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Pneumatic Control System of Automatic Production Line Using Two Method of SCADA/HMI Implement PLC

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Abstract

This study focuses on the implementation of interfaces for human machine interaction (HMI) control and monitor automatic production line. The automatic production line can performance feeding, transportation, sorting functions. The objectives of this study are implemented two SCADA/HMI system using two different software. TIA portal software is used to build HMI, alarm, and trends in touch panel which is helped an operator to control and monitor the production line. LabVIEW software is used to build HMI and trends in the computer screen and is linked with Microsoft Excel (ME) to generate information table helped to monitor the performance of the pneumatic equipment. The production line can do performance feeding, transportation, sorting functions, is designed and simulated in FACTORY IO software and implemented. S7-1200 PLC employed to control the automatic production line using ladder logic diagram on TIA PORTAL V13 software. Two methods are adopted to create Human Machine Interface (HMI) for monitoring the status of the system (touch panel interface and LabVIEW interface). The communication between master program TIA PORTAL V15 software and slave program LABVIEW is through OLE Process Control (OPC) service. OPC offers greater flexibility and lower costs of development, integration, and assembly for controlling and monitoring the industrial process, as well as OPC involves a wide variety of data resource. As a result, the realized system enables two human interfaces for controlling and monitoring the physical values of the pneumatic system processes and parameters. In addition, it provides a way for different software packages to access values from control device (PLC) assisting to monitor the performance of the pneumatic equipment. The implemented system can be applied the laboratory for reducing the distance between theoretical knowledge and practical applications for engineering students. It plays a significant role in developing the ability of innovation and practical application. furthermore, the implemented system of the production line is a prototype with an actual production situation which is very close to the actual environment control process in the factory.

***Keywords**: SCADA, HMI, pneumatic system, TIA portal software, LabVIEW, PLC.*

1. Introduction

SCADA is an abbreviation of Supervisory Control and Data Acquisition. SCADA is the most modern tool used for collecting data designed to assist operators in the operation of the any system using real-time and historical information[1]. SCADA system task has data acquisition of the field devices, so it can process these data with the control systems, such as PLC or RTU. The processing data is displayed as symbols, alarms, trends, and reports. The evolution and sophistication of current computing technology played an active role in SCADA system development. SCADA components have been made depending on the technology evolution. SCADA components are shown in figure (1).

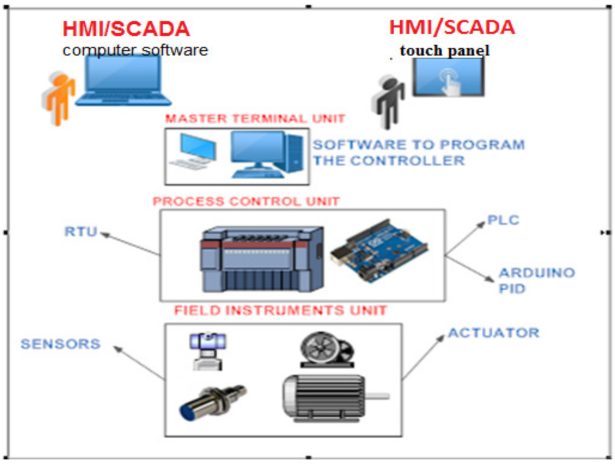


Fig. 1. SCADA Components.

The HMI is connected to the SCADA supervisory computer to access live data to monitor the parameter, drive the diagrams, alarm handling and report generation[2] HMI can be a part of the computer program that communicates with the user, such as LabVIEW[3] or visual basic[4]. HMI can be a touch panel (HMI screen) which administers of the running components of the SCADA system[5].. HMI can also be web a server interface, as shown in figure (2) [6]. A contribution of this study is to use two methods for implementing SCADA/HMI to control and monitoring the pneumatic components applied in the manufacturing sector.

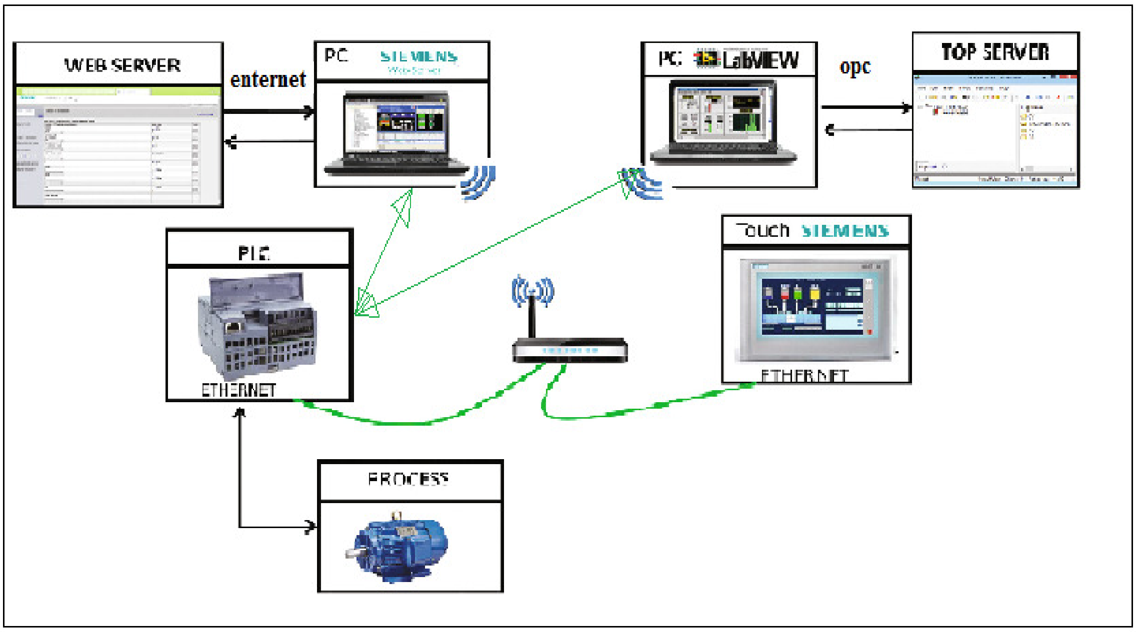


Fig. 2. HMI Type.

The pneumatic system is used in this work because the pneumatic components are simple in design, easily fitted, with relatively low maintenance cost (economic) and have long working life. It also unaffected by overload and do not produce heat [7]

2. Methodlogy

Many steps are required for building the desired system starting from a vision or concept of the system design for defining the system, and the system function. After getting an idea for the design, the actual development of the system of hardware and software selection started to cost avoidance. Also, the system is simulated to check whether the system can actually do its function. Then the prototype of the production line is fabricated as shown in figure (3).

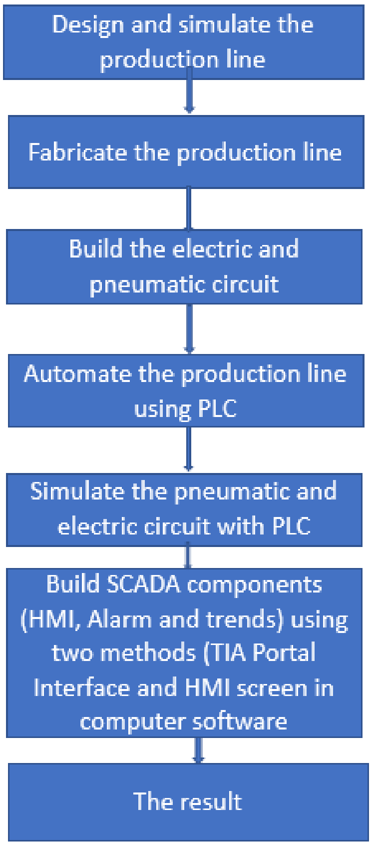


Fig. 3. the methodology.

3. The Hardware Components

The important hardware components used to perform the SCADA/HMI will be described below:

A. The Production Lines

The production line consists of feeding unit, transforming unit and sorting unit. The feeding unit is the first unit of the system providing a work piece to other units. It mainly consists of work piece tube, push cylinder, proximity sensor and IR sensor, as shown in figure (4).

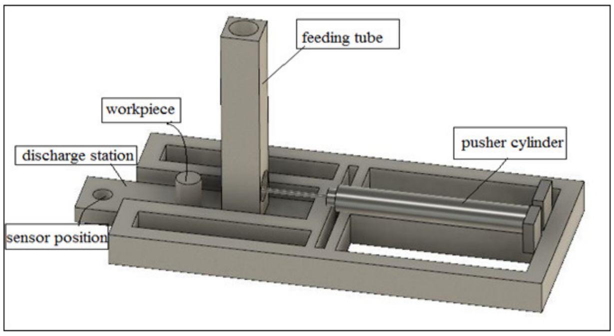


Fig. 4. The feeding unit.

The transforming unit consists of the robotic arm employed to achieve the transfer function of the work piece in the production line and IR sensor for specifying the existence of the work piece, as shown in figure (5).

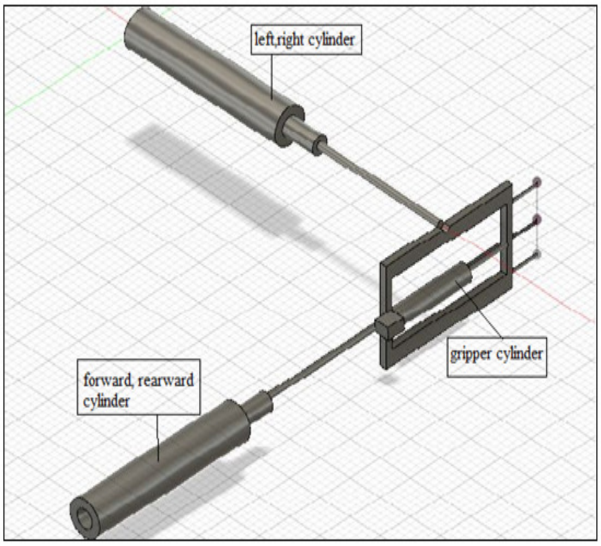


Fig. 5. The transforming unit.

As the sorting unit consists of belt conveyer, push cylinder, inductive proximity sensor to detect metallic workpiece, DC motor to drive the conveyor belt and IR sensor to detect the existence of the work piece, as shown in figure (6).

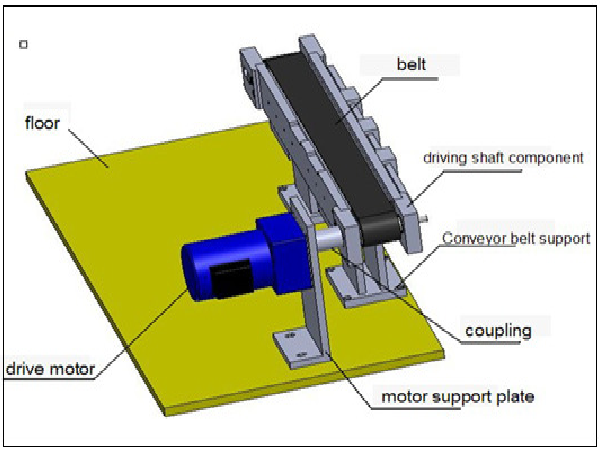


Fig. 6. The sorting unit

B. Inductive Proximity Sensor

Proximity sensor has various ways to detect, including the use of electromagnetic induction caused by eddy current in the detection of metallic objects. The Eddy current effect is that metal objects in an alternating magnetic field The metal produces internally alternating eddy current, and the eddy current will generate its magnetic field reactions on such a physical effect [8]. In the selection and installation of sensors. It should seriously be considered the detection distance, set distance to ensure a reliable production line of sensors moves. This distance varies from one type to another.

C. Infrared Sensor (IR)

An infrared sensor is an electronic gadget transmitted to detect a few parts of the environment. An IR sensor can quantify the warmth of an article and recognizes the movement, so it can recognize objects. The abundancy reaction of infrared (IR) sensors which is dependent on the reflected amplitude of the surrounding articles is non-straight and relies upon the reflection attributes of the item surface [9]. An IR sensor comprises of an IR LED and an IR Photodiode they both are called as photo – coupler. At this, point, when the IR transmitter emanates radiation, it achieves the article and a portion of the radiation reflects back to the IR collector. In view of the force of the gathering by the IR recipient, the yield of the sensor is characterized [10].

D. Programmable Logic Control (Siemens S7-1200 PLC)

The S7-1200 controller provides flexibility and power to control a wide variety of devices. The compact design, flexible configuration, and powerful instruction set combine to make the S7-1200 a good solution for controlling our system [11], as shown in figure (7).

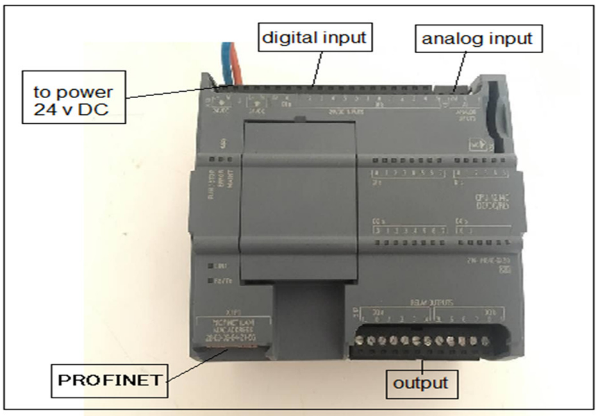


Fig. 7. S7-1200 PLC

4. Implement the Production Line

The system of automatic production line is made of steel structure, composed of feeding unit, transforming unit and sorting unit. Each unit is connected mechanically and electrically with other units in the system to make automatic production line. Each unit is mainly a pneumatic control system, but the conveyer belt is driven using DC motor, as shown in figure (8) and the system control diagram is shown in figure (9).

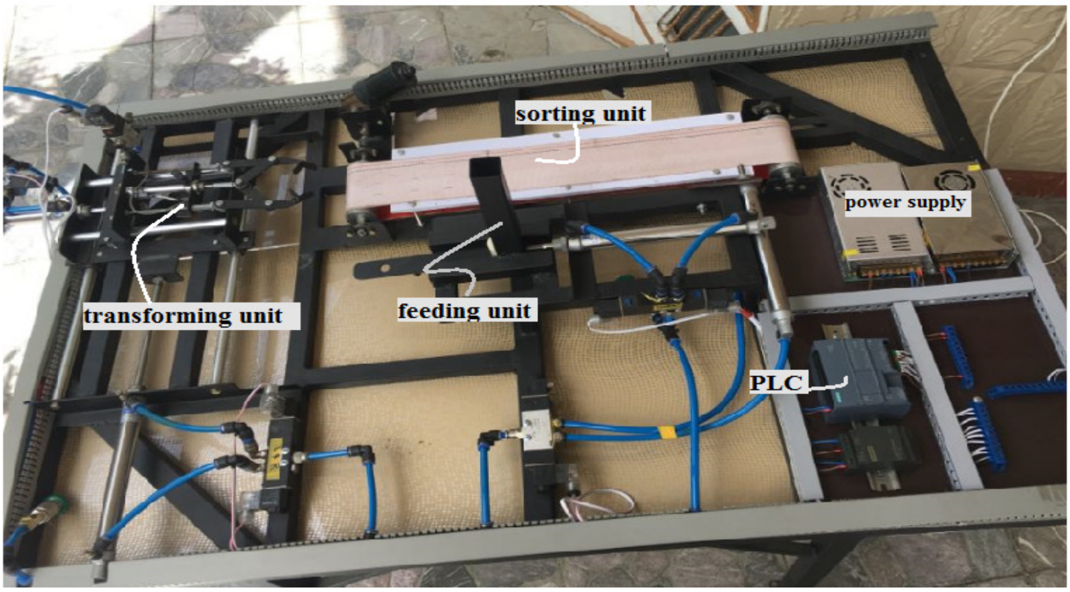


Fig. 8. The production line.

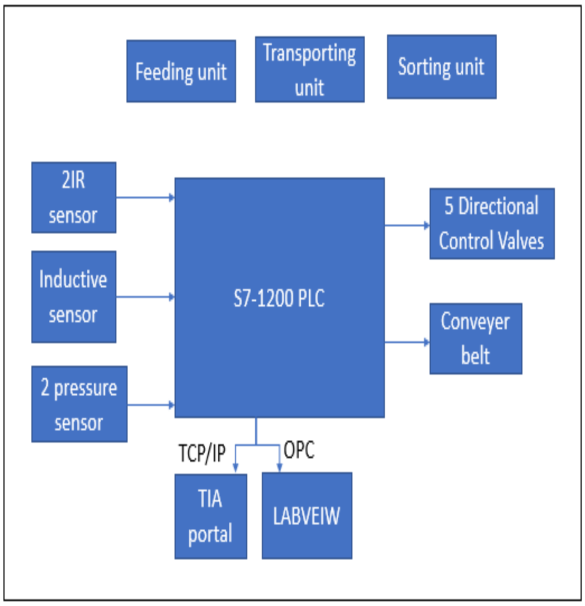


Fig. 9. The system block diagram.

5. Design and Implement SCADA/HMI System

Step7 TIA portal software is used to control all units of automatic production line. In the first step, the tags of all digital and analogue inputs, outputs and timer were added as shown in figure (10). Then, the ladder diagram (main OB) was built to do the required actions for this project as explained previously. After implementing the field instrument unit, process control unit and the master terminal unit, the HMI were consequently implemented as a result. Two methods were used to represent other SCADA components (HMI, alarms, and trends). The first method was implemented by using TIA portal software to form a touch panel screen. Another method was implemented by using LabVIEW to form HMI screen in computer software.

Default tag table

	Name	Data type	Address	Retain	Visibl...	Acces...	Comment
1	start	Bool	%I0.0		✓	✓	
2	discharge sensor	Bool	%I0.1		✓	✓	
3	waiting sensor	Bool	%I0.2		✓	✓	
4	feeding cylinder on	Bool	%Q0.0		✓	✓	
5	feedin cylinder off	Bool	%Q0.1		✓	✓	
6	forward cylinder	Bool	%Q0.2		✓	✓	
7	forward sensor	Bool	%I0.3		✓	✓	
8	gripper cylinder	Bool	%Q0.3		✓	✓	
9	gripper sensor	Bool	%I0.4		✓	✓	
10	left cylinder	Bool	%Q0.4		✓	✓	
11	ungripper cylinder	Bool	%Q0.5		✓	✓	
12	rearward cylinder	Bool	%Q0.6		✓	✓	
13	right cylinder	Bool	%Q0.7		✓	✓	
14	ungripper sensor	Bool	%I0.5		✓	✓	
15	Tag_1	Bool	%M0.0		✓	✓	
16	Tag_2	Bool	%M0.1		✓	✓	
17	left sensor	Bool	%I0.6		✓	✓	
18	sorting cylinder on	Bool	%Q1.0		✓	✓	
19	conv	Bool	%Q1.1		✓	✓	
20	metalic sensor	Bool	%I0.7		✓	✓	
21	sorting cylinder off	Bool	%Q1.2		✓	✓	
22	Tag_3	Bool	%M10.0		✓	✓	
23	Tag_5	Real	%MD4		✓	✓	
24	pressure real 1	Real	%MD10		✓	✓	
25	pressure sensor1 input	Int	%IW64		✓	✓	

Fig. 10. PLC tags.

A. Touch Panel Interface

For the implementation of the HMI in a touch panel, the software TIA PORTAL is used. TIA PORTAL is the engineering tool from Siemens company adopted for Programming, communication, diagnostics, testing and arrangement for S7-1200PLC [10].In this study, TIA PORTAL software was used to automate the production line and build the SCADA/HMI system. First of all, the type of the touch panel was selected. Then, the HMI tags were created and linked with PLC tags. These tags were used to connect HMI panel with sensors and actuators on actual device. These sensors and actuators were connected with PLC I/O port. HMI screen was designed to represent the actual system. HMI helped to visualize the values generated in the process. TIA PORTAL software is used for the implementation of the HMI, alarms and trends in touch panel, as shown in figure (11).

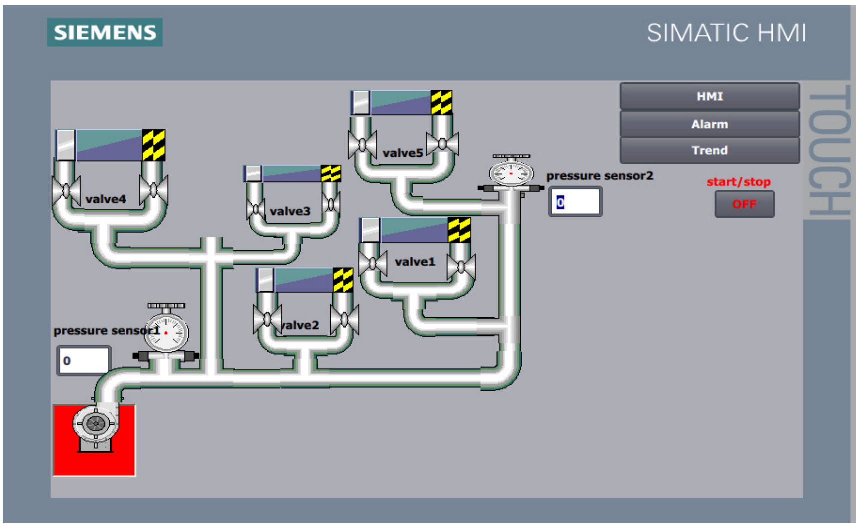


Fig. 11. HMI in touch panel.

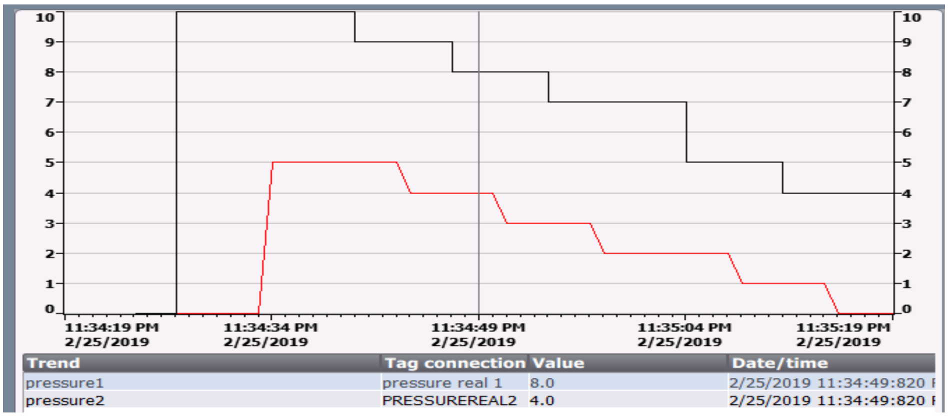


Fig. 12. trend in touch panel.

Two alarms were sat up. The discrete alarm would be appeared if there were not enough number of the work piece in the feeding tube. Moreover, the analog alarm would be showed as well if the pressure in pipes was higher than desired value, as shown in figure (13).

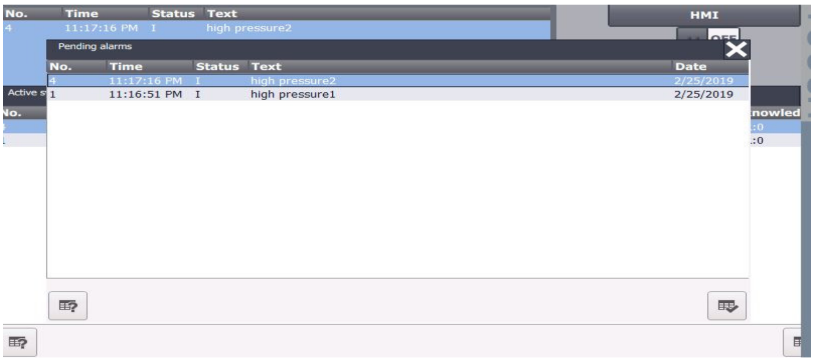


Fig. 13. Alarm in touch panel.

B. LabVIEW Interface

LabVIEW is framework building programming for applications from national instrument company required testing, estimation, and control with fast access to equipment and information experiences [12]. The LabVIEW System Design Software, software was used as a resource to perform the

HMI interface through a PC; therefore, it allowed the programming of an environment helped to visualize the values collected in the process. These are presented in a graph to help the interpretation of the changes. After implementing and controlling the production line, the communication between the supervision unit (PC & HMI) and master terminal unit (software to program PLC) may be implemented using NIOPC service. So, OPC service was used to enable S7-1200 PLC software (TIA portal) to communicated with LABVIEW. OPC service configuration can be described below

A-open new channel.➡ insert plc drive (SIEMNS TCP IP). ➡ select network adapter (Realtek PCle GPE [192.168.1.1].

B-Then open new device. ➡ Select device model (S7-1200). ➡ insert device ID (192.168.1.100).

C-Finally, tag is added according to plc tag

D-Then value of tag automatic is added to OPC client,

HMI was designed and implemented on PC screen as shown in figure (14) and figure (15) shows the trend. HMI was implemented using LABVIEW software for monitoring the process of all units and the pneumatic components. LABVIEW was used as OPC client while STEP7 TIA PORTAL is acted as OPC server.

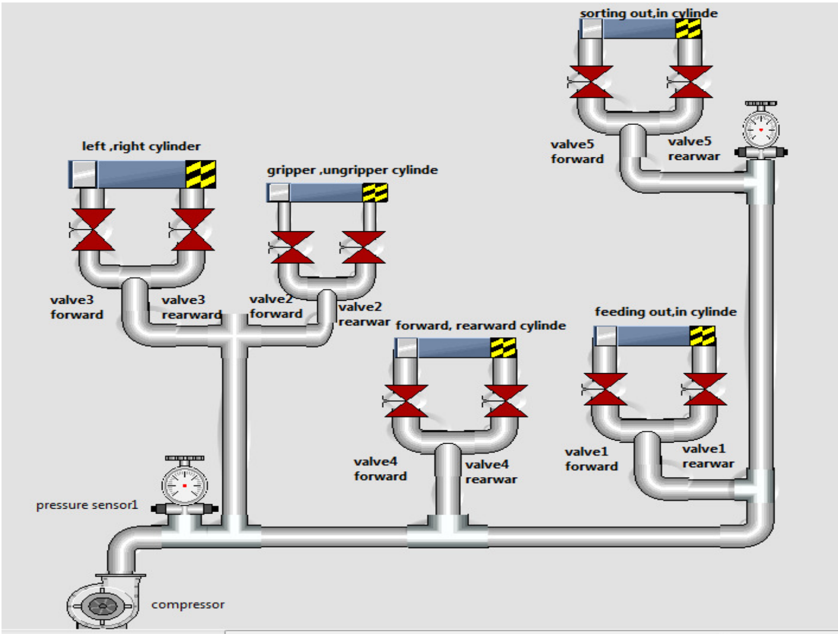


Fig. 14. HMI in PC screen.

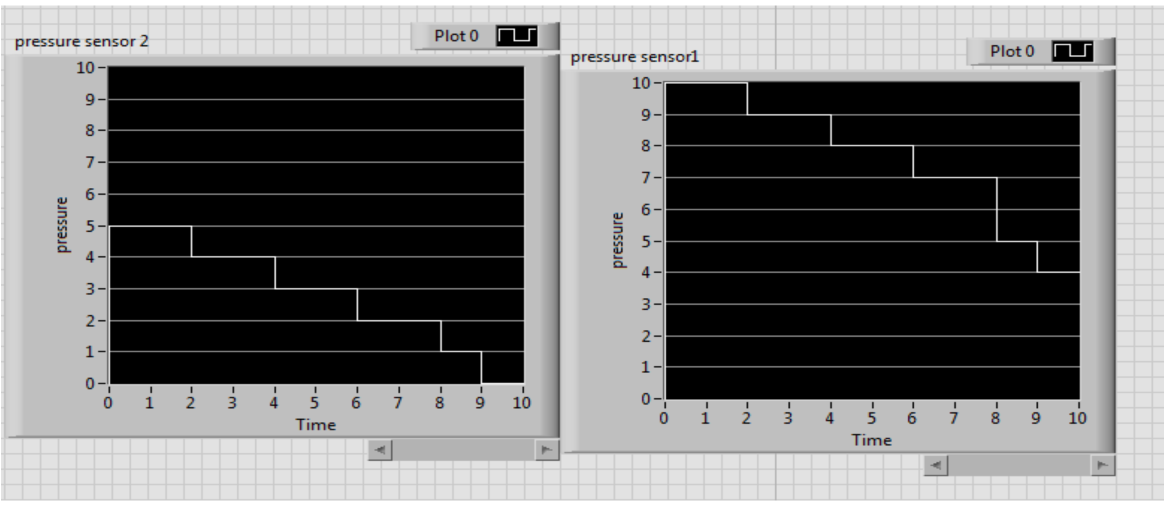
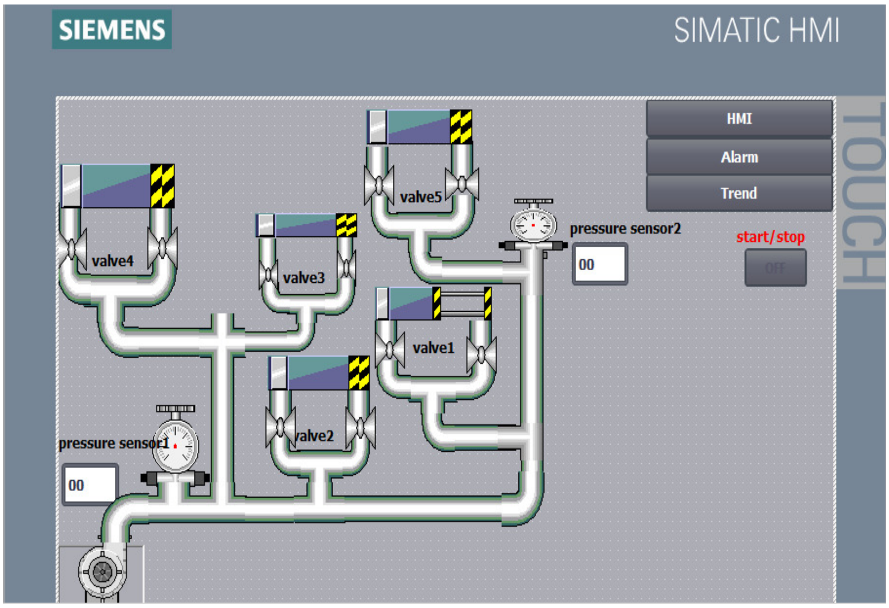


Fig. 15. the trend in pc screen.

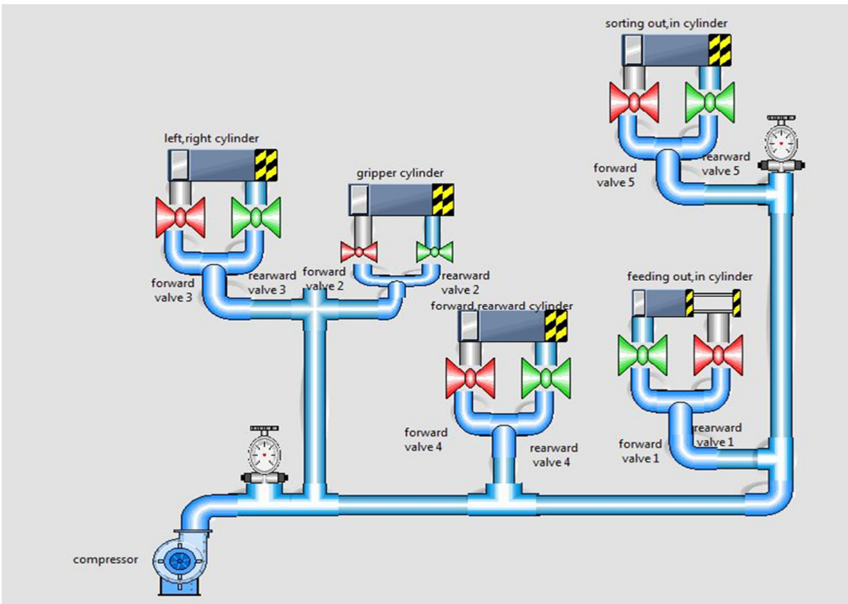
6. Result and Discussion

As a result, the realized system enables two human interfaces for controlling and monitoring the physical values of the pneumatic system processes and parameters, and provide away for different software packages to access values from control device (PLC) which helps to monitor the performance of the pneumatic equipment. Two SCADA/HMI system were implemented using two different software. TIA portal software used to build HMI, alarm, and trends in touch panel which helped the operator to control and monitor the production line. LabVIEW software was utilized to build HMI and trends in the computer screen and was linked with Microsoft Excel to generate the pressures to pressures drop information table helped to monitor the performance of the pneumatic equipment.

1- When the start switch was pushed and there are enough number of the work piece in the feeding tube, the feeding cylinder was set to push the work piece to the waiting tube, as shown in figure (16) which displays the TIA Portal interface and LabVIEW interface

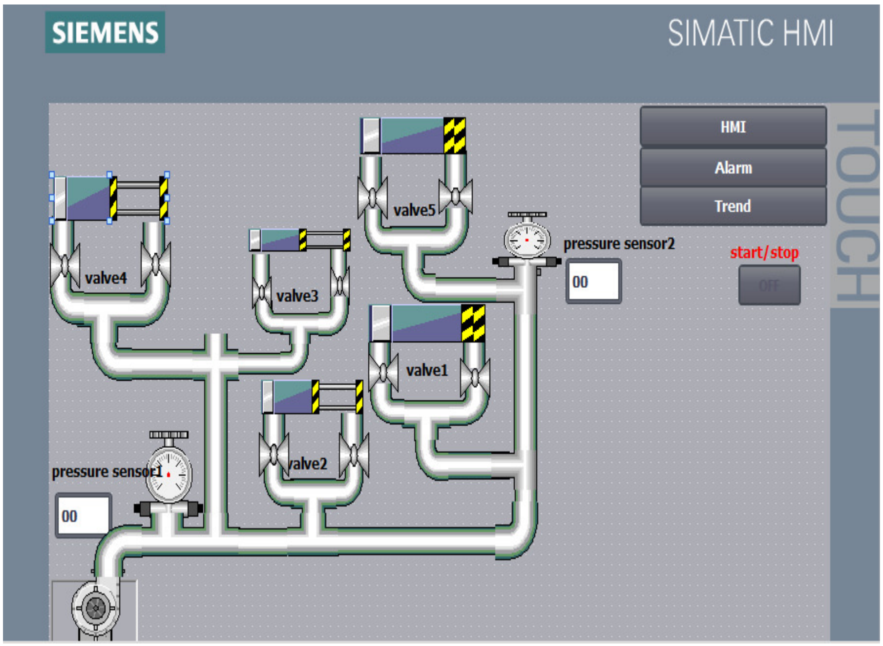


A-TIA portal interface.

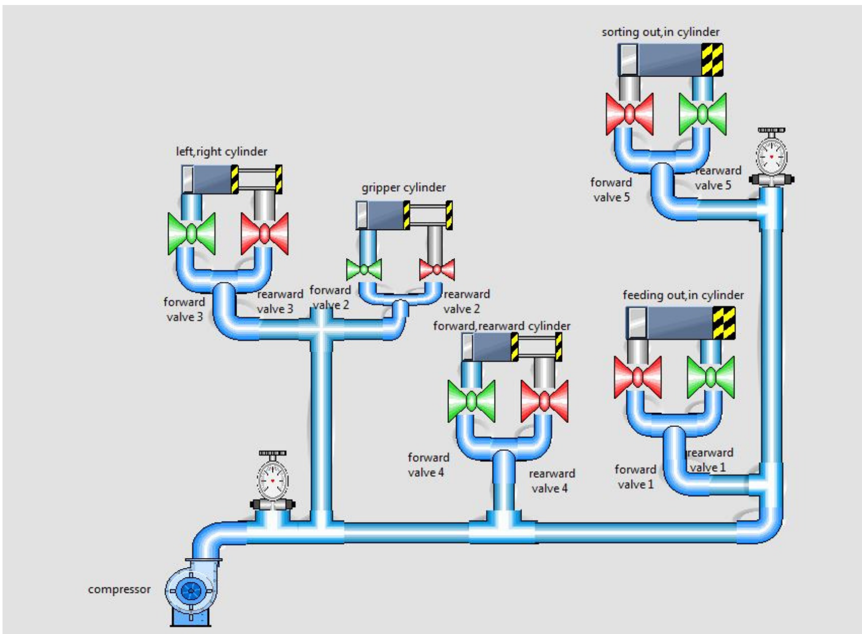


B-LabVIEW interface
Fig. 16. Two HMI result of feeding unit start.

2-When the work piece reached the waiting station. The feeding cylinder out was reset and feeding cylinder rearward was set as well. In addition to the robotic arm that moved to the left direction (left cylinder set and right cylinder reset) and forward (forward cylinder set and rearward cylinder reset); then, the griper clamped the work piece (the clamping cylinder set and unclamping cylinder reset) as shown in figure (17)

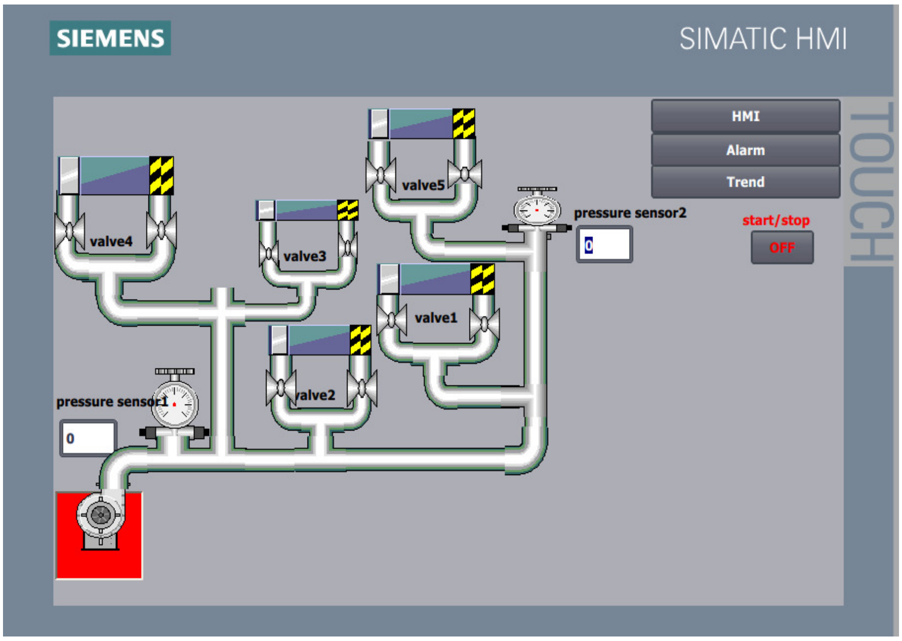


A-TIA Portal screen

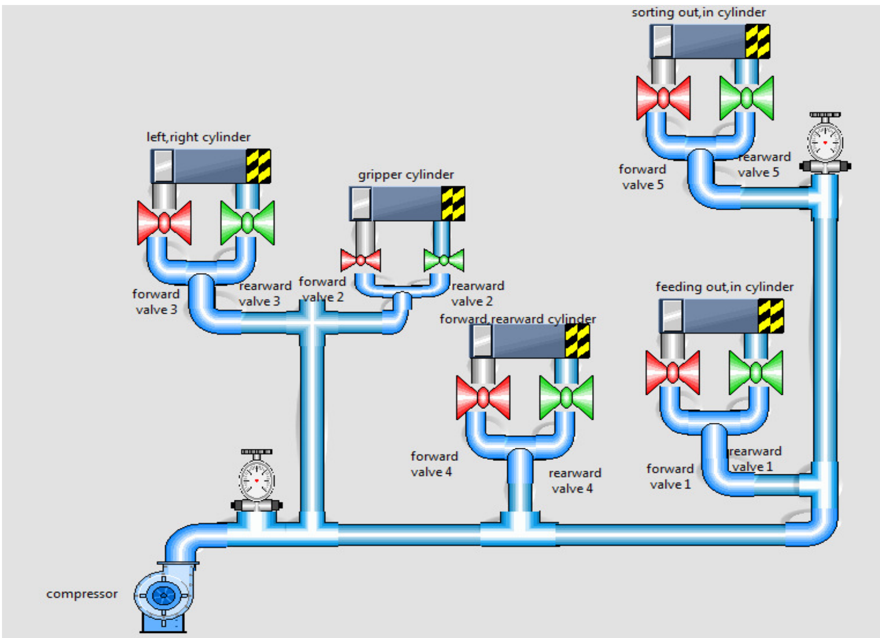


B- LabVIEW screen
Fig. 17. Two HMI result robotic arm started.

3- The robotic arm moved to right side (right cylinder set and right cylinder reset). When the robotic arm got to right side the gripper unclamped the work piece (the unclamping cylinder set and clamping cylinder reset). Finally, the robotic arm moved to rearward (the rearward cylinder set and forward cylinder reset) and the conveyer at sorting unit started as shown in figure (18).



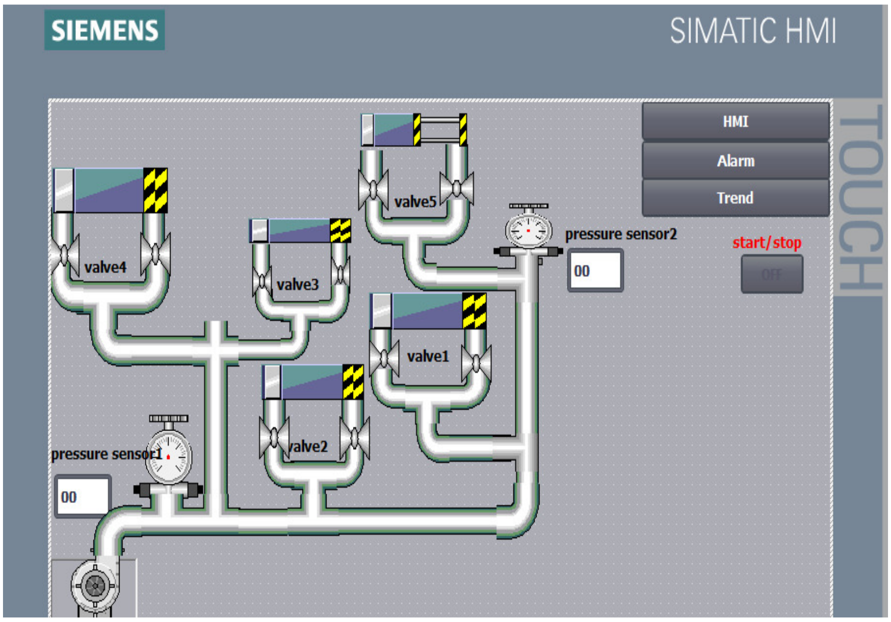
A-TIA portal screen.



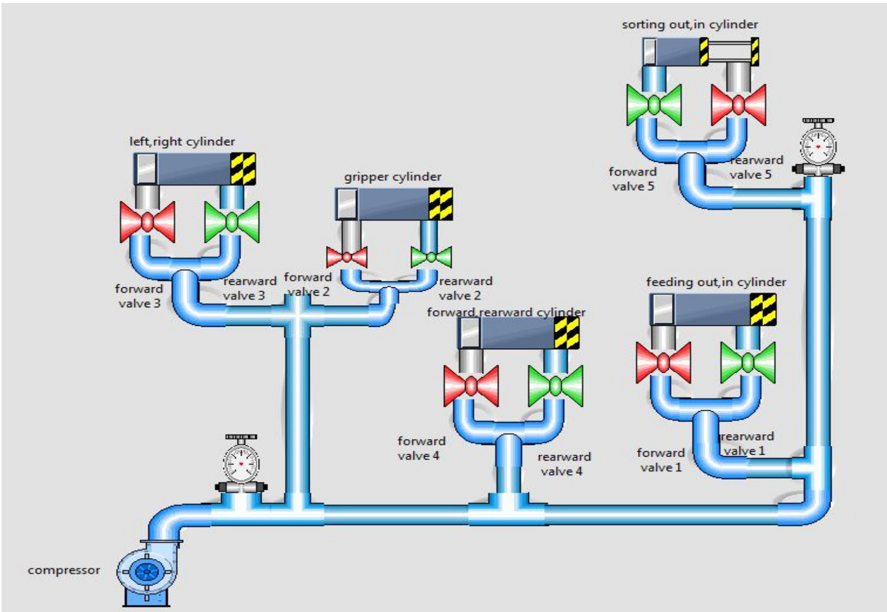
B- LabVIEW screen

Fig. 17. Two HMI result robotic arm stop and sorting conveyer start.

4- If the work piece was metallic, the conveyer would be stopped (reset) and the sorting cylinder was on(set), as shown in figure (19).



A-TIA Portal screen.



B- LabVIEW screen.

Fig. 19. Two HMI result sorting cylinder start

7. The Conclusion

To design the fabrication of the automatic production line and robotic arm which is driven by the pneumatic system. Building HMI/SCADA by using two methods: the touch panel interface and computer interface utilizing diverse software for the programming of each of them facilitating the immediate monitoring. TIA portal software is used to build (HMI, alarm, and trends) in touch panel helped the operator to control and monitor the production line. LabVIEW software is applied to build HMI and trends in the computer screen and is linked with Microsoft Excel (ME) to generate the pressures to pressures drop information table helped to monitor the performance of the pneumatic equipment. Success of monitoring the pneumatic system components (compressor, valves, cylinders and compressed air distribution network). Success of enabling the commutation between the master software (TIA PORTAL) with slave software (LabVIEW) by using NIOPC service. The project can be customized to suit any other industrial requirements. Thus, this method can be used to automate any industrial process to develop the manufacturing sector.

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تنفيذ نظام مراقبة واشراف وتحكم لخط انتاجي ألي بطريقتين باستخدام المتحكم المنطقي المبرمج

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الخلاصة

ركز هذا العمل على تنفيذ واجهات المستخدم الرسومية (HMI) للتحكم ومراقبة خط الإنتاج التلقائي. خط الإنتاج الأوتوماتيكي الذي يمكنه أداء وظائف التغذية ، النقل ، الفرز للقطعة المصنعة. أهداف هذا العمل: تنفيذ نظام اشراف ومتابعة وتحكم باستخدام طريقتين مختلفين. يستخدم برنامج TIA لإنشاء واجهة المستخدم الرسومية والإنذار والجداول البيانية في لوحة اللمس مما ساعد المشغل على التحكم في خط الإنتاج ومراقبته. اما الطريقة الثانية باستخدام برنامج LabVIEW لإنشاء واجهة المستخدم الرسومية واالجداول البيانية في شاشة الكمبيوتر وتم ربطه ب(Microsoft Excel) لإنشاء جدول معلومات الذي يساعد الصيانة في مراقبة أداء المعدات الهوائية. نتيجةً لذلك ، يمكّن للنظام تحقيق واجهتين رسوميتين للتحكم في القيم الفيزيائية لعمليات ومعلمات النظام الهوائي ومراقبتها ، ويوفر حزم برامج مختلفة للوصول إلى القيم من جهاز التحكم (PLC) مما يساعد على مراقبة أداء معدات التي تعمل بالهواء المضغوط. يمكن استخدام النظام المطبق في المختبر لتقليل المسافة بين المعرفة النظرية والتطبيقات العملية لطلاب الهندسة، وسوف يلعب دورًا مهمًا في تطوير قدرة الابتكار والتطبيق العملي. بالإضافة إلى ذلك ، يعد النظام المطبق لخط الإنتاج نموذجًا أوليًا له وضع إنتاج حقيقي قريب جدًا من عملية التحكم الفعلية في المصنع.