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Process Automation and Mixture Filling System Design

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Abstract

The aim of this paperis to test and validate the design of Ayran liquid mixing systems by performance and availability. Non human controllers are used to implement critical tasks in to Ayran automation design. According with the suitable programming languages and software's, the manufacturing ability and availability of application have been growed. Mechanical and electronics knowledge partnership is made to produce mechatronics which is the best synthesis of engineering knowledge. In this work, after a general description of the Programmable Logic Controller (PLC) based systems, we carried out designing and sets of components and equipments controlled with PLC. In this paper Ayran making and filling automation design were described. Design results have been compared with traditional one. PLC software is also supported with WinCC SCADA simulation software.

Keywords: Automation system, Design, PLC, Ayran, Scada.

1. Introduction

Design has been performed continuously for centuries. It was only by the middle of the 20th century when design an intense human activity became the focus point of controller and its techniques. Design philosophies, models, design phases, methods and techniques have been developed (Evduomwan NFO et al. 1996, Finger S and Dixon JR 1989). According to Ullman (1992), the product design process consists of six phases (see on Fig. 1).

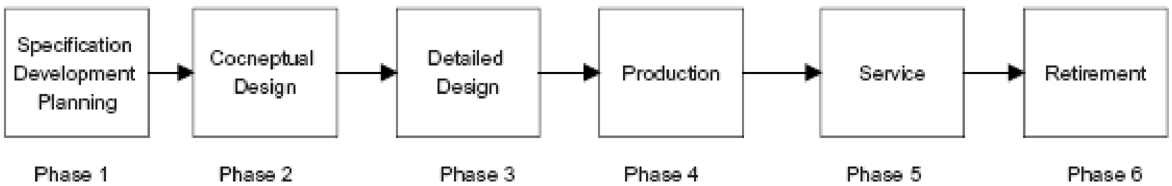


Fig. 1. The product design process

Wani and Gandhi (1999) developed a maintainability index for mechanical systems. Maintainability is an important aspect of the life-cycle of a product and plays significant role during its service period. It facilitates the performance of various maintenance activities, such as inspection, repair, replacement and fault diagnosis that must be performed in quick possible time but also with optimal resources. Weight factors are applied to map the degree of facilitation among them. The maintainability index is determined by the permanent of a matrix that has as elements these weight factors. Permanent is a standard matrix function used in combinatorial mathematics and it is similar to determinant without the alternating signs. Permanent matrix takes into account all the possible combinations among the attributes.

Byun and Elsayed (1996) presented a producibility index vector, which provides a quantified measure that takes into account both the quality and cost requirements for production. The producibility is defined as a measure of the desirability of a product and the process design in terms of quality and manufacturing cost.

Moulianitis et al. (2002) introduced a mechatronics index that includes three elements namely, intelligence, flexibility and complexity which characterize most of the mechatronics products. The attributes of every element is analyzed and formulated. The intelligence level of a system is determined by its control functions and a structure for information processing of mechatronics systems is used to model intelligence. A technique to measure the flexibility of manufacturing systems was used for the estimation of the flexibility of a mechatronic product. The various types of flexibility were classified in three main categories, namely: product flexibility, operation flexibility and capacity flexibility. The complexity was modeled using seven elements. Weighted mean used to formulate this index and the maximum value of this index indicates the best solution.

Vitturi (2004) studied on the implementation of PC-based automation systems has been favoured by the recent considerable diffusion of field networks, which allow for the realization of manufacturer independent configurations. In this paper, after a general description of the PC-based automation systems and he consider, as an example of application, the automation of blowing machines producing PET bottles. Vitturi's research results have shown, as far as the tests executed, that the performances of the PC-based automation system are better than those of the traditional one.According to Buur (1990), the trade-in of increasing the intelligence and flexibility is the increase of complexity, which is likely to cause difficulties in designing the product and in the interface between the product and the use.

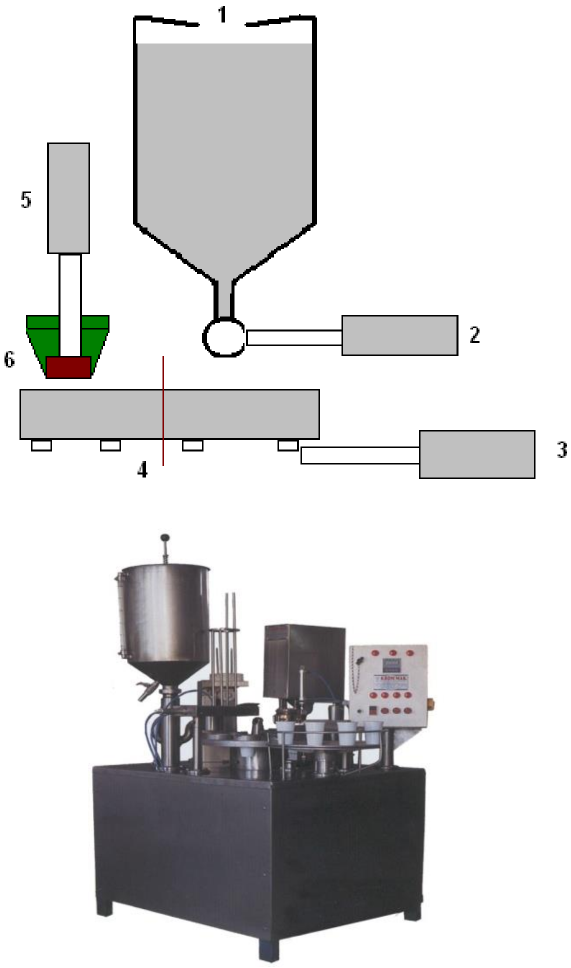
1.1. Introduction of The Factory Automation of Ayran Process

Ayran is a word that comes from Turkish literature and in all languages spelling same in Turkish. Ayran is a yoghurt drink produced in Turkey. Ayran is traditionally manufactured by addition of water at a level of 30–50% and salt at a maximum level of 1% to yoghurt. Salt is added at a maximum level of 1 g100 g_1 to impart flavor (TSE, 1982). However, with the increased demand and advancement in manufacturing technology, ayran is now produced from homogenized and pasteurized (90–95°C, 5–10 minute) milk using prophylactic acid cultures which increase consistency and reduce serum separation. In the industrial manufacture of ayran, milk with adjusted dry matter content is fermented using exopolysaccharide producing cultures and the viscous curd obtained is further diluted with salt-containing water. Ayran is separated from other fermented milk beverages being a yoghurt drink with salt and without any fruit flavoring. The Shelf life of ayran is reported as 10–15 days at 48C by the manufacturers. Ayran is prone to textural instability during storage due to its low pH as other acidic milk beverages. Main textural defects in ayran are low viscosity and serum separation during storage. Ayran should have a high enough viscosity for good mouth feel. Ayran sold at retail in Turkey was found to have up to 30% serum separation (unpublished data). Nowadays Ayran is also directly made from yoghurt bacterium into mixing bowls. Yoghurt bacterium, water and salt definite ratio mixed into mixing bowl aided with mixer. Due to ayran manufacturing there are many difficulties and negativities being done mixing ratio of each elements and ambiance factors.Also, ambiance and conditions of the mixing bowl is suitable that ayran making cool place, pure and clean bowl etc.

In the first part of this paper, describe the general structure of the PLC-based automation systems and mechatronics design structure. The results obtained from a practical application designed to investigate the possibility of adopting a PLC based automation system and Ayran mixing and filling system as a replacement of the traditional one semi automatic manuel system was presented. After that a mechatronics design application of PLC based system called Ayran Production and Filling System. Finally the results obtained have been compared with those of an equivalent machine equipped with a traditional Ayran filling system based on manual pneumatic circuit works.

2. Ayran Filling System Modeling

The Ayran automation project was aimed at studying the possibility, availability and economical usage of adopting a PLC based system for producing ayran, in alternative to that in use based on a traditional semi automatic manual filling machining system. The kind of Ayran filling machines consider in this paper are used to fill Ayran to pet glass and closed the mouth of the glass. At a maximum rate of semi automatic-manuel filling machine 950 glass per hour. The semi automatic manual system is only fills the Ayran or other liquid drinks in to pet glass. Semi automatic-manuel system is not available for mixing the materials which are base of Ayran. That's why more efficient and useful mechatronics design on Ayran making and mixing process detail structure was worked (Fig.2).



1.Mixture tank, 2, 3, 5. Pneumatic cylinders, 4.Rotating table 6.Closing unit

Fig.2. Traditional semi automatic Ayran filling machine.

The features that made of Ayran like yoghurt bacterium, water, salt and milk etc., tanks and mixing unit design is an important part of the unit. There are 3 material bowl/tank have been in design for these materials. Outlets of each tank have connecting the electrical motor. When the sensor started the electric motor, concerned outlet opened and material forward the mixing tank. Level control duties have to be controlled by sensors aided software (Fig.3).

Also the Ayran automation system was equipped with UPS and relief valves in order to safety react to power and pneumatic failures and attacks. When such events or conditions occur, a suitable recovery task is immediately started on PLC programming aided with PC which is still working since supplied by power supply.

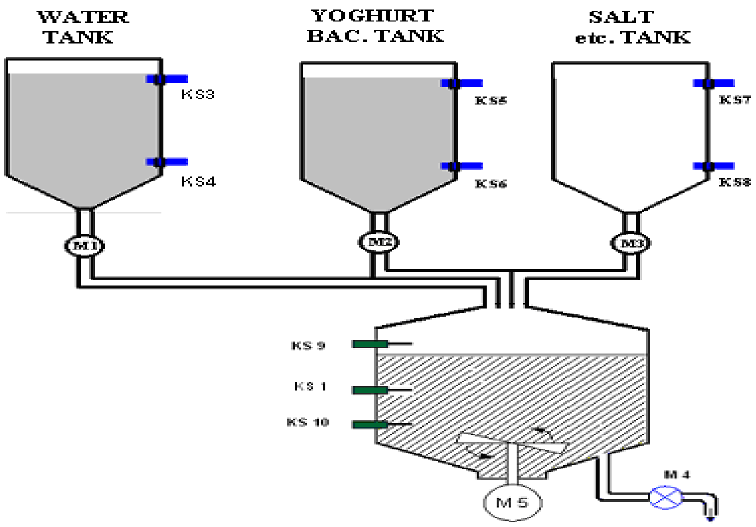


Fig. 3 Ayran Mixing and filling automation schematic diagram

Preliminary material architecture defined on Table 1. Table 1 describes the set of equipments and devices likely to be formed and employed in the Ayran mixing and filling automation system. And also the total costs of the equipments can be described.

Table 1. Ayran automation equipments and their costs

	Each (USD)	Total (USD)
1.GE S7 901-3BF00-OXAO E-Stand PC/PPI Cable2 Pcs.	350	700
2.CPU SIEMENS S7224 24 V 2 Pcs.	400	800
3.Power Supply 24 V DC 2 Pcs.	250	500
4. Sensor 4 gradated 20 Pcs.	100	2000
5.Electropneumatic Valfe 24 V DC 10 Pcs.	380	3800
6.Electrical Pump 2 Pcs.	4000	4000
7.Personal Computer	3500	3500
8.Mixer and mixing tank	500	500
9.Pneumatic cylender 4 Pcs.	80	320
10. Pneumatic 3/2valfe 6 Pcs	40	240
11. Pneumatic 5/2 valfe 4 Pcs.	140	480
12. Pneumatic NOR valfe 2 Pcs.	80	160
13. Pneumatic OR valfe 2 Pcs.	100	200
TOTAL		18.000
Other Equipments		
1. Pipe diameter 10mm 30 meters, hosepipe diameter 3mm 30 meters	5	300
2. Lamp (different colours) 8 Pcs.	1,5	12
3. Row material tanks / bowls 2 Pcs. (Big size)	100	200
4. Row material tanks / bowls 3 Pcs. (Medium size)	50	150
5.Plastic Hosepipe 25 meters+ Plastic Pipe 25 meters	5	250
TOTAL		1.000

2.1. Selecting Controller

As can be known a controller completely implements the machine and all its operational sequences. Programmable logic controllers (PLC) is the most useful and usage controller unit in automation systems. International competition, including demands on rapid product changes, there is an industrial trend towards technically advanced but also customized products manufactured in small batch sizes. This asks for increased flexibility in modern production systems, where the concurrent development of new products and production processes is crucial to meet demands on reduced costs and shortened time-to-market. This typically lead to more complex control programs that must be known to be correct at the time the production system is put into operation (Anders Hellgren et. al., 2004). Programmable logic controllers (PLCs) are arguably the most important tool for control of automated production systems. Though the programming languages for modern PLCs are highly standardized (ISO/IEC, 2001), these languages can be easily characterized as 'low level'. There is very little support for any high level structuring, which obviously complicates the development of correct PLC programs. One approach to raise the correctness-level of PLC programs may be called virtual verification (Richardsson and Fabian, 2003).Also PLC is powerful controller and allows monitoring and available with scada software's. According to economical life and usage, programming, design features and design requirements that selecting PLC for a main control unit of our Ayran making and filling design. And the other feature to selected PLC is, if some files containing process data damaged could not be necessary to introduce modifications on system structure. Only programming ladder status changed than modified and prepared the unusual system equipments.

For the selected controller of Ayran mixing automation system PLC, ladder programming on Step7 software was used. Step7 is stronger, useful and suitable programming software for the S7 224 and other equipments that we used. Output signals, roles and timers etc. have been introduced on the programmer ladder page.

2.2. Modeling and System Software

Ayran automation system worked and controlled under SCADA software (Fig.4). Scada software is available for powerful monitoring to sending with the system status. Siemens Win CC V6 software being used because of S7 series PLC synchronized and worked properly with this. Also WinCC V6 allows C, C++ and Basic programming databases.

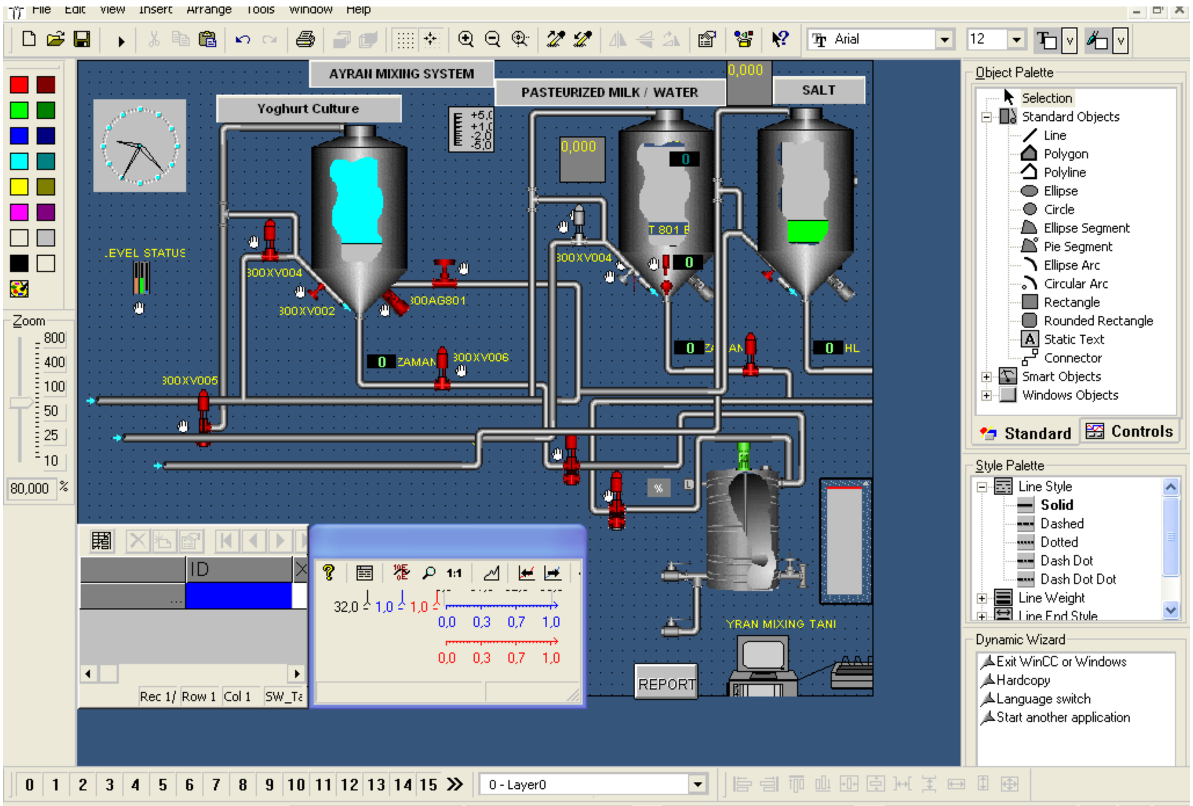


Fig 4. WinCCDesignCenter view

In WinCC library there are many application written those programming languages which are used make a new project for industrial controls. When starting Ayran mixing application with WinCC the application details and PLC programming output signals was determined. After that designated and made tags for the system used with WinCC library, design center and tags editor as can be seen on Fig. 5.

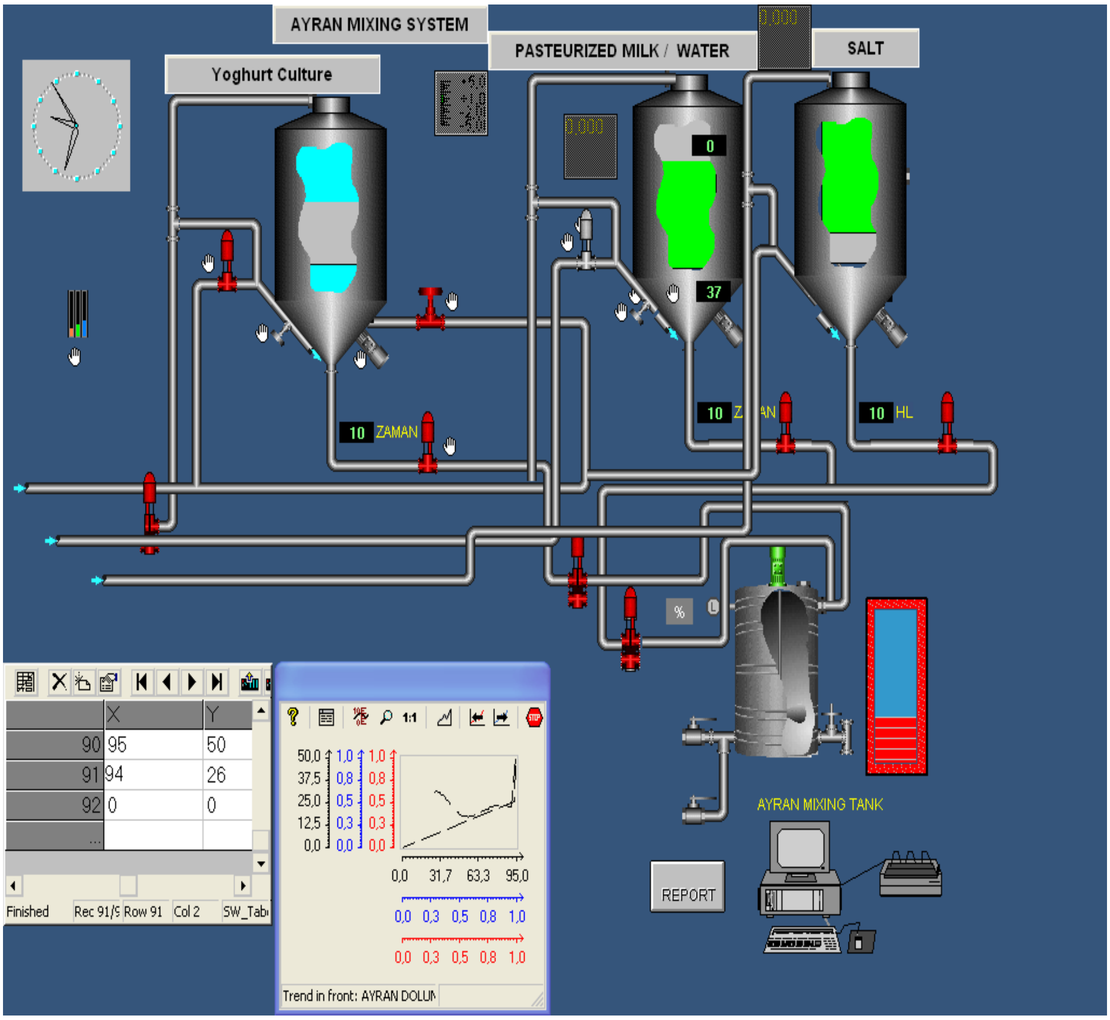


Fig.5. Ayran automation tanks control scene

S7 224 PLC CPU was the communicated WinCC aided with PcAccess software because of WinCC V6 is not allows S7 224 PLC CPU access and communicate without base software. When uploaded the software PC to PLC CPU, WinCC control center worked properly. WinCC started with the cycling and monitoring application on PC monitor. WinCC is critical operation on this process.

3. Results and Test Performed

The tests described have been performed during the suitable conditions of the Ayran mixing and filling machine. In semi automatic manual Ayran filling machine which controlled under human operator time data and operation features by timer and manual counter of the system were measured.

The first round is the analysis of the system performances and their comparison with those of traditional semi automatic system. Those performances figures and data have to be confirmed by experimental measurements. For these reasons it was possible to measure delays, outputs and equipment behaviors by software and PLC.

Table 2. Availabilities of semi automatic system and PLC controlling system

Compeering availabilities of Ayran filling systems	*Semi automatic Ayran filling system*	*Ayran Automation System with PLC controller*
Ayran mixing capability	Unavailable	Available
Level measuring	Unavailable	Available
Critical temperature measuring	Unavailable	Available
To keep temperature to supervise level	Unavailable	Available
Control the number of production per hour	Available	Available
Supports the suitable ratio of mixing each materials	Unavailable	Available
Risk of accident	Unavailable / Available	Available / unavailable
To keep elements fresh	Unavailable	Available
To keep Ayran mixture fresh	Unavailable	Available
Cleaning reliability	Unavailable	Available
Operator needs for each cycle	Needed	Not Needed

Ayran automation design which controlled with PLC and WinCC, the actual control programmer was modified the instructions necessary to set the output signals in response to the variation of the input. Both signals were wired on the digital input module and one digital output module respectively. The existing system configuration and S7 software content of the Ayran automation system in order to perform the test. The input was supplied with S7 ladder PLC programmer. According to this programmer line steps system equipment and instruments were worked and generated output signals. This signals triggered the working pivots and pneumatic devices etc. Output signals and system instruments actions measured and calculated. WinCC outputs and control actions helped us for measuring and to get time and production data values.

4. Discussion

As can be seen everything about Ayran mixing and filling system aided with WinCC software. With WinCC, operational details, working conditions, mixture ratio and level control features always reported. That's the reason of this control software, Ayran mixing and filling system worked strong and saved time. In semi automatic system numbers of production are 950 per hour (In Fig. 6). PLC controlled new system application data and reason showed numbers of production are 1800 per hour (Fig. 7). Defected filling or mixing is only 1 unit per day were measured but in semi automatic system this defected number is 10 units per hour as can bee seen Figure 8. And also system succeeds seen on Table 3.

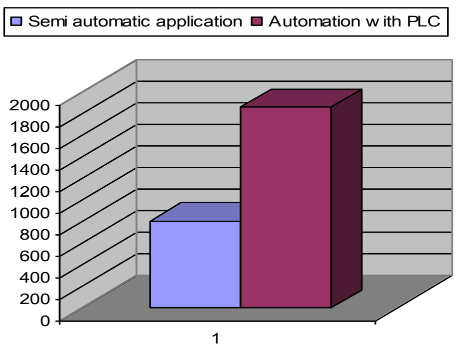


Figure 6. Production numbers per hour

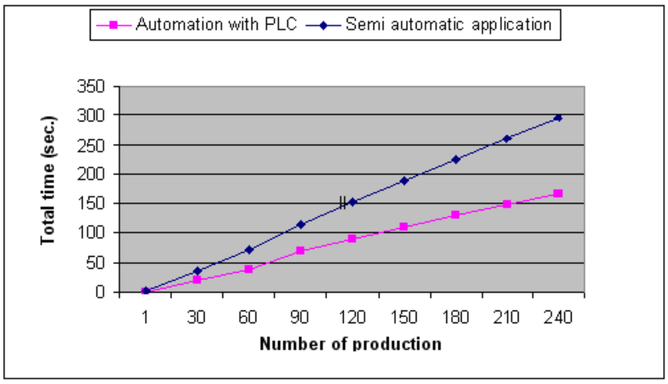


Figure 7. Total number of production comparison in 300 seconds

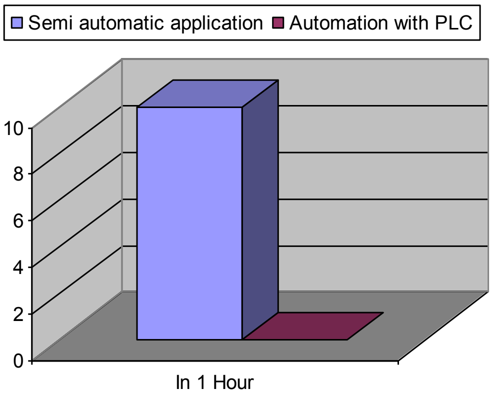


Figure 8. Defected products

Table 3. Ayran automation design gains against on semi automatic system

Production variables	Chancing (%)	Increase	Decrease
Number of production	% 190	✓	
Time for each production	% 190		✓
Time for production cycle	% 200		✓
Number of defected products	% 95		✓

4. Conclusions

This paper emphasized the opportunities, challenges and consideration the PLC based automation systems for Ayran drink. Practical measurements have been carried out on semi automatic Ayran filling machine. After calculations on PLC controlled system, software design and WinCC project synchronized the equipments properly. The measurements and software outputs showed us as far as the test executed, that the performances and production capabilities of SCADA software aided PLC based Ayran mixing and filling system is the best solution of this work. Other traditional and semi automatic filling systems are not adequate to the firm which works on liquid drinks. Also PLC based system as a valid alternative that currently in used systems. Semi automatic systems can not mixing capability. They have only one tank for filling. But PLC based system has 3 material tank and mixing bowl. This has been flexibility feature to the PLC based systems. Finally, validity of the measurements and software signal curve tables has been confirmed by the obtained in practice that an analysis may be used to the behavior of the Ayran drink filling systems.

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