# Improving Productivity and Quality in Manufacturing by Applying Computer Vision Systems (Image Processing Technique)

[1]Ali Hussein Humod*, [2]Assoc. Prof Dr. Zulkiflle Leman, [3]Ir. Razali Samin, and [4]Negin Ashrafi.

[1,2,3,4]*Department of Mechanical and Manufacturing Engineering, Universti Putra Malaysia, 43400, Selangor, Malaysia*

***Abstract :** Automated inspection systems is the target for all automated organizations. The objective zero defect considers as a challenge for many industries since there are many factors effect on production line. Increase scrape items effect on productivity and environment; rework produced items as bottle neck for production lines and decrease products rates. The objectives for the research project focused on four main concerning, Evaluate automated inspection and control system in manufactures. Redesign online inspection system for some industrial case studies for the purpose of enhancing Quality control, tracking quality control in manufacturing systems and embedded improving computer vision systems in the production lines levels, and reduce defect items by correct parameters during the production lines. Research project focused on some case studies like (plastic, hot stamping, assembly, and textile) industries in Malaysia and Iraq. Computer vision systems was the common methods since it considers as non-destruction testing system. One of the machine vision systems techniques is image processing technique. Image processing algorithm implement by using MATLAB and Simulink. The developed points in this research focused on interpret defects and signal feedback for correcting deviations in the setting parameter for the fabrication machines. This system will help manufacturers to understand faults for their products online during fabrication route. Three main functions were using feature matching, color recognition and orientation and recognize the object functions. The results for this system showed that the ability for the system to know the weak points in the produced items and the production systems and accurate them with keeping on the stability for the automated system. Growth in information technology and cameras will improve system capabilities in different fields and adaptable for heavy environments.*

***Keywords:** MATLAB, Digital image processing, Simulink, Feature matching, Color recognition, Object recognition.*

## I.    Introduction

Productivity and Quality are two terms occupied the planning for every manufacturing systems in each phase of product or project design, start from the idea phase until finished product phase. Quality control, is a process by which entities review the quality of all factors involved in production. Controls include product inspection, where every product is examined visually, and often using a stereo microscope for fine detail before the product is sold into the external market. Inspectors will be provided with lists and descriptions of unacceptable product defects such as cracks or surface flaws for example.

Quality control underlines testing of products to uncover defects and reporting to management who make the decision to allow or deny product release, whereas quality assurance attempts to improve and stabilize production (and associated processes) to avoid, or at least minimize, issues which led to the defect in the first place. [1]

The development of the automation systems in the manufacturing structures led to increase the productivity obviously. Although for this development, still the quality issue have not insured one hundred percentage. Because to ensure the quality indeed will lead to decrease the productivity. Evolution in testing and measurement techniques have the ability to check diverse factors for products. By accompanied the automation system with inspection device during online production (production process) have the ability to enhance the inspection system starting from the raw material for the product until finished product. Then in this research, will try to evaluate the inspection system by using image process technique in the production lines and study its effect on the production procedures in each operation. So our study will focus on the automation and semi-automation system and review the machine vision system and specific with image processing. Also find the relationship between the digital image details and information and production parameters like (temperature, pressure, stress, roughness, etc.).Finally try to review the machine vision versus human perception. [2]

Finished products during the mass product inspected by laboratory devices and they are choosing the samples randomly, for example one item each fifty. The chosen sample will be the judge for the fifty if they are good or rejected. The defects on the product refer to weakness in production lines in one of its stations. This fault in stations lead to lose in the parts then the expectation saving that it coming from automation system will be missing in these mistakes. This research project, cover and focus on quality and productivity in manufacturing fields and it will try to achieve some objectives: To evaluate automated inspection and control system in manufactures, To redesign the online inspection system for some industrial case studies for the purpose of enhancing quality control, For tracking quality control in manufacturing systems and embedded improving computer vision systems in the production lines levels. The research project cover and survey some automation or semi-automation. The research focus on four case studies like (plastic, stamping, assembly, and textile) industries in Malaysia and Iraq. Plastic industry is the main case study for studying then the evaluation will discuss on the other three case studies.

## II. Research contribution

From the previous works on detect defects or recognize objects by using computer vision (image processing technique) has been discussed the faults individually. The decision for these faults were recording and reporting. The research project of improving productivity and quality in manufacturing by applying computer vision (image processing technique) used MATLAB program to analyze three main issues for quality assurance, feature matching, color recognition and objective orientation and recognition. The contribution here will be by listing the defects in look up table and finding their causes and remedies. The suggested design for inspection create decision from knowing the reasons and cures and compare the results values with other look up tables for parameters using in the manufacturing systems like matching, coloring and orientation. So the main idea is to track the defects and try to avoid their causes.

## III. Methodology of the Work

The study for this project is motivated on the productivity and quality for products in manufacturing area. The development in automation systems and industries devices have been making the productivity increase in patent frame, but still there are many defects in the products and items in the production line or assembly line especially in mass production lines. Quality control in any factory responsible on the defects checking by using different techniques. Some of these department for inspection product separate and it is checking the finished product and the others embedded in the production lines. In our study, we evaluated the automated or semi-automated manufacturing products from the raw material to finished product. This evaluation will try to redesign the plant layout and fix machine vision system in some parts to follow each operation and find the weak points. This machine vision system will be implemented by using image processing techniques. The results have been compared based on the production cycle time, different in product and the complexity for these systems. During the survey and results, we tried to find if the inspection system by using vision machine is as bottleneck in the product line, the reliability, and flexibility. The achievement in this research that if there is ability to make the machine vision by using image processing close to human perception. The limitation for the collection Data in this research is the access to the full automation manufacturing to make the survey. Or provide the suitable questionnaire that it is acceptable from these factories. Prepare the questions stage have to be during the ongoing research. The data collection will be conclude and extract in the next research stages. The procedures for this project followed as shown in the flow chart in **Fig. 1**.
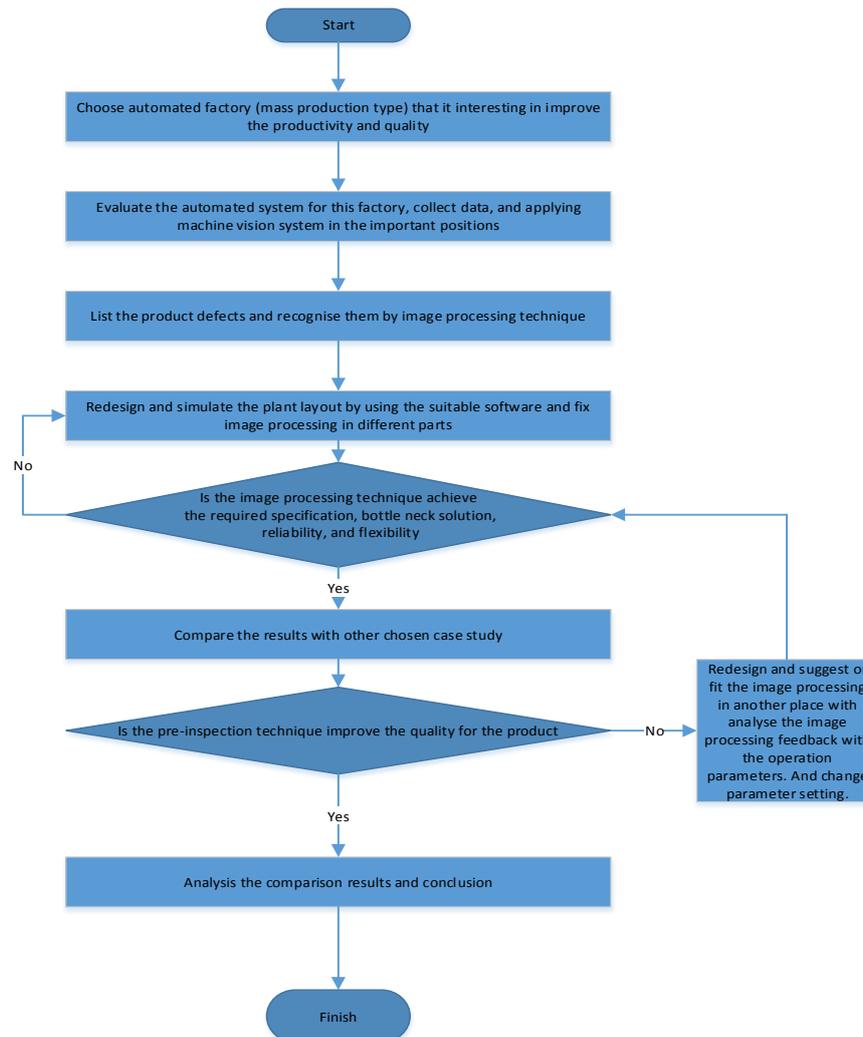
**Fig.1. Flow Chart Show the Procedure for the Research Project**

### 3.1 Tool Description

In brief, the main tools for image processing system are: plant layout where it depends on the chosen case study (plastic industry), Image acquisition and digitization by using CCD or CMOS cameras but in the research project we had used Three web cams, Image processing and analysis, there are different analyse software one of them MATLAB and Simulink was using here, Interpretation, the difficulty for the project was by translate the defects to warning signals and tracking the defects in the production line and use the look up table to find the deviation in the setting parameters.

### 3.2 Collect the Data

The data that had been collected divided into two section: First section: Survey it was questionnaires from some industries inside Malaysia and Iraq to know the quality control techniques that have been used. Second section: Real Data from the chosen case study for Simulation design, these data will be process in MATLAB and Simulink. Plastic industry was used to know the defects for their products. The real data from case studies, evaluation the collection defects data (causes and remedies) and filtrate them based on the common defects. And also based on the possibility to fix the parameters in time.

It is very important to know major issues. As we know the quality issue it focuses on knowing defects and try to fix them. We tried to list down most defects in plastic parts that can be traced back to three sources: The material being used to make products, the processing of the material in the mold, and the machine itself. We have grouped defects together by their most common cause; however one or more factors may contribute to a defect. Problem with raw material, problem with machine itself and problem the processing all of them share in plastic part defects.

1- Common defects linked to the plastic resins or additives being used to manufacture a part include: Color streaks, Delamination, Discoloration, Embedded contaminates, and Splay marker or silver streaks.
2- Common defects linked to the processing of the plastic resin in the mold include: Blistering, Burn marks, Cold slugs, Flow marks, Sink marks or shrinkage voids, Stress cracking or stress crazing, and Stringing
3- Common defects linked to improper mold design and/or maintenance include: Drag marks, Flash or burrs, Jetting, Short shot, and Warping.

Most of defects listed here can be addressed by making change to the processing, the material or the mold itself. The best way to avoid these part defects is to work with a plastic injection molded that has a great deal with experience with various resins and their applications.
Our aim caring for productive and qualitative. By fill in the questionnaire by selective companies and industries. During their experience in the manufacturing and inspection field. Their answers on this study was valued.

**3.3 Simulation model contents**
The final simulation model for our suggested model (online-inspection) contain of four main stages: Image processing analysis functions (feature matching, colour recognition, orientation and object recognition) blocks, Controller stage where PID controller have been used in this simulation, Cameras; here there are three cameras, and there is opportunity to expand them, and other tools like (trigger to control cameras operation, clocks, and monitors) and reference image block (where the references images key in).

## IV. Procedures and Results
### 4.1 The Final Simulation Model
From the three MATLAB functions that have been presented and implemented, feature matching, color recognition and object recognition and orientation, all of them figured by using GUI's. Three of them combine in GUI screen to be the last final model for our pre- inspection system. As shown below in **Fig. 2, Fig. 3, Fig. 4, Fig.5 and Fig. 6** represent the GUI and Simulink screens blocks.
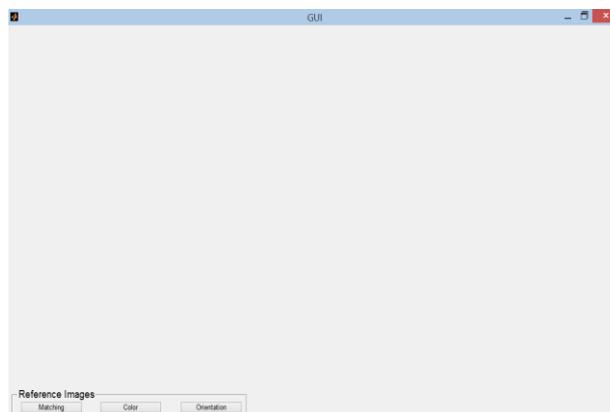


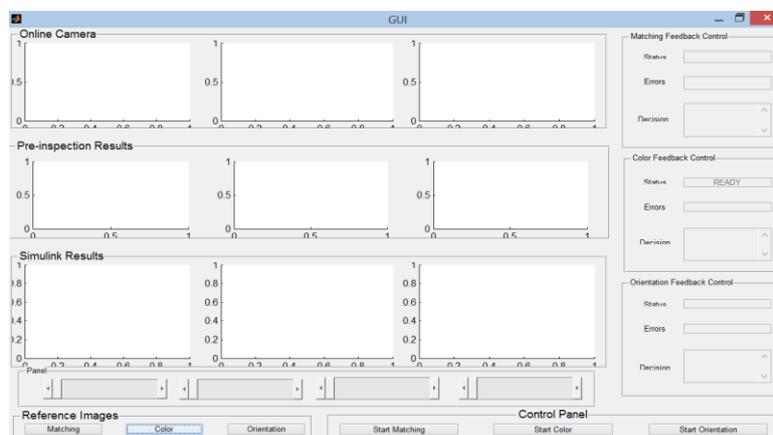**Fig. 2. GUI Screen for the Pre-Inspection System in Its Initial Stage before Key- In the References.**



**Fig. 3. GUI Screen for the Pre-Inspection System after Key in the References Images.**
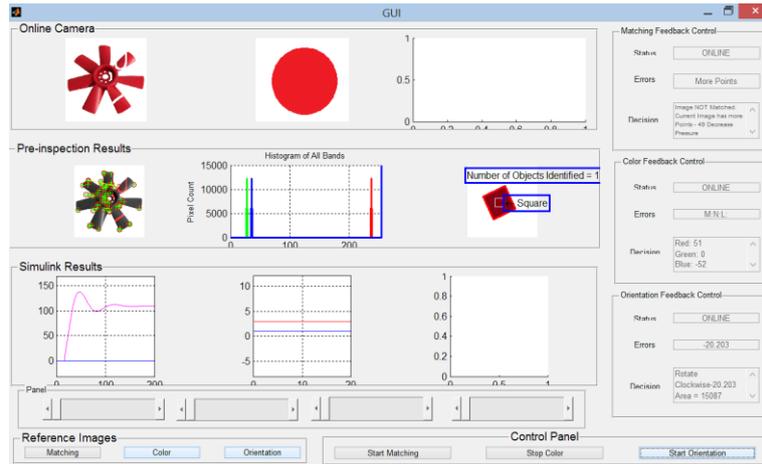
**Fig. 4. GUI Screen for the Pre-Inspection System during It's Implementing and Generate the Results.**
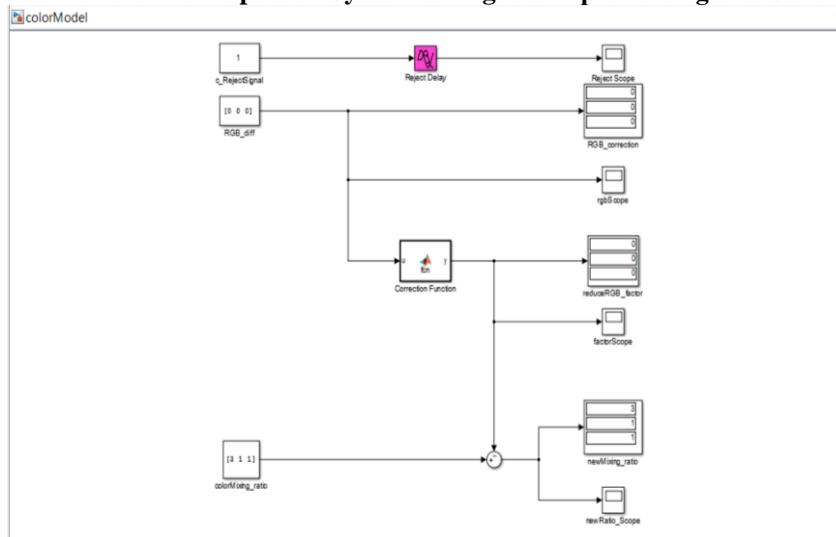


**Fig. 5. Simulink Diagram for the Pre-Inspection System (Colour Model).**
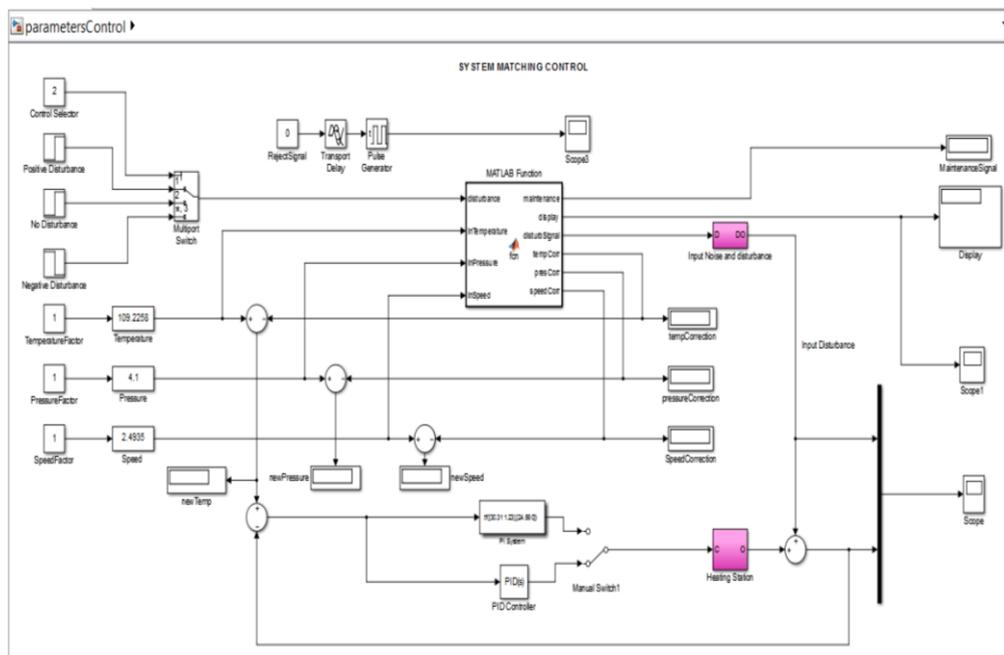


**Fig. 6. Simulink Diagram for the Online-Inspection System (Feature Matching Model).**

**4.2 Samples Analyses**

Experiments applied on some plastic parts with defects to check the functionality for the suggested online inspection system. Feature matching function rejected the defect items and count them. After exceed the limitation for the flaws, the system sent correction signals to the control system where for feature matching is PLC and for colour recognition is mixing control. For orientation systems there is one decision send to the servomotor to correct the angle into the desired position. **Table 1** Compare the GUI results with operator's observation in Plastic Industry.

For Feature matching, we took some samples and checked the results with the reference images. In feature matching analyses the feedback signal for the Simulink based on the selection from the look up table function, where this function has three main parameters (temperature, pressure, speed) and can be expend based on the produced items. The selection in this function compared GUI decision with the setting points (pressure, temperature, speed).finally the feedback signal had sent back to the control system for correction procedure. We have to note that the correction signal will not send until pass the counter limit for example (Counter = 20 defects). It should be note that the system should be stable during the production and correction procedures so the steady state should be observe all the time.

The item color analyzed and compared with the reference image. The decision for GUI give RGB values differentiate , these values transferred in Simulink function to decrease or increase color ratio and the ratio compared with setting ratio (3:1:1) with setting tolerance 30 or any ratio set in the control system for the color mixer. The new ratio send after exceed the counter limitation. The correction ratio had been sent to the mixer system after pass the counter limit based on the accuracy for the produced items and to keep the control system stable.

The main purpose of orientation is to correct the angle for the produced object for many determination like assembly or sorting purposes. Then the GUI decision shows the corrected angle and these signal send to the servomotor in the production line or robot arm other clockwise or counter clockwise movement. The results for the item in object recognition GUI is detect it shape near to square and it has to rotate with clockwise angle -20.203 and its area in pixel 15087.Intial stage for orientation recognition has to set the desired angle for the production or assembly operation.   Parallel PID controller is used in Feature matching Simulink model where this block implements continues and discrete time PID control algorithms and include advance features such as anti-windup, external reset, and signal tracking. We can tune the PID gains automatically using the ''Tune-button'' (requires Simulink control design) here in this model gains are (proportional (P): 0.8817, Integral (I): 0.035, and Derivative (D): -4.797) and filter coefficient (N): 0.03796. Compensator formula (continues –time) shown in equation (1) and compensator formula (discrete-time) shown in equation (2), the main purpose is to keep system stable against the parameter changes during production line. The paragraph for the system stability shows in **Fig. 7**.

$$P+I. (1/S) +D. (N/ (1+N (1/S))) \dots\dots\dots\dots\dots\dots\dots\dots. \qquad (1)$$
$$P+I. (Ts. (1/ (Z-1))) +D. (N/ (1+ (N.Ts. (1/ (Z-1)))))\dots\dots\dots\dots. (2)$$

**Table 1. Compare the GUI Results with Operators Observation**

| No | The detection Type | GUI Results | Operators Observation |
|----|---|---|---|
| 1 | **Feature Matching**<br><br>**1- Pattern**<br>**2- Crack**<br>**3- Holes** | The results will appear between 5-10 seconds as shown below: | The result will be between (60-120) second based on the item complication. |
| | | Either: Image Matched<br><br>Or: Image not matched | Either: item matched |
| | | | Or: Item not matched |
| | | Error:  current images has more points for example -49 decrease. | The item will be reported to the QC with the defect type and numbers. |
| | | The feedback decision will be decrease or increase (temperature, pressure, speed .etc.). | The feedback decision will be entered manually based on the operator experiences |
| 2 | **Colour recognition** | The results will appear between 5-10 seconds as shown below: | The result will be between (30 -60) based on the colour accurate. |
| | | Image either :<br><br>N: N: N = colour equal.<br>M: N: M= not equal.<br>L: N: L =not equal. | The item that it has different colour will be reported to the QC to check it by spectrometer device. |

| | | | |
|---|---|---|---|
| | | L: N: N =not equal.<br>M: N: N= not equal.<br>L in any part= not equal.<br>M in any part= not equal. | |
| | | The feedback decision will be :<br>Decrease or increase (RED, Green, Blue) ratio for the injected control in blending system. | The feedback decision will be decrease or increase the colour level in blending system. |
| 3 | **Orientation + recognition** | The results will appear between (5-10)  seconds as shown below: | The result will be between (10 – 20) second. |
| | | Either:  the image is in correct orientation error = 0<br><br>Or: error = +/- angle | By naked eyes will see the orientation for the object. |
| | | The feedback decision will be:<br>Rotate Clock wise =angle<br>Rotate Counter clock wise = Angle<br>Object area in pixels<br>The feedback decision will be sent the signal to the servo motor to correct the object on the set orientation. | The decision will be by change objects on the set angle and every object will take between (30-60) second |

Comparison above shows that the online inspection system success to detect the defects in ideal time compare with the manual time that operators spend in test the products. The System more fixable to deal with different types of industries. What may need is extract the defects and the causes and their remedies. Study the defects carefully for each product will increase the accuracy for the inspection system. The main advantage for this system that there is no bottle neck, since it has rejected system for the defect items and the capturing images will be during the production line working and the stoppage for trigger will take between 5-20 seconds and the same time to analyze the images. The disadvantage for this method is the industry environment. Where any blur or dust will effect on the image resolution.
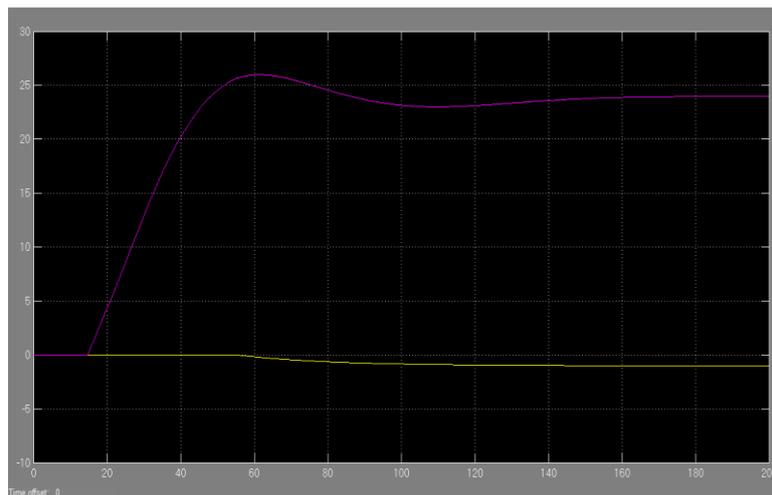

**Fig. 7. Show the Paragraph for the System Stability.**

## V.    Conclusion and Recommendation

Some of the most important applications of machine vision system in manufacturing are systems that ensure quality control of manufacturing products. In this research project, we discuss two big issue in manufacturing sectors, productivity versus quality. When we worked on improving the online inspection system, we have seen that productivity and quality are related, they are two sides of the same coin, and we can have both. The quality management can improve productivity, the number of units produced from available resources. Improve quality by reducing defects will increase good output. In fact, virtually all aspects of quality

improvement have a favorable impact on different measures of productivity. Labor productivity and machine productivity. Improve the quality of material and parts and improving job design and work activity.

Automated inspection system, is one of the fundamentals to achieve full automation system in manufacturing. So this research focused on implementing the inspection online during the production lines stages starting from entering raw material until getting finished products. Studying and analyzing the defects in the product items and make the possible corrections on the control system. The final model that it has shown above based on its design on the common defects in our case study (plastic industry), (holes, cracks, deviation, warping, burn marks, dimensional defects and etc.). Feature matching, color recognition, and orientation are the MATLAB tools that enable us to translate the defects and convert them to feedback signals into the control system. The decision to modify the control system depend on the produced items, where in the simulated model there is counter to calculate the number of defects. When the flaws access the limitation will pass, the signal send to change the setting parameters in the control system. Attribute with this model rejected system its duty to refuse any defect item.

By comparing the online inspection results from plastic factory with the other case studies (hot press forming, Textile, and assembly) industries. It shows the ability for the suggested design to implement on those factories by taking into account providing good environment for capturing the items images and study the relationships between the defects and setting parameters.

There are many challenges face this system. Illumination and factory environment regard main challenge where that one effect on the resolution for the snapping images. Another challenges is how to translate the defects to the suitable signals to change the setting parameters. Fixing the lookup table should be by experts to achieve the accuracy to detect the parameters for the production lines. Increase new produced items lead to increase the probability to get new defects.

Online-inspection system need many factors to achieve full automated inspection system. The challenges for these types of inspection systems are illumination and plan layout environment. So by developing the illuminations and enhance good plant layout design will increase the usability for this system. The good points for this system is up to date because it is implement by using MATLAB program where this program manage by huge number of scientists and researchers. Another issue it is expandable system to connect with many sensors and correct many types of parameters. The system can be used not just in manufacturing system but also in food fields and sorting system. Especially for recycling issue where all industries these days looking for clean environment and sustainability. Its advantages in decrease the waste will belong with benefit for both manufacturing and environment.

The suggest system has the ability to be embedded in robots system especially the robot that it works in inspection field by fixing the camera on the robot arm. For sorting and recycling systems, this online-inspection system has the ability to separate different part with different colours by using colour and shape recognition.

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