followed for motor selection [8]:

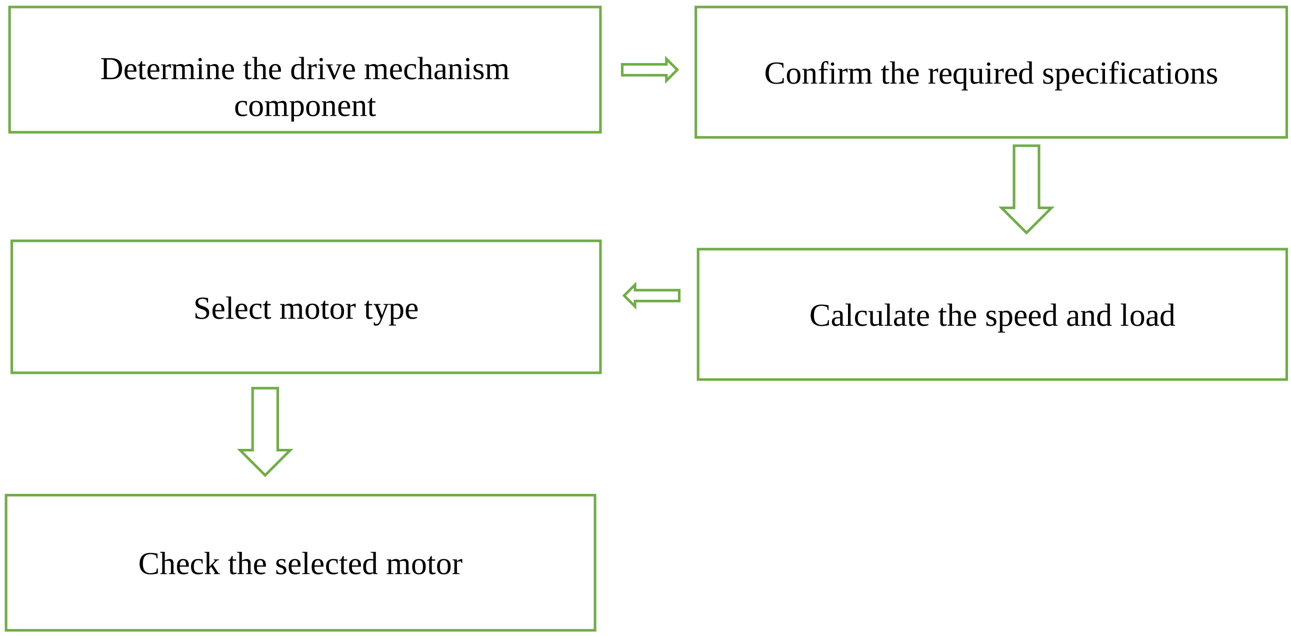


Table 3.1 list of weights

Total mass of load(M1)	**10 kg**
Friction Coefficient (μ)	μ= 0.3
Gearbox radius (r)	r =10 cm
Belt mass and roller (M2)	1.5 kg
Linear Belt speed (desired)	V=0.5 m/s
Motor power source	Single phase 220 V , 50 Hz
Acceleration time	t = 1 sec

- Determine the Gear ratio:

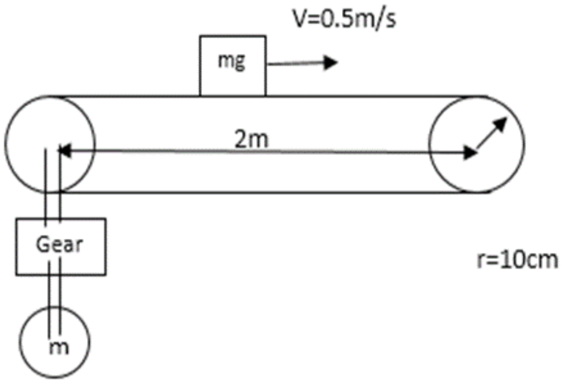


Figure 3. 12 Block Diagram of Conveyor.

The angular speed at the gear shaft is:

$v = r \cdot w \Rightarrow \omega = \frac{v}{r} = \frac{0.5\ m/S}{0.1\ m} = 5\ rad/s$
(3.1)

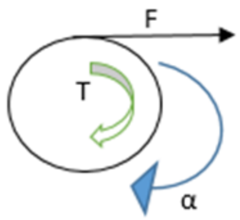
Assume that the speed of motor is 1500 rpm, then the desired speed in rpm is:

$$n = w \cdot \frac{60}{2\pi} = 5 \cdot \frac{60}{2\pi} = 48\ rpm \quad (3.2)$$

the gear ratio is:

$i = \frac{100}{48} = 31.25$ ⇨we choose i=30.

- Calculate the required torque



From newton equation:

$\sum T_0 = J_0 \cdot \alpha$

$T - F \cdot r = J.\alpha \qquad ,J = m.r^2$

$T - F \cdot r = m.r^2.\alpha$

$T = m.r^2.\alpha + F \cdot r \qquad ,F = mg.\mu$

$$T = m.r^2.\alpha + mg.\mu.r \quad (3.3)$$

Now, the acceleration time must be known and from the curve:

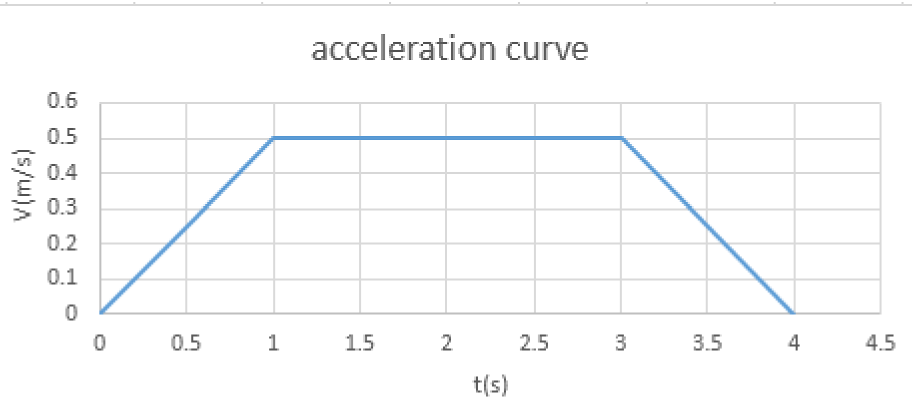


Figure 3.13 velocity -time diagram

$$\alpha = \frac{\Delta w}{\Delta t} = \frac{w2 - w1}{t2 - t1} = \frac{a}{r} \quad \text{, a is linear acceleration} \tag{3.4}$$

, α is angular acceleration

from the figure (3.8) these coefficients can be determined as follows:

$$a = \frac{v2 - v1}{t2 - t1} = \frac{0.5\ m/s}{1\ s} = 0.5\ m/s^2 \tag{3.5}$$

$$\alpha = \frac{0.5\ m/s^2}{0.1\ m} = 5\ rad/s$$

by substitution in (3.3) the obtained shaft torque is:

$$T = (10 * 0.1^2 * 5) + (10 * 9.81 * 0.3 * 0.1) = 3.443\ N.m$$

The final motor torque with transfer ratio of 30 times is:

$$T_m = \frac{Tg}{30} = \frac{3.443}{30} = 0.12\ N.m$$

The actual angular and rpm speed of desired motor respectively is:

$$w_m = 5 \times 30 = 150\ rad/s$$

$$n = 150 \times \frac{60}{2\pi} = 1432\ rpm$$

the power consumed by the motor is:

$$p = T * w = 0.12 \times 150 = 18\ watt \tag{3.6}$$

Select **4IK25UC-30*** motor with following specifications:

table 3. 2 motor selection specifications

Item #	Frame Size	Output Power	Voltage (VAC)	Electromagnetic Brake	Type	Shaft/Gear Type	Gear Ratio (X:1)	Output Shaft Diameter	Rated Torque	Rated Speed (rpm)	Permissible Load Inertia	Web Price	Add To Cart / Contact Sales
4IK25UC-30A	3.15 in	25 W (1/30 HP)	Single-Phase 220/230 VAC	Not Equipped	Lead Wire	Parallel Shaft Gearhead	30 :1	5/8 in.	38 lb-in	60	1530 oz-in^2	**$161.00**	Add To Cart Request Quote
4IK25UCT2-30A	3.15 in	25 W (1/30 HP)	Single-Phase 220/230 VAC	Not Equipped	Terminal Box	Parallel Shaft Gearhead	30 :1	5/8 in.	38 lb-in	60	1530 oz-in^2	**$182.00**	Add To Cart Request Quote
4IK25UC-30	3.15 in	25 W (1/30 HP)	Single-Phase 220/230 VAC	Not Equipped	Lead Wire	Parallel Shaft Gearhead	30 :1	15 mm	38 lb-in	60	1530 oz-in^2	**$161.00**	Add To Cart Request Quote

*for more details, kindly refer to appendix A.

3.3 Pneumatic Design:

Pneumatic technology deals with the study of behavior and applications of compressed air in our daily life in general and manufacturing automation in particular. Pneumatic systems use air as the medium which is abundantly available and can be exhausted into the atmosphere after completion of the assigned task.

3.3.1 Basic Components of Pneumatic System:

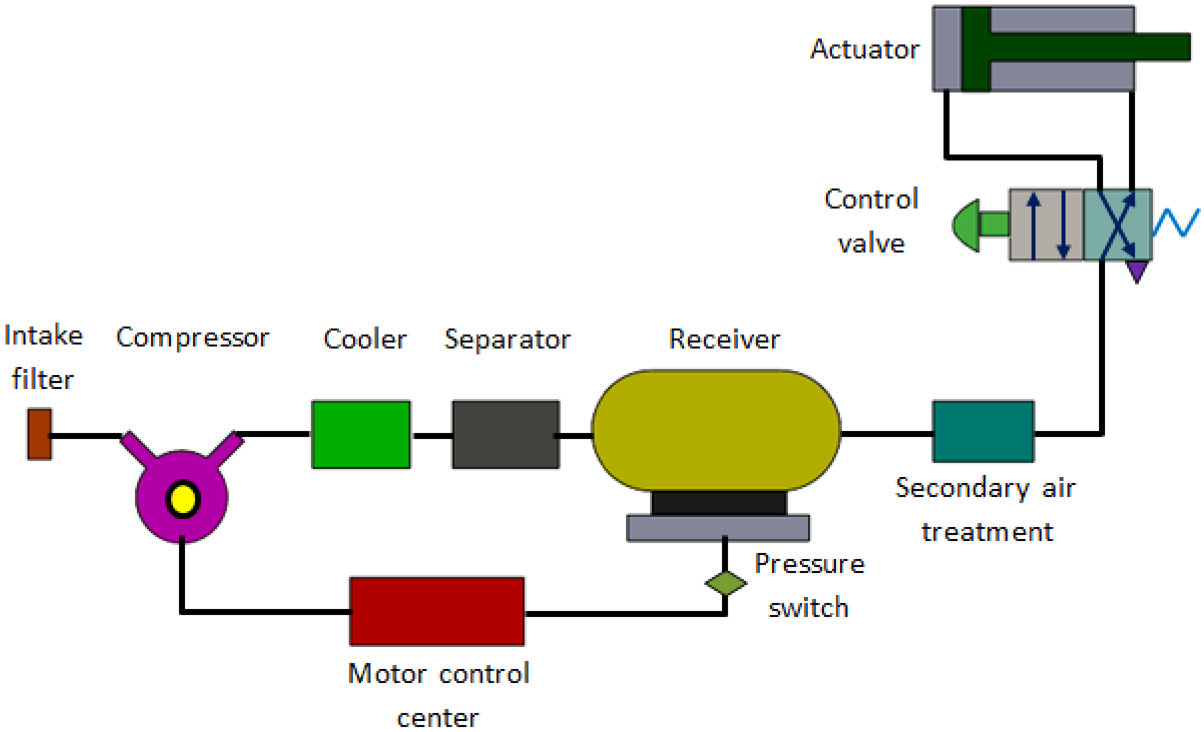


Figure 3.14 Components of a Pneumatic System.

The main components of a pneumatic system are shown in fig3.9

a) **Air filters:** These are used to filter out the contaminants from the air.

b) **Compressor:** Compressed air is generated by using air compressors. Air compressors are either diesel or electrically operated. Based on the requirement of compressed air, suitable capacity compressors may be used.

c) **Air cooler:** During compression operation, air temperature increases. Therefore, coolers are used to reduce the temperature of the compressed air.

d) **Dryer:** The water vapor or moisture in the air is separated from the air by using a dryer.

e) **Control Valves:** Control valves are used to regulate, control and monitor for control of direction flow, pressure etc.

f) **Air Actuator:** Air cylinders and motors are used to obtain the required movements of mechanical elements of pneumatic system.

g) **Electric Motor:** Transforms electrical energy into mechanical energy. It is used to drive the compressor.

h) **Receiver tank*:*** The compressed air coming from the compressor is stored in the air receiver.

Pneumatic systems have a lot of advantages:

a) High efficiency

b) Simple design

c) Safety

d) Easy selection of speed and pressure.

3.3.2 Cylinder calculation:

The diminution of flexing piston is calculated by the following equations [9]:

$$F=P\times A \tag{3.10}$$

Where: F: Force (N).

P: Pressure (bar) = 6 bar

A: Cross section area of the piston rod

According to Newton second law, the force can be calculated by the following equation:

$$F=M \times g \tag{3.11}$$

Where M: mass of prism (kg)

g: Acceleration of gravity (m\s^2)

$F=1*9.8=9.8N$

$P=8\ bar$

For the retracting stroke on a double acting cylinder:

$$FR = p\ (D2 - d2)/4 \times P \times \mu \qquad (3.12)$$

Where: FR represents the cylinder thrust to retract

D = piston diameter

d = piston rod diameter

P = available pressure

µ = efficiency

we select the **ISO cylinder DSBG-32-400-PPSA-N3**1645470 [10]

Standard cylinder DSBG

Product Finder | Software

Standard cylinder DSBG

- Sturdy tie rod design
- Diameter 32, 40, 50, 63, 80, 100, 125, 160, 200, 250, 320 mm
- Stroke length 1 ... 2800 mm
- Force: 483 ... 48255 N
- Double-acting
- Position sensing
- Fixed/adjustable/self-adjusting cushioning

The electro pneumatic design is shown on the following diagram:

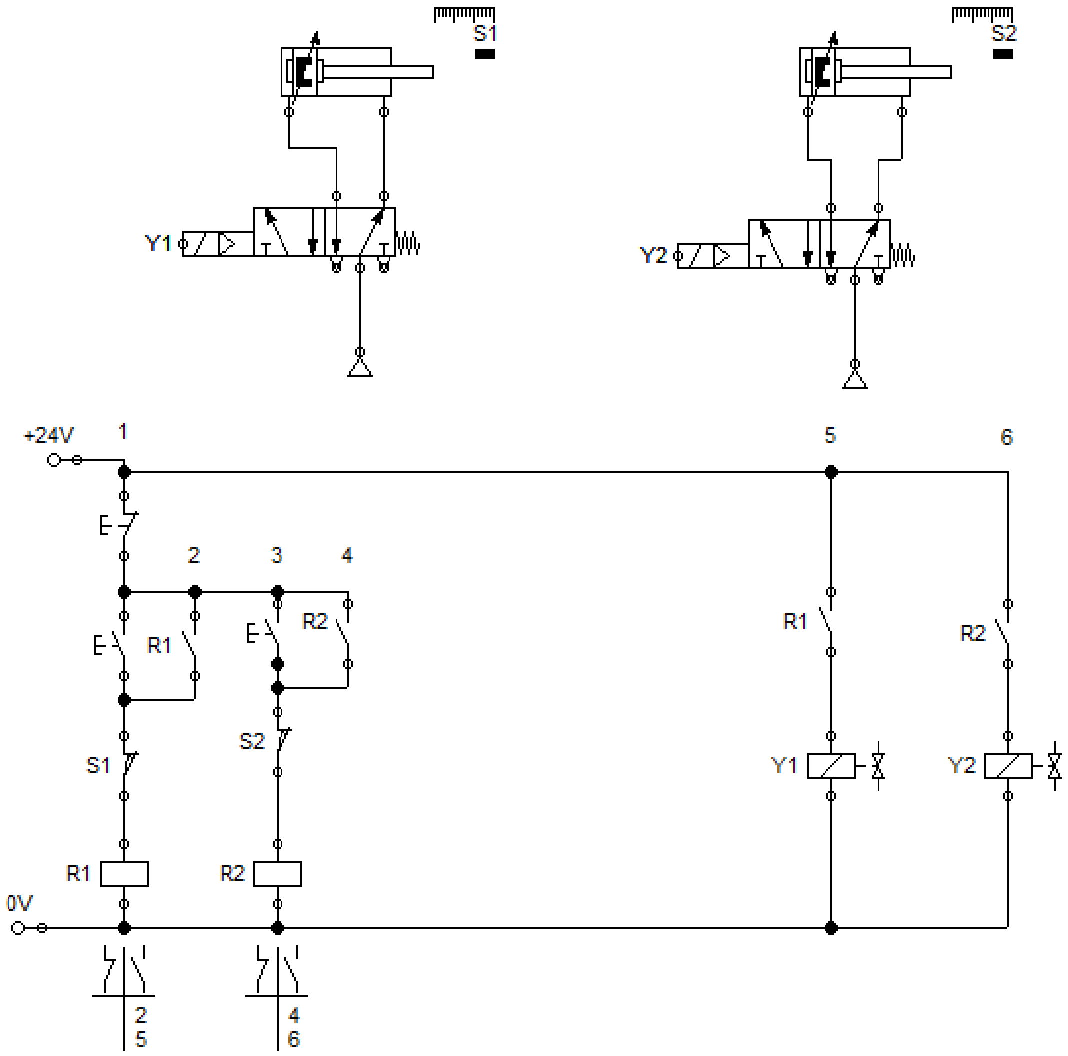


Figure 3. 15 Electro Pneumatic design.

3.4 Programming Design:

The machine will use the "Image Matching" strategy to recognize the type of classifying.

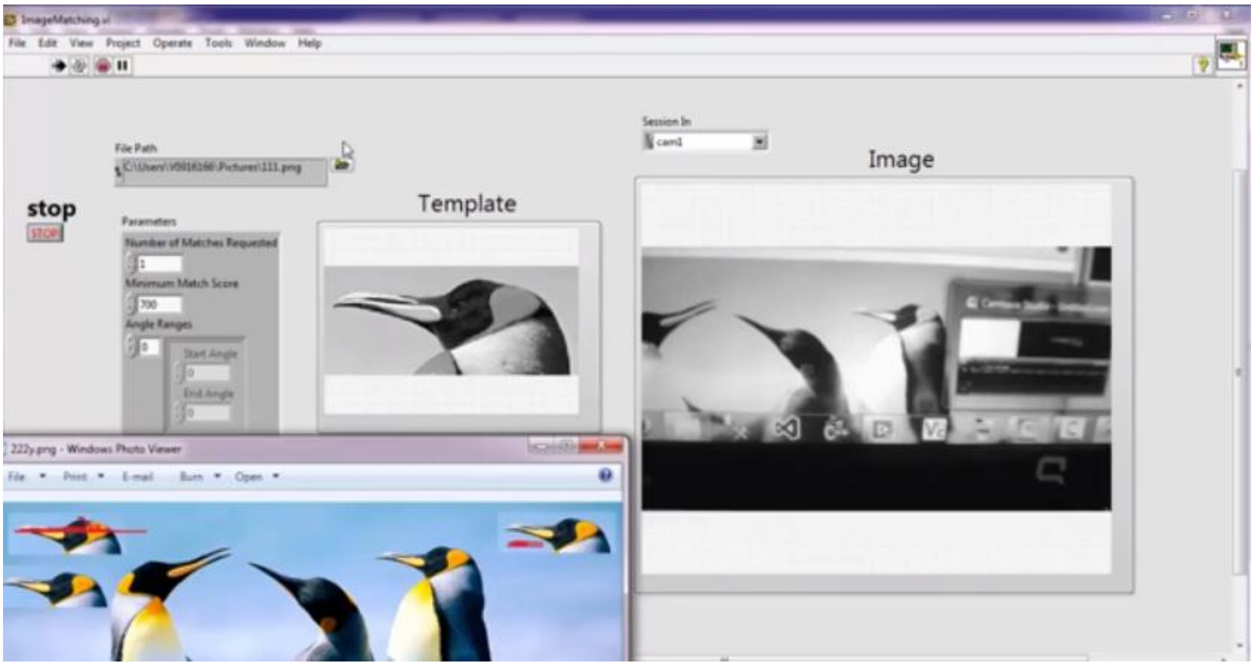


Figure 3.16 Front panel of image matching.

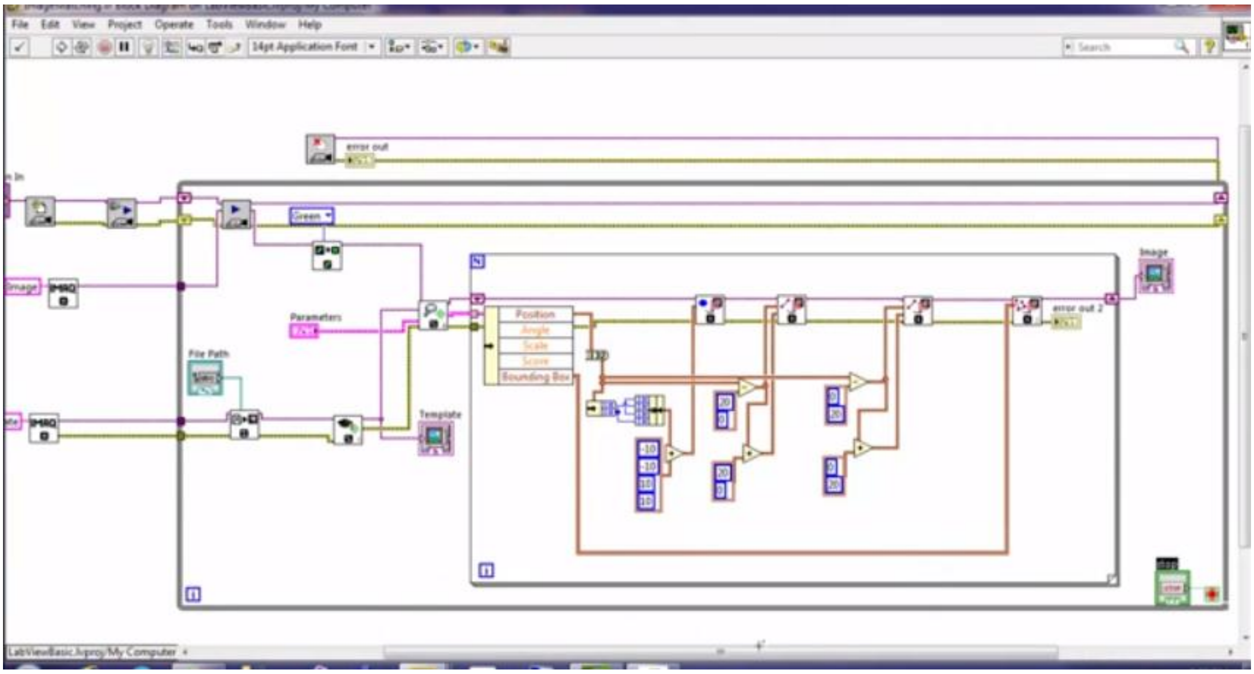


Figure 3. 17 Block Diagram of Image Matching.

The following table consists of inputs, outputs and control method of proposed machine:

table 3. 3 system inputs, outputs and controls method.

<table>
<tr><th>Control method</th><th>System input</th><th>System output</th></tr>
<tr><td rowspan="3">LabVIEW environment
Based on vision module.</td><td>sensors</td><td>Induction motor</td></tr>
<tr><td>Industrial camera</td><td>Cylinder 1 extended (y1)</td></tr>
<tr><td>Compressor, valves</td><td>Cylinder 2 extended (y2)</td></tr>
</table>

4

Chapter 4: Practical implementation

- Practical elements.
- Programming code.
- Improvement solution for 180° design.
- Proposed design for 360° defect detection.

4.1 Practical Parts:

4.1.1 Conveyor:

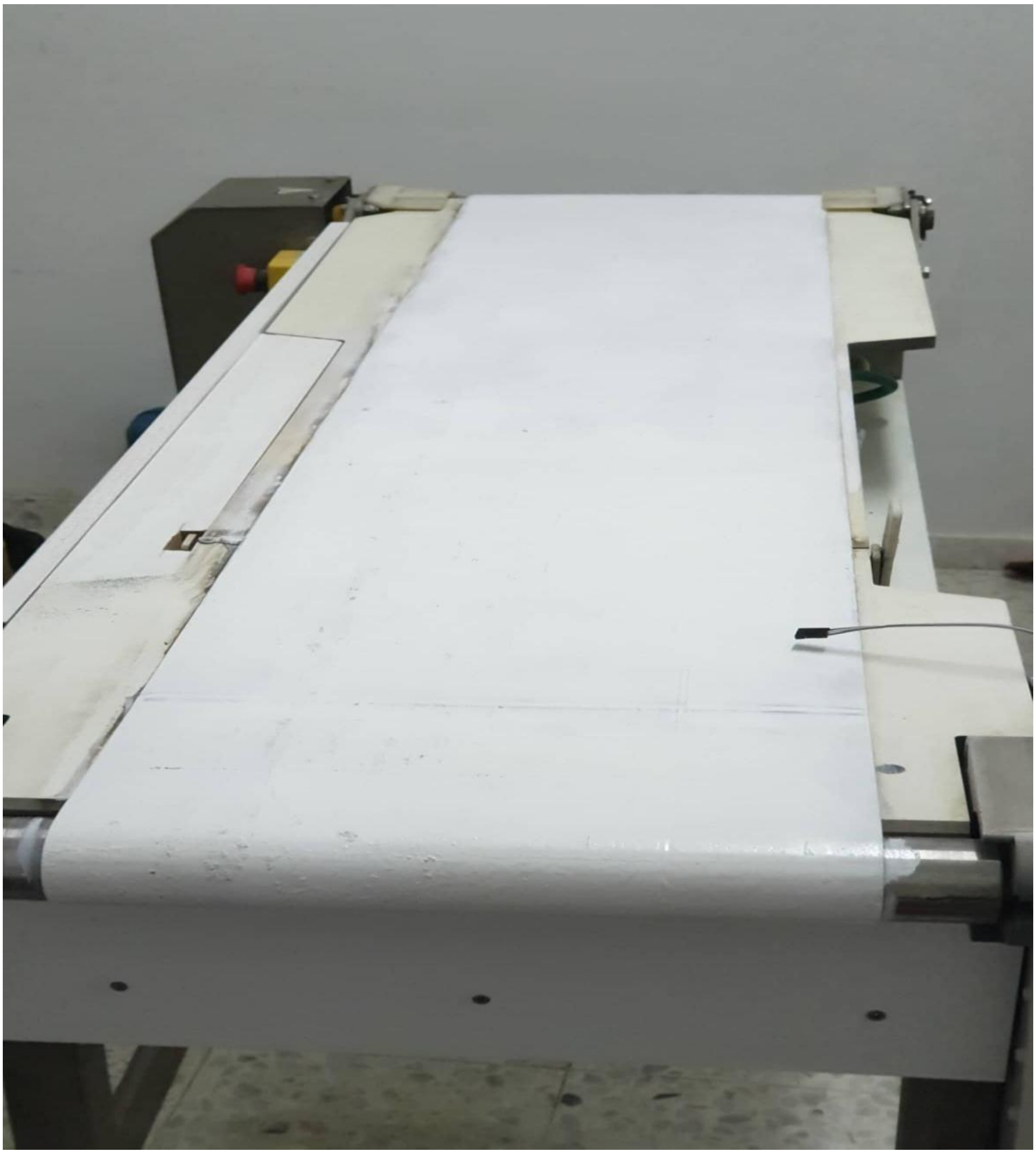


figure 4.1 image of practical conveyor

The conveyor has following specifications:

- Stainless metal conveyor.
- 1.5-meter length.
- 40 cm width.
- 1-meter height.

4.1.2 Variable Frequency Drive (VFD):

figure 4. 2 VFD Omron

The VFD used in practical implementation has the properties of:

- J7 Omron VFD.
- One phase (220V) input voltage.
- Three phase (220V) output voltage.
- 500-watt Power.

4.1.3 Motor and Gear:

Figure 4.3 motor and gear

- TS63C4 Three phase motor (220V).
- 220-watt Power.
- 0.64 Power Factor.
- 1.56 A current in delta connection.
- Gear ratio i=10.

4.1.4 Cylinders and Valves:

figure 4.4 Cylinder.

- Double acting cylinder.
- 5/2 pneumatic valve electrical activated spring returned.

4.1.5 Camera and Camera’s Stand:

Figure 4.5 image camera's stand

- Logitech C270 HD webcam, 720P video.

4.1.6 Accessories:

- Relays Modules.
- Industrial Relay.
- Push Buttons and Emergency.
- Sensors.

4.2 Programming Code:

The code based LabVIEW vision module 2016, it divides to several sub VIs as follows:

4.2.1 Image Acquisition VI:

The procedure of image acquisition is to over write the new image on old one, this achieve small memory suspension, efficiently processing of taken image and basis on “on Demand Acquisition” technique.

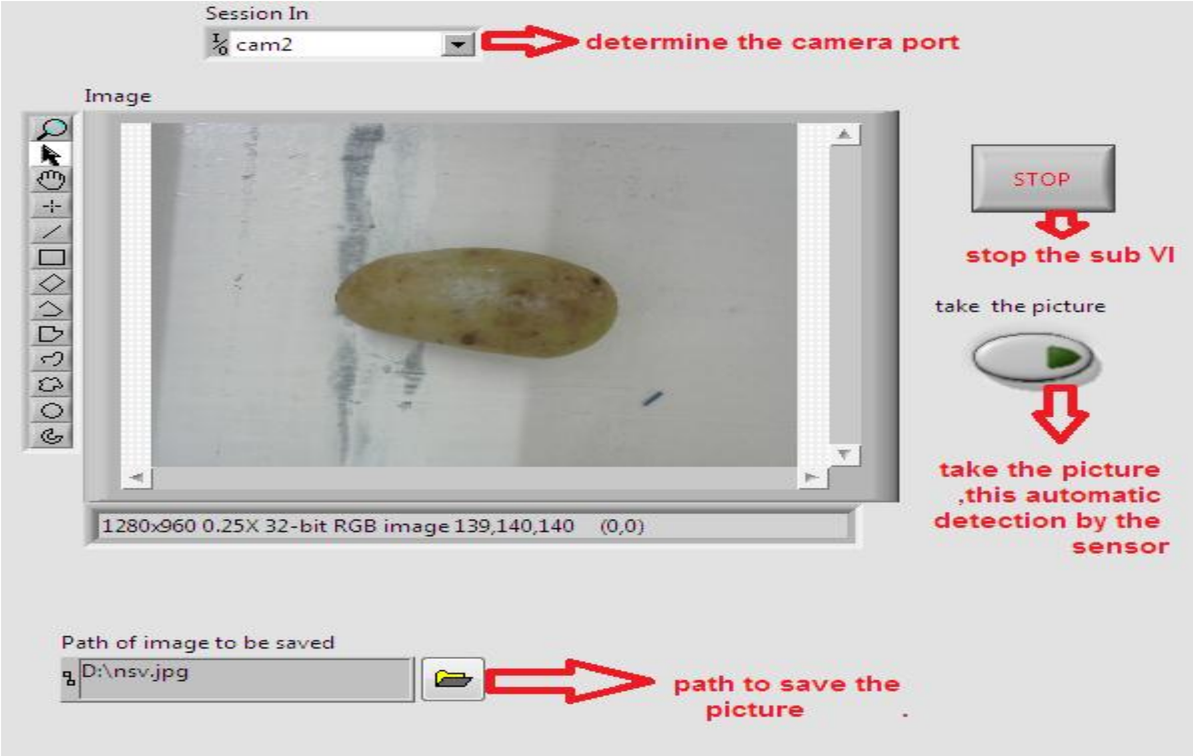


Figure 4. 6 Image of Acquisition VI

- The Button “take the picture” found for manual calibration. The automatic taking the pictures implemented by sensor detect the item when it reaches the camera’s area.

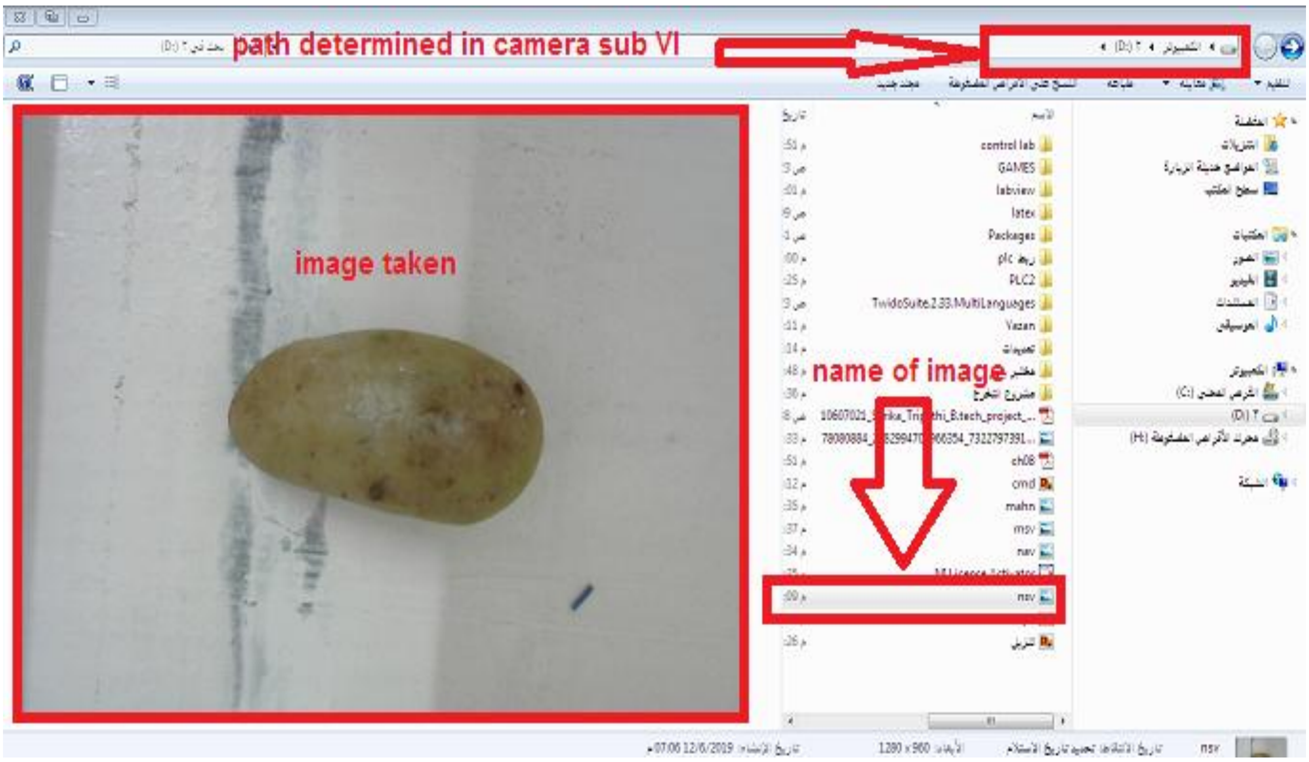


Figure 4. 7 image of saved path of the image

4.2.2 Sizing Detector VI:

In this VI, the size detection operation is performed. When the large item detects, the program will interface the decision by LED on the Front Panel of the program. The same thing occurs for the small item.

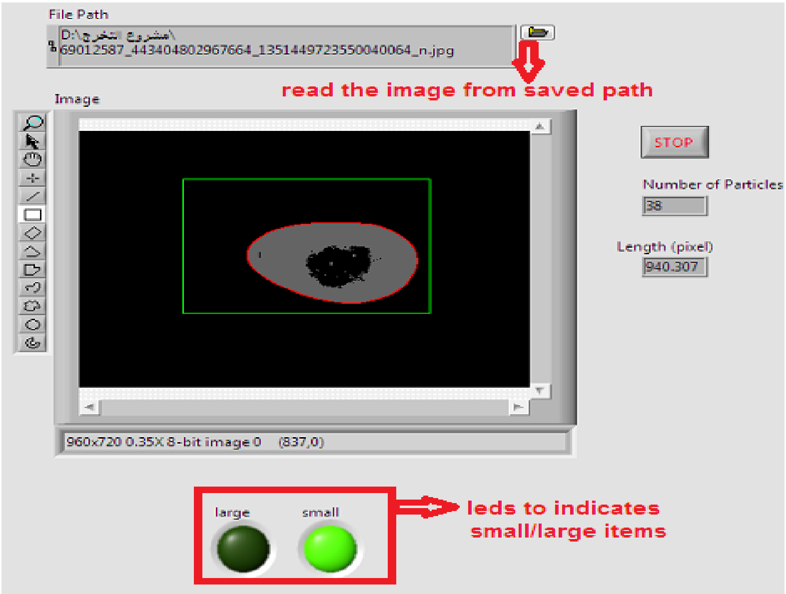


Figure 4.8 image of small item detection

- The size detect VI continuously reads the image saved by Image Acquisition VI, and then determine the small/large items.
- This decision is sent to cylinders for the sorting operation.

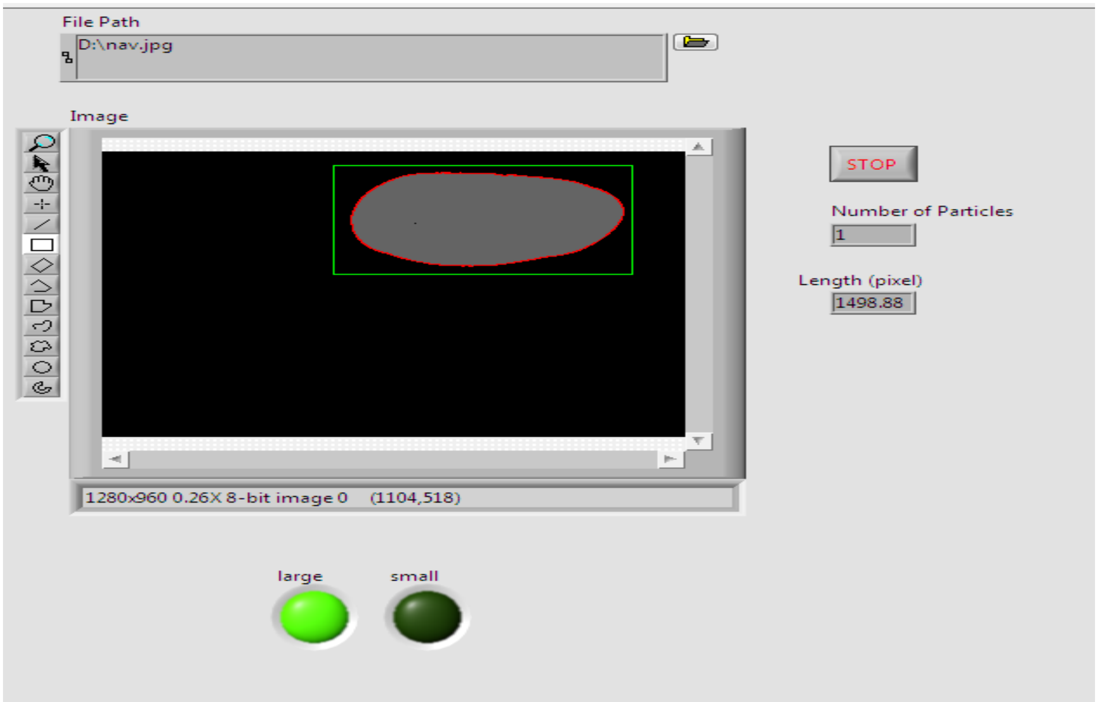


Figure 4. 9 image of large item detection

4.2.3 Defect Detector VI:

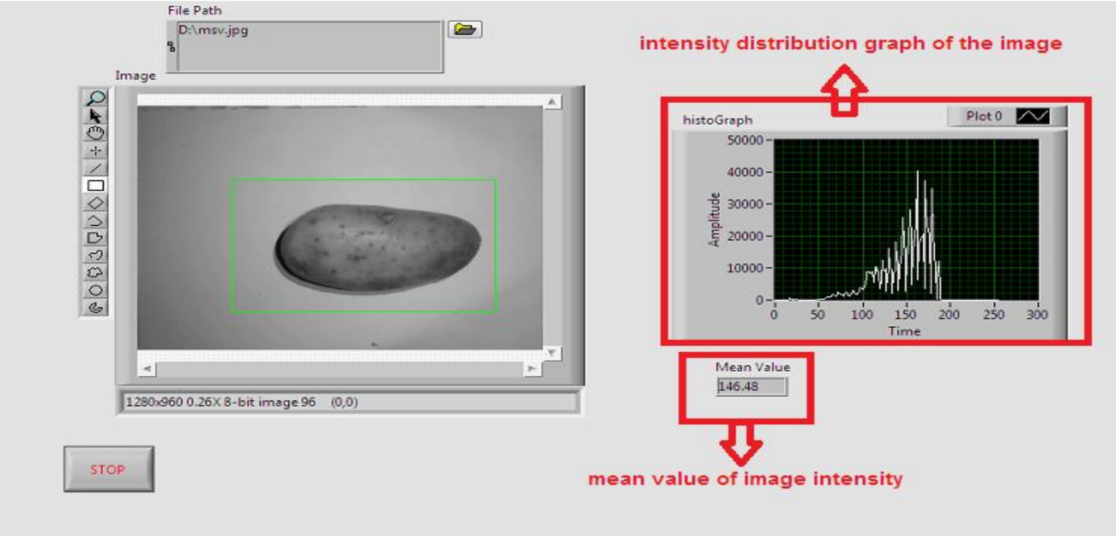


Figure 4. 10 Defect Detection

4.2.4 Main VI Project:

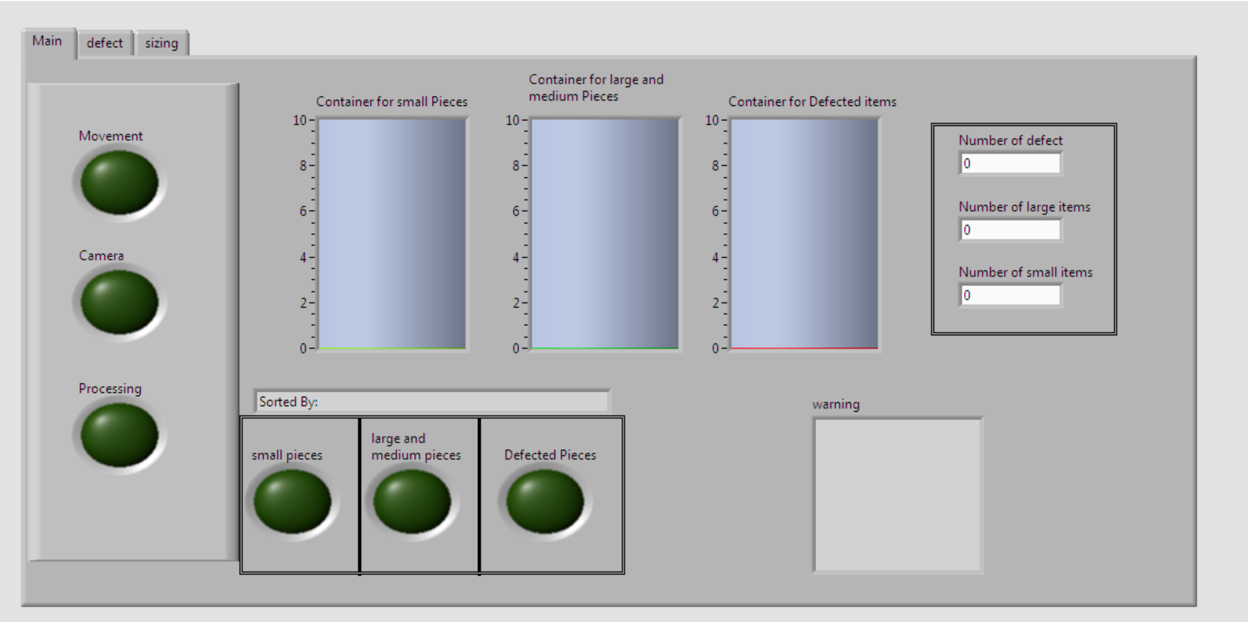


Figure 4.11 Main VI

4.3 Improvement solution for 180° Design:

The improvement offers that the closed loop system of weights detection for the container. When the container reaches certain weight, the program indicates that the container should be replaced.so, the system achieves constant weight of various sorting categories.

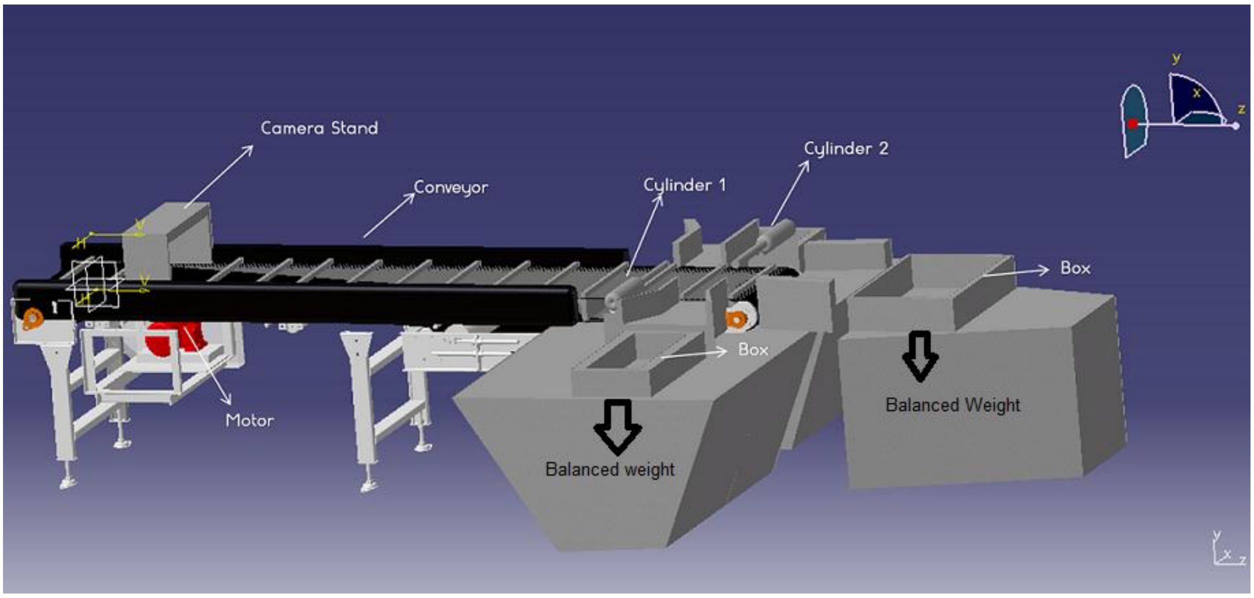


Figure 4. 12 Proposed Solution of 180°

4.4 Proposed Design for 360° Defect Detection:

- Circular Vacuum Solution:

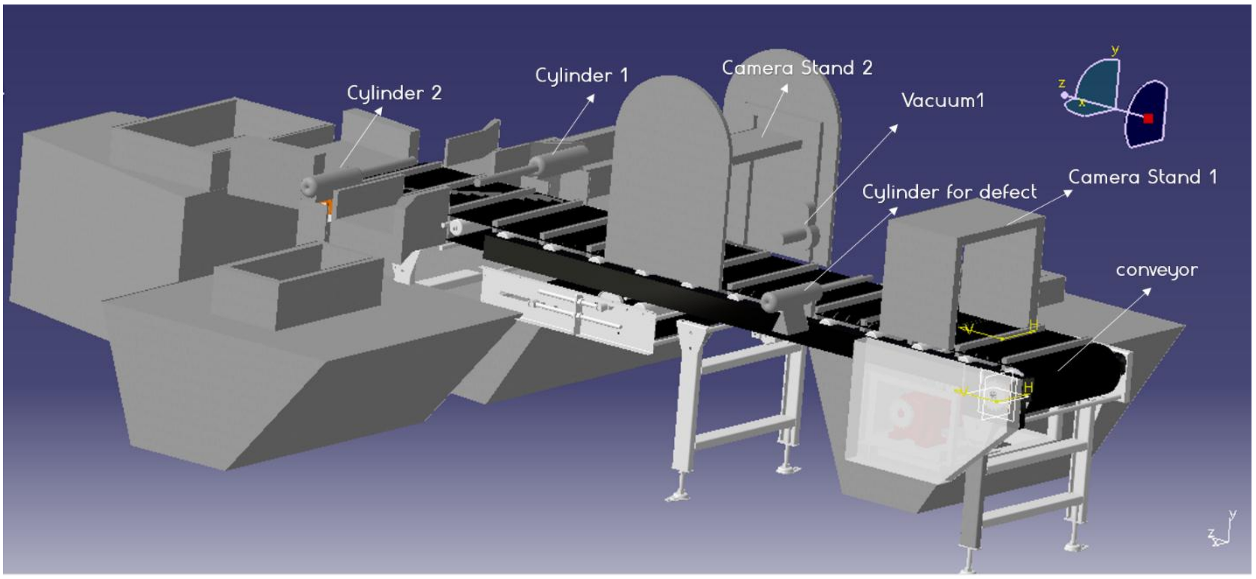


Figure 4.13 Design for 360° Vacuum Solution

This solution stands for two cameras every one covers 180°. After the system takes the image, checking for defected Pieces performed. And then, the Pieces enter the Vacuum contour to check another 180° preview.

- Glass 360° Defect Detection:

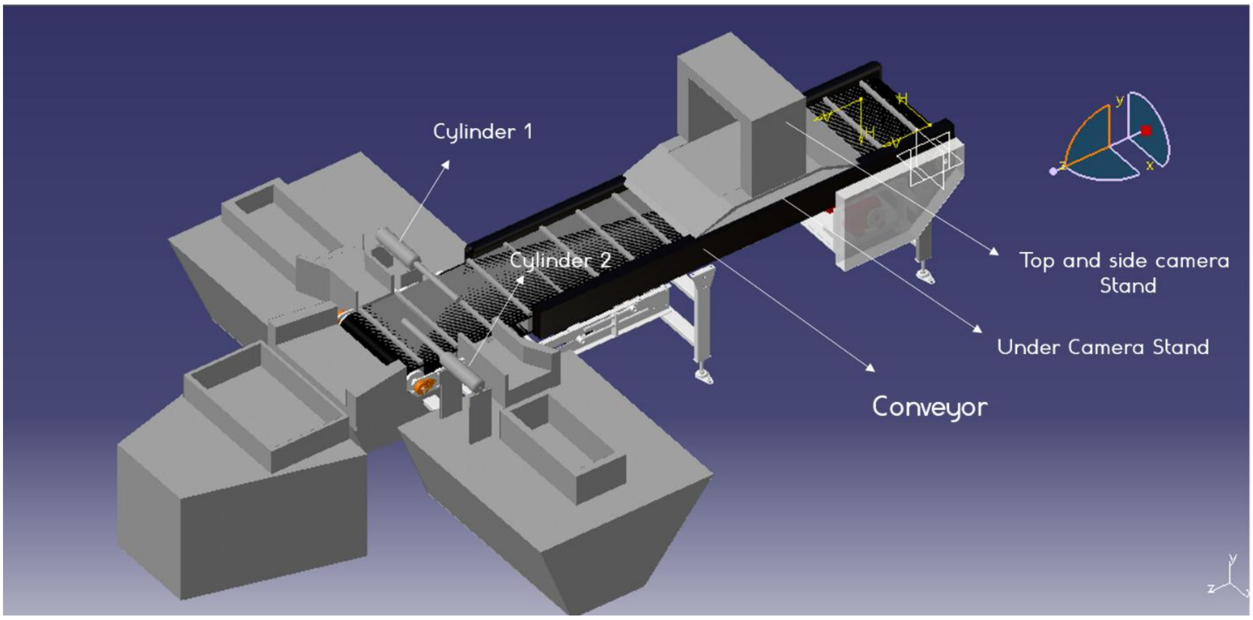


Figure 4. 14 Glass Proposed solution

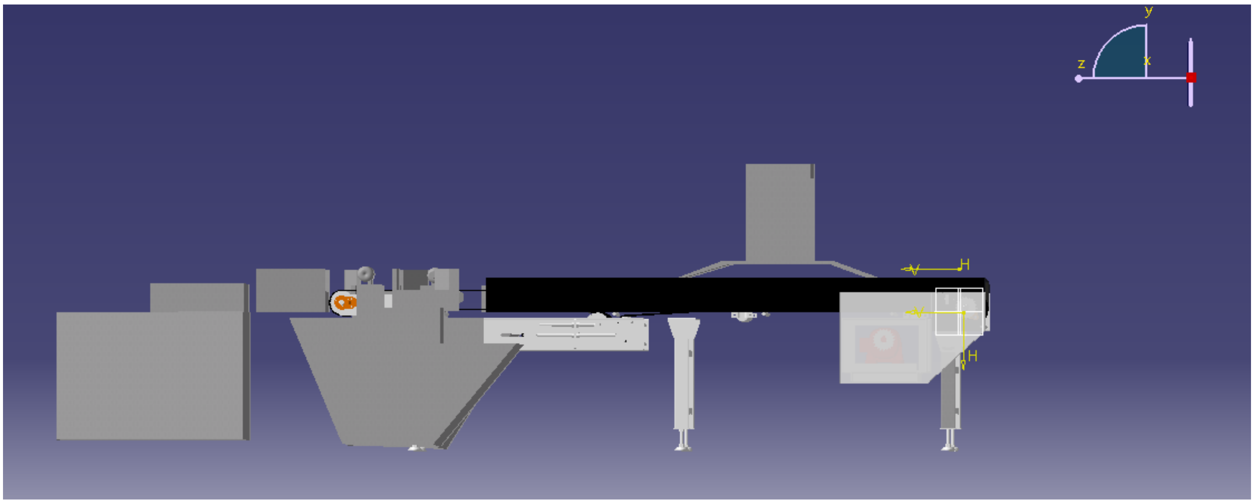


Figure 4. 15 Cross sectional of proposed design

Conclusion:

This work enhanced a new technology that can be used in agricultural sector which it is image processing with mainly vegetable. However, reducing human mistakes through sorting operations have been avoided.

The designed prototype has the capability of sorting for various agricultural crops because its base of sorting program has been generally designed with sorting. This can be performed with a little changed in programming code.

When there are enough budget and investment, the designed porotype module can be scaled to a real size vegetable sorting system that can be sold for the local Palestinian agricultural market.

Future work:

The prototype has designed for one type of potato, so, the future work will start at the end of this design, it is going to be developed onto other types of potato’s types that allows the user to determine the potato’s type to be sorted, and then, the prototype is going to be extended onto other crops with precisely sorting and new technology!

However, the design can be improved with modern image processing techniques based on labview platform.so, this need to learn how to use the image processing in industrial fields.

Recommendations:

Recommendations according the project’s prototype:

1. Bringing enough supporting of budget and investment to improve this design onto proposed 360° defect and sorting solutions.

2. Working on scaling the proposed prototype to real agricultural world, using this solution gives farmer qualified product to export it.

3. This design should be the starting point of using the image process techniques with other industrial fields.

4. Using the labview data dash board to monitor the sorting process.

5. Using advanced drivers that compatible with labview environment, ex (DAQ, MYRIO).

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Appendixes:

Appendix A

Product Line of Induction Motors (RoHS)

Series	Voltage (VAC)	Type	Motor Frame Size, Output Power										
			□42 mm (□1.65 in.)	□60 mm (□2.36 in.)	□70 mm (□2.76 in.)	□80 mm (□3.15 in.)			□90 mm (□3.54 in.)				□104 mm (□4.09 in.)
			1 W, 3 W (1/750 HP, 1/250 HP)	6 W (1/125 HP)	15 W (1/50 HP)	25 W (1/30 HP)	40 W (1/19 HP)	60 W (1/12 HP)	40 W (1/19 HP)	60 W (1/12 HP)	90 W (1/8 HP)	150 W (1/5 HP)	200 W (1/4 HP)
World **K** Series	Single-Phase 110/115	Lead Wire	●	●	●	●			●	●	●		
		Terminal Box				●			●	●	●		
		Conduit Box				●			●	●	●		
	Single-Phase 220/230	Lead Wire		●	●	●			●	●	●		
		Terminal Box				●			●	●	●		
		Conduit Box				●			●	●	●		
	Three-Phase 200/220/230	Lead Wire		●		●			●	●	●		
		Terminal Box		●		●			●	●	●		
		Conduit Box				●			●	●	●		
2-Pole, High-Speed Type	Single-Phase 110/115	Lead Wire					●	●		●	●	●	
	Single-Phase 220/230	Lead Wire					●	●		●	●	●	
	Three-Phase 200/220/230	Lead Wire								●	●	●	
		Terminal Box										●	
BH Series	Single-Phase 110/115	Cable											●
		Terminal Box											●
	Single-Phase 220/230	Cable											●
		Terminal Box											●
	Three-Phase 200/220/230	Terminal Box											●

■ Product Line of Gearheads (RoHS)

Gearhead			Applicable Motor			Rated Life (hours)	Low Noise
Type of Gearhead		Type of Pinion	Series	Output Power	Type of Pinion		
Parallel Shaft	Long Life, Low Noise **GN-S** Gearhead	**GN** Type Pinion Shaft	World **K** Series	6 W~ 40 W (1/125 HP~ 1/19 HP)	**GN** Type Pinion Shaft	10000	●
	GN-K Gearhead	**GN** Type Pinion Shaft	World **K** Series	1 W~ 40 W (1/750 HP~ 1/19 HP)	**GN** Type Pinion Shaft	5000	
	Long Life **GE-S** Gearhead	**GE** Type Pinion Shaft	World **K** Series	60 W, 90 W (1/12 HP, 1/8 HP)	**GE** Type Pinion Shaft	10000	
Right-Angle Shaft	Hollow Shaft Gearhead	**GN** Type Pinion Shaft	World **K** Series	25 W, 40 W (1/30 HP, 1/19 HP)	**GN** Type Pinion Shaft	5000	
		GE Type Pinion Shaft	World **K** Series	60 W, 90 W (1/12 HP, 1/8 HP)	**GE** Type Pinion Shaft	5000	
	Solid Shaft Gearhead	**GN** Type Pinion Shaft	World **K** Series	25 W, 40 W (1/30 HP, 1/19 HP)	**GN** Type Pinion Shaft	5000	
		GE Type Pinion Shaft	World **K** Series	60 W, 90 W (1/12 HP, 1/8 HP)	**GE** Type Pinion Shaft	5000	

■ General Specifications

• *World **K** Series*

◇1 W (1/750 HP), 3 W (1/250 HP) Type

Item	Specifications
Insulation Resistance	100 MΩ or more when 500 VDC megger is applied between the windings and the case after rated operation under normal ambient temperature and humidity.
Dielectric Strength	Sufficient to withstand 1.5 kVAC at 50 Hz or 60 Hz applied between the windings and the case for 1 minute after rated operation under normal ambient temperature and humidity.
Temperature Rise	Temperature rise of windings are 75˚C (135˚F) or less measured by the resistance change method after rated operation under normal ambient temperature and humidity with connecting a gearhead or equivalent heat radiation plate*.
Insulation Class	UL/CSA standards: Class A [105˚C (221˚F)], EN standards: Class E [120˚C (248˚F)]
Overheat Protection	Impedance protected
Ambient Temperature	−10~ +40˚C (+14~ +104˚F) (non-freezing)
Ambient Humidity	85% or less (non-condensing)
Degree of Protection	IP20

◇6 W (1/125 HP)~90 W (1/8 HP) Type, 2-Pole/High-Speed Type

Item	Specifications
Insulation Resistance	100 MΩ or more when 500 VDC megger is applied between the windings and the case after rated operation under normal ambient temperature and humidity.
Dielectric Strength	Sufficient to withstand 1.5 kVAC at 50 Hz or 60 Hz applied between the windings and the case for 1 minute after rated operation under normal ambient temperature and humidity.
Temperature Rise	Temperature rise of windings are 80˚C (144˚F) or less measured by the resistance change method after rated operation under normal ambient temperature and humidity with connecting a gearhead or equivalent heat radiation plate*. [Three-phase type: 70˚C (126˚F) or less]
Insulation Class	Class B [130˚C (266˚F)]
Overheat Protection	6 W (1/125 HP) type has impedance protection. All others have built-in thermal protector (automatic return type) Open: 130±5˚C (266±9˚F), Close: 82±15˚C (179.6±27˚F)
Ambient Temperature	Single-phase 110/115 VAC, Single-phase 220/230 VAC, Three-phase 220/230 VAC: −10~ +40˚C (+14~ +104˚F) (non-freezing) Three-phase 200 VAC: −10~ +50˚C (+14~ +122˚F) (non-freezing)
Ambient Humidity	85% or less (non-condensing)
Degree of Protection	Lead Wire Type: IP20 Terminal Box Type, Conduit Box Type: IP54 (excluding the installation surface of the round shaft type)

* Heat radiation plate (Material: Aluminum)

Motor Type	Size: mm (in.)	Thickness: mm (in.)
1 W (1/750 HP), 3 W (1/250 HP) Type	80×80 (3.15×3.15)	5 (0.20)
6 W (1/125 HP) Type	115×115 (4.53×4.53)	
15 W (1/50 HP) Type	125×125 (4.92×4.92)	
25 W (1/30 HP) Type (2-Pole, High-Speed **4IK40** Type, **4IK60** Type)	135×135 (5.31×5.31)	
40 W (1/19 HP) Type (2-Pole, High-Speed **5IK60** Type)	165×165 (6.50×6.50)	
60 W (1/12 HP), 90 W (1/8 HP), 150 W (1/5 HP) Type	200×200 (7.87×7.87)	

The selected motor main specifications:

4IK25UC-30, 25 W (1/30 HP) Induction Gear Motor (30:1 Gear Ratio, Single-Phase 220/230 VAC)

Request Quote