I.J. Education and Management Engineering, **2018, 5, 1-10**
Published Online September 2018 in MECS (http://www.mecs-press.net)
DOI: 10.5815/ijeme.2018.05.01

Available online at http://www.mecs-press.net/ijeme

An Approach for Software Development for the Management of an Assembly Line

Gergana Kalpachka [a, *], Georgi Kotsev [a]

[a] *South-West University „Neofit Rilski“, 66 Ivan Mihailov Str., 2700 Blagoevgrad, Bulgaria*

Received: 23 April 2018; Accepted: 13 June 2018; Published: 08 September 2018

Abstract

The article presents an approach for software development for the management of an assembly line. Basic software tools and hardware solutions that are needed for the development of the software are described. Design of specific software for the management of an assembly line for bottling liquid food products is presented. A specially developed algorithm for the management of the assembly line is described. The realization of the management of the assembly line in the programming environment Simatic Manager Step 7 and the developed user interface in the graphical environment Simatic WinCC Flexible are also presented. The design of software for the management of an assembly line for bottling liquid food products is extremely important for the development of automated manufacturing in Bulgaria. After detailed testing of a trial version of this software, it will be used in Bulgarian company for the management of an assembly line for bottling liquid food products. The developed software is an open system that can be continuously updated and improved. This software is applicable in all manufacturing plants for bottling liquid products from canning, pharmaceutical, cosmetic industries and many others.

Index Terms: Assembly line, Automation, Management, Software, User interface.

1. Introduction

The automation of manufacturing involves technical, economic and social issues. The technical focus of automation enables:

- All functions of the management and control of production to be carried out by technical means and automatic devices;

* Corresponding author
E-mail address: kalpachka@swu.bg

- The technological processes to be organized and carried out with such speed, accuracy and reliability that no one can provide.

Assembly lines are part of automated manufacturing. Through them is organized a stable and continuous production process, which is characterized by:

- Striving to create a consistency of their structure;
- Persistence of the cycle for an unit of production;
- Regular sequence of the process.

Using a software with various programming environments and applications, such as CAD/CAM systems, for the management of assembly lines is a contemporary method in automated manufacturing.

One type of assembly line is for bottling liquid products like food, cosmetics and others.

The progress of computers and technologies and their use in assembly lines is making the topic of this article up to date.

This article presents an approach for software development for the management of an assembly line for bottling liquid food products.

In Part II of the article are presented features and opportunities of the assembly lines. Basic software tools and hardware solutions that are needed for the development of the software for the management of assembly lines are described.

In Part III of the article is presented the design of specific software for the management of an assembly line for bottling liquid food products. A specially developed algorithm for the management of the assembly line is described. The realization of the management of the assembly line in the programming environment Simatic Manager Step 7 and the developed user interface in the graphical environment Simatic WinCC Flexible are also presented.

In the final part of the article, main conclusions are formulated and the applicability of the developed software is also mentioned.

The used literature on the theme is presented at the end of the article.

2. Assembly Lines – Features and Opportunities

An assembly line is a group of machines connected to each other with transport devices, which have a common control [1].

The processing of the manufactured products, their inspection and their transport from one machine to another is done automatically.

Automated assembly lines may include part of the technological process or the complete manufacturing process of a product [1].

The assembly form of the organization of manufacturing requires workplaces and equipment to be arranged during the course of the technological process based on a predetermined tact and synchronization of operations.

The tact is the main feature of the assembly line. It is expressing an interval of time for which the line creates a finished product. It also helps to achieve dynamism and continuity of the manufacturing. This is the main output value in the design of assembly lines [1].

The tact of the assembly line is used to coordinate the time interval of the manufacturing operations, the speed of the transport devices and to determine the number of workers.

Another important characteristic is the pace of the assembly line – value that is reciprocal of the tact and which expresses the quantity of output production per unit of time. The pace characterizes the throughput rate of the assembly line. It also influences on the choice of technological equipment [1].

Quality control of finished products or those that are in the process of automated manufacturing should be done by visual inspection systems that use digital cameras and software for image processing. These systems

are programmed for execution of specific tasks such as counting objects on a conveyor, reading serial numbers, detecting surface defects and others [1].

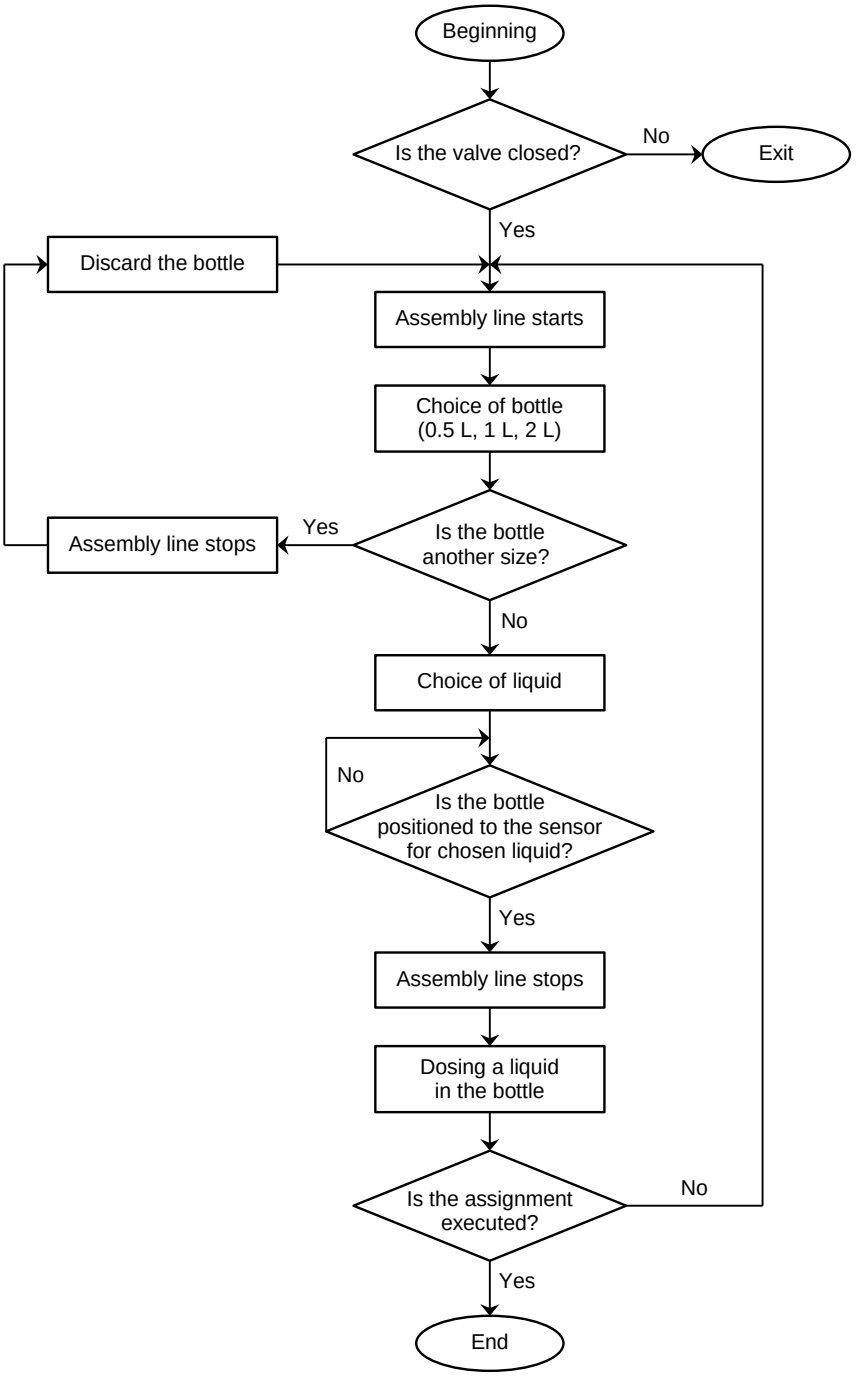

Fig.1. An Algorithm for the Management of the Assembly Line.

The most modern systems for visual inspections can make several checks in a same moment on an object and all can be configured by choosing between some main types (for example: checking for availability, position, checking of selected parameters, etc.) [1].

Software development for the management of assembly lines must follow basic principles, including: brevity of the technological process, continuity (movement of products without interruption) and consistent tact of the manufacturing process (repeatability of processes at equal time intervals).

Various software tools and hardware solutions may be used during the software development [2–11], including:

- Programmable Logic Controllers (PLC);
- Input-output modules of PLC;
- Hand-Held Terminals (HHT);
- PLC software;
- Communications networks in the industrial environment by using PLC;
- Sensors – inductive and capacitive sensors, optical sensors, etc.;
- Impulse water meters;
- And others.

3. An Approach for Design and Realization of Software for the Management of an Assembly Line for Bottling Liquid Food Products

3.1. An Algorithm for the Management of the Assembly Line

An algorithm for the management of an assembly line for bottling liquid food products has been developed while the approach has been creating. On Fig. 1 is shown the developed algorithm that is used to create a program for the management of the assembly line.

The assembly line can not start working until the pneumatic valve is not in position „closed“ and the quantity of finished production, that must be manufactured, is not set (Fig. 1).

3.2. Realization of the Management of the Assembly Line in the Programming Environment Simatic Manager Step 7

On Fig. 2 are shown the components of the developed software for the management of an assembly line for bottling liquid food products in the programing environment Simatic Manager Step 7 [12; 13].

Organizational blocks (OB) provide a link between the user program and the operational system (Fig. 2 and Fig. 3).

Only the organizational block OB1 is considered as an example. All of the created blocks can not be presented due to the limited volume of the article.

OB1 has the lowest priority among all organizational blocks (OB). The maximum cycle time is preset to 150 ms and it can be changed.

Function blocks (FB), system function blocks (SFB), functions (FC) and system functions (SFC) can be called in the field of OB1. An example structure of OB1 is presented on Fig. 3 [12].

Function blocks (FB) are program units that are widely used in the object-oriented modelling and programming. They are considered to be analogs of the integrated circuits. In accordance with the principles of object-oriented programming, the internal variables on FB are inaccessible for other blocks outside it. FB can be programmed by any of the languages that are defined in the standard.

In the organizational block OB1 there are four functional blocks: System, Basic device, Dosing, Auto_Cycle (Fig. 4).

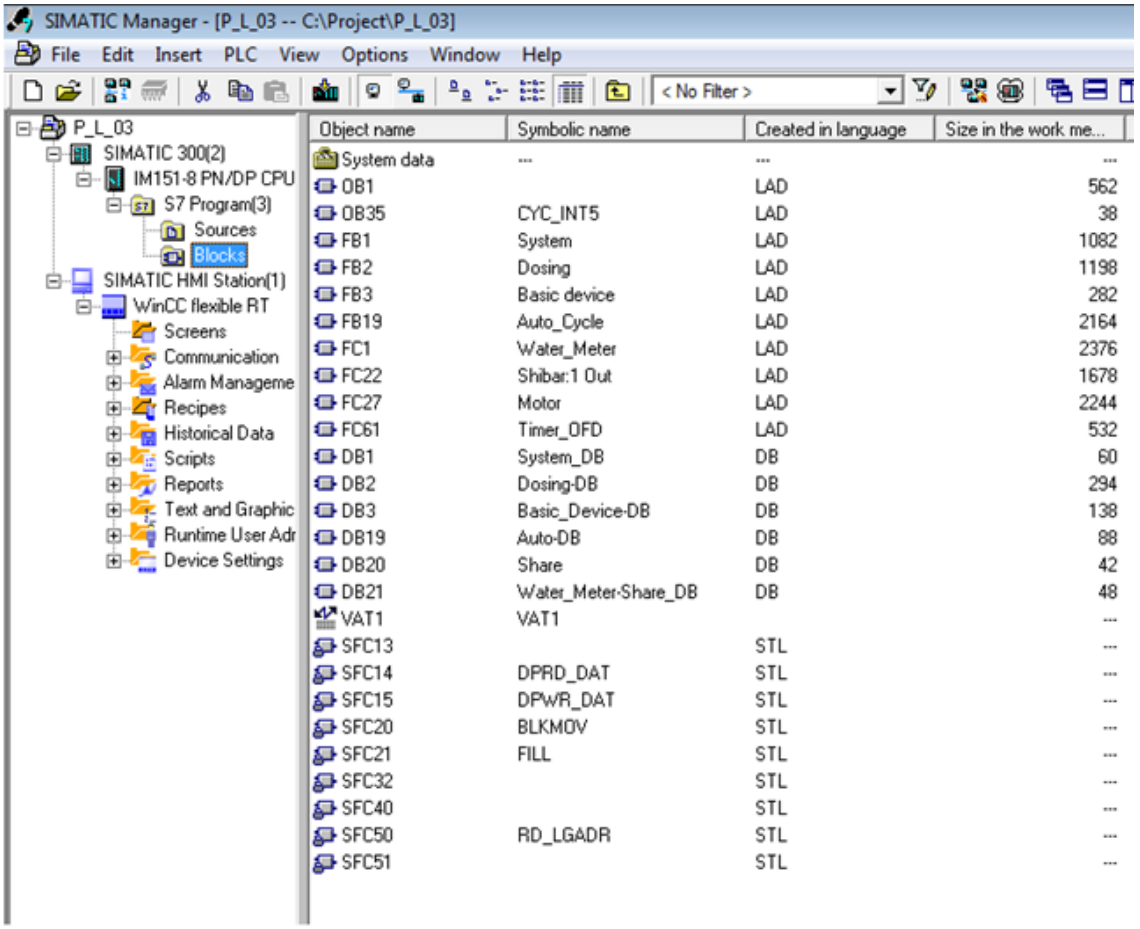

Fig.2. Components of the Developed Software.

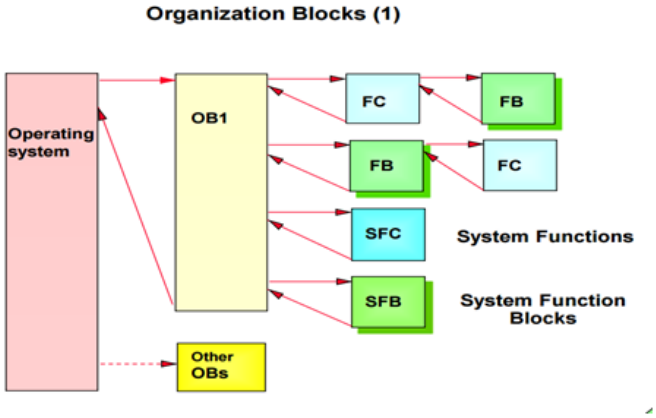

Fig.3. A Structure of the Organizational Block OB1.

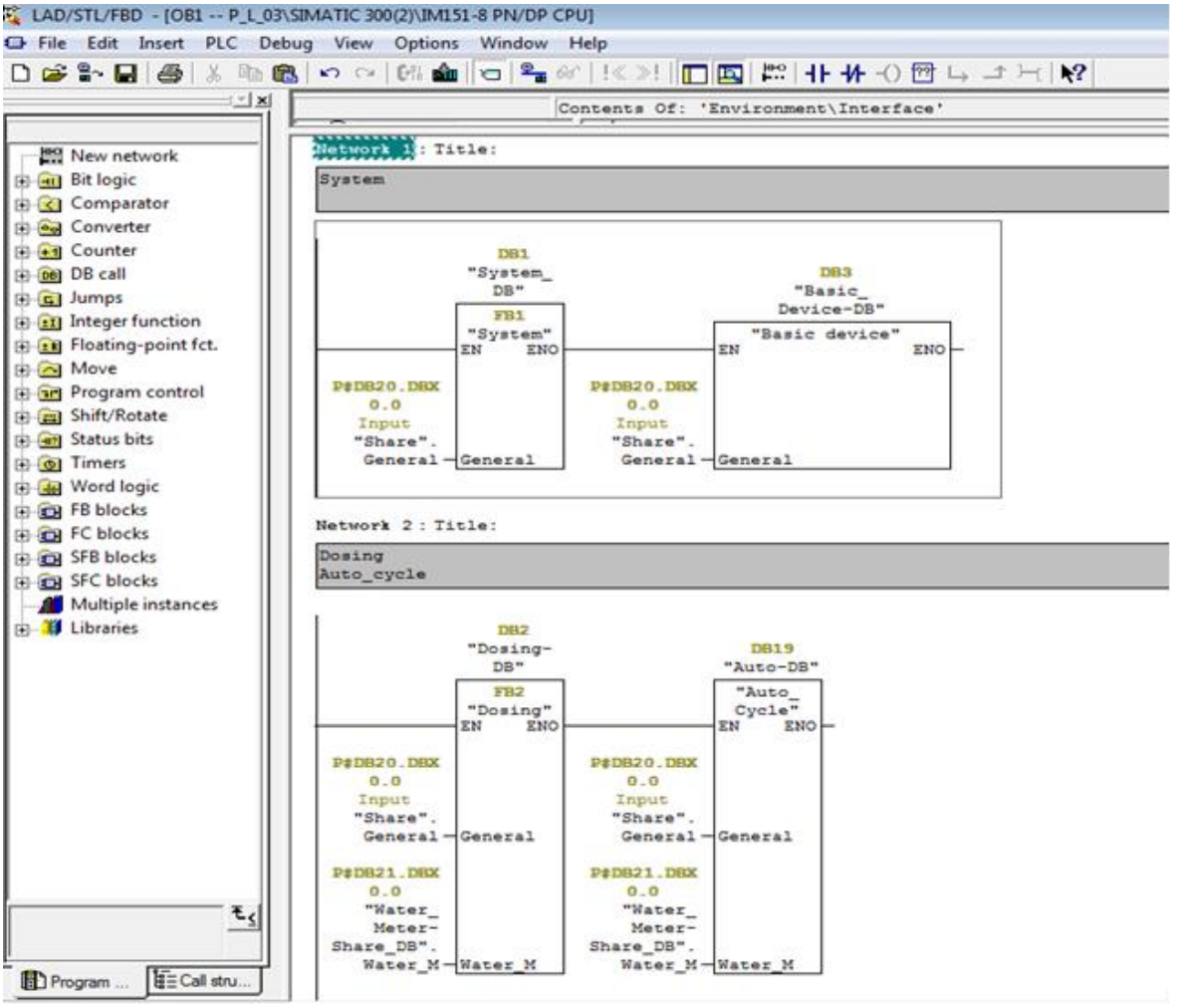

Fig.4. Functional blocks in OB1.

3.3. Developing a User Interface for the Management of the Assembly Line in the Graphical Environment Simatic WinCC Flexible

The user interface for the management of the assembly line is developed by using graphical environment Simatic WinCC Flexible [14].

Required objects that are located in the graphical environment are the following: transport line, ejection valve, three dosing valves, text boxes related to dosing of the liquids, buttons (Auto, Stop, Restart). Once these objects are created, they are positioned and assimilated with the respective functions of the programming environment Simatic Manager Step 7.

Visual Basic scripts have been used to develop the user interface.

The script Load_Liter (Fig. 5) can be activated by pressing the button Auto. It is used to initialize a value of the selected volume of a bottle and liquid.

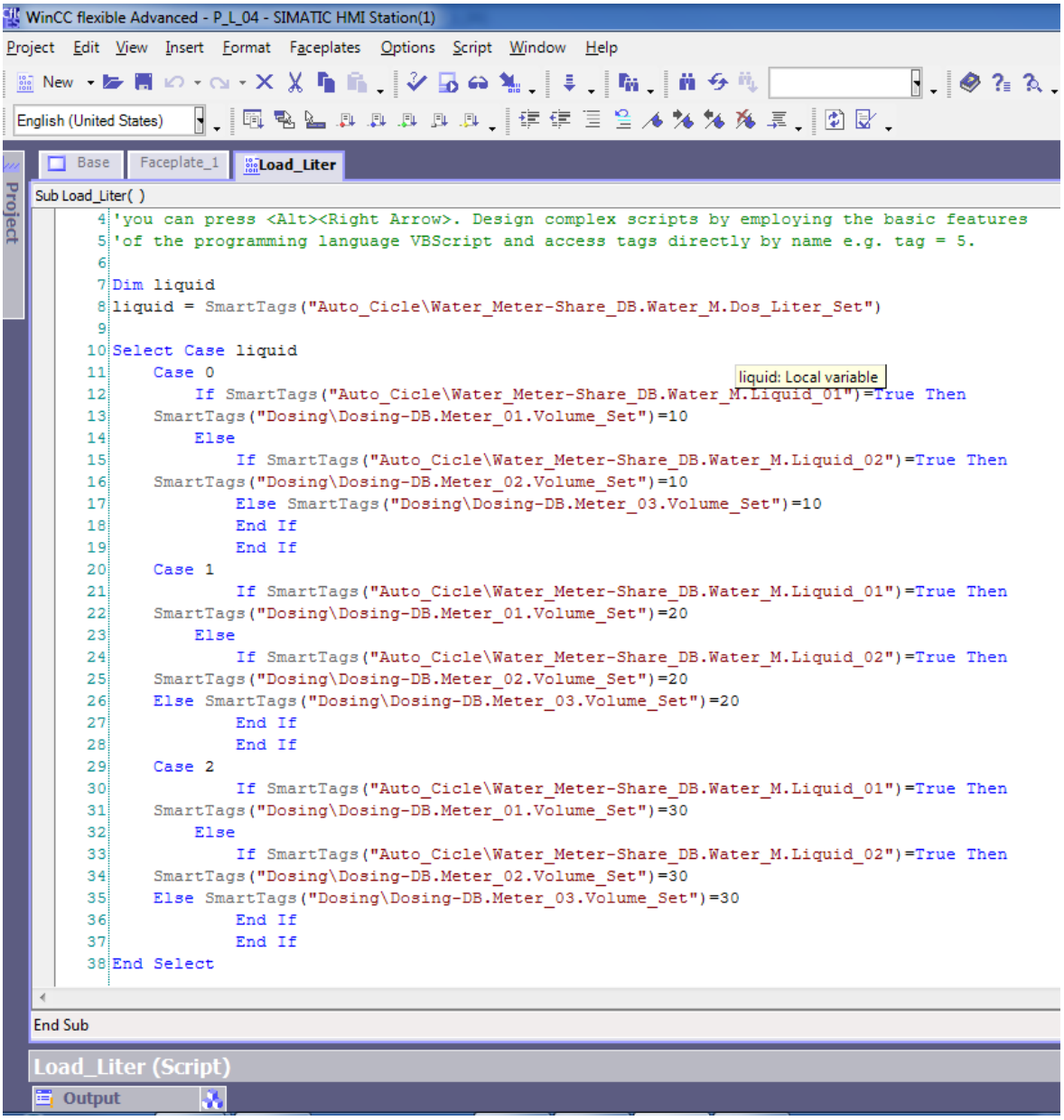

Fig.5. A script Load_Liter.

On Fig. 6 and Fig. 7 is presented the finalized user interface of the developed software for the management of the assembly line for bottling liquid food products. All devices and blocks with controllers are positioned on this screen.

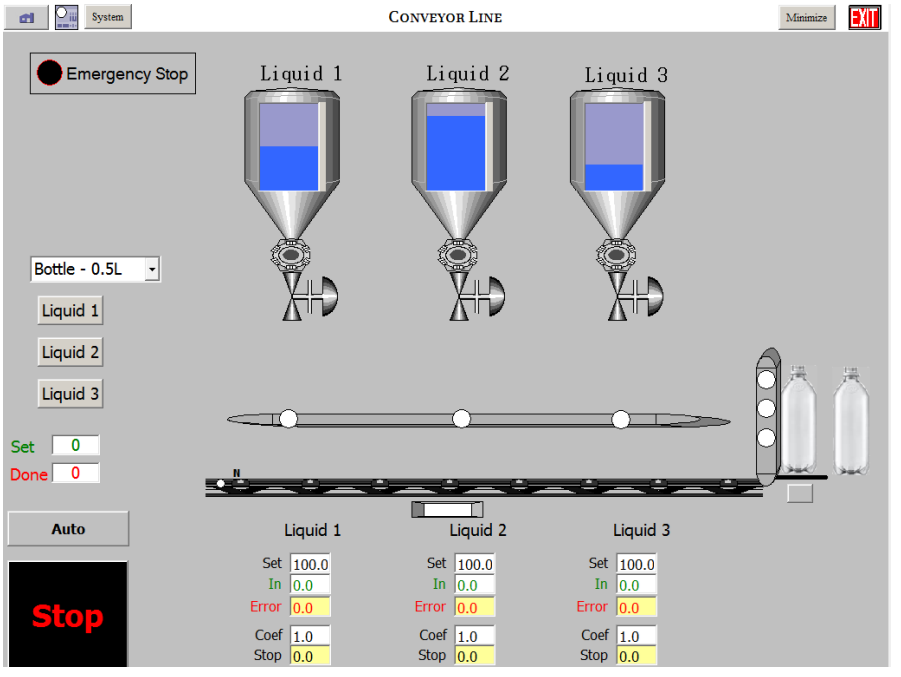

Fig.6. An user Interface.

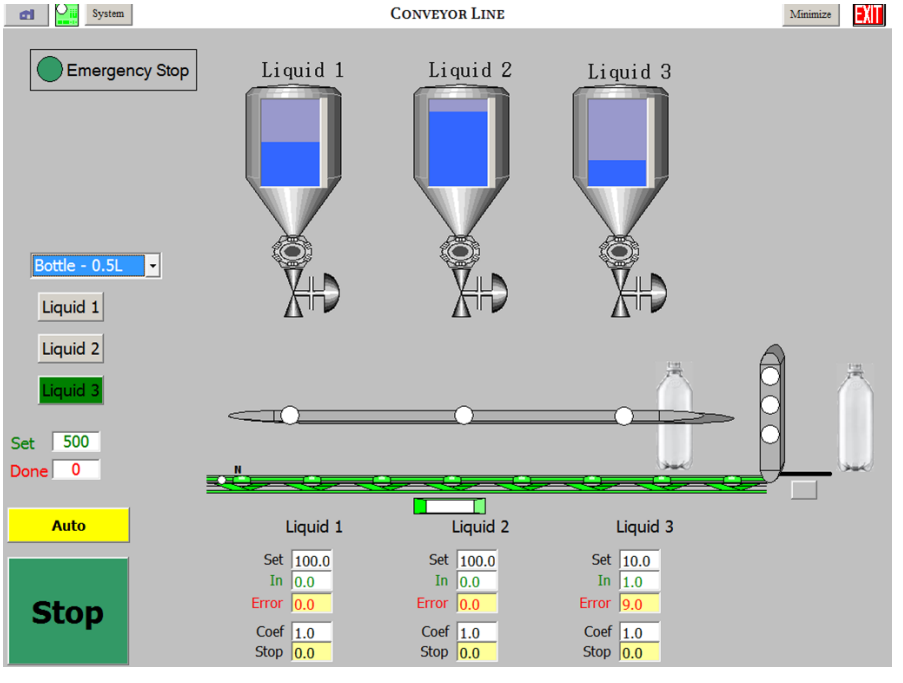

Fig.7. An user Interface.

The functionalities of the developed software are described in details in the User guide.

4. Conclusion

The article presents an approach for software development for the management of an assembly line.

The approach is illustrated through the design and realization of specific software for the management of an assembly line for bottling liquid food products.

Programing environment Simatic Manager Step 7 is used for developing of the software and graphical environment Simatic WinCC Flexible is used for developing of the user interface.

After detailed testing of a trial version of this software, it will be used in Bulgarian company for the management of an assembly line for bottling liquid food products.

The introduction of software for the management of assembly lines is effective at large volume of production.

The using of software for the management of assembly lines leads to: a high technological level of manufacturing, synchronization of operations and shorter time for their execution, reducing the errors, better production quality, creating conditions for maximum usage of production and labor resources, improving work efficiency, reducing the costs.

The developed software for the management of an assembly line is an open system that can be continuously updated and improved. This software is applicable in all manufacturing plants for bottling liquid products from canning, pharmaceutical, cosmetic industries and many others.

Acknowledgements

The article has been developed under the scientific and research project № RP-B2/18 of the South-West University „Neofit Rilski“, Blagoevgrad, Bulgaria, 2018.

References

[1] “Automated Technology Lines”, *Engineering Review*, Bulgaria, № 4, pp. 52–56, 2012 [“Автоматизирани технологични линии”, *Инженеринг ревю*, България, № 4, с. 52–56, 2012].

[2] S. Abdelhedi, K. Taouil and B. Hadjkacem, “Design of Automatic Vision-based Inspection System for Monitoring in an Olive oil Bottling line”, *International Journal of Computer Applications*, vol. 51(21), pp. 39–46, 2012.DOI: 10.5120/8330-1968

[3] H. Jack, *Automating Manufacturing Systems with PLCs (Version 5.0)*, 2007.

[4] B. Rekiek, A. Dolgui, A. Delchambre and A. Bratcu, „State of Art of Optimization Methods for Assembly Line Design“, *Annual Reviews in Control*, vol. 26, issue 2, pp 163–174, 2002. https://doi.org/10.1016/S1367-5788(02)00027-5

[5] K. Sacha, “A Simple Method for PLC Programming”, in *Real-Time Programming*, Oxford: Elsevier, 2003, pp. 27–31.

[6] J. Vetelino and A. Reghu, *Introduction to Sensors*, New York, USA: CRC Press, 2011.

[7] E. Parr, *Programmable Controllers, Manual for the Engineer*, Moscow, Russia: BINOM Laboratory of Knowledge, 2007 [Э. Парр, *Программируемые контроллеры, Руководство для инженера*, Москва, Россия: БИНОМ Лаборатория знаний, 2007].

[8] A. Todorov, S. Yordanova, S. Djiev and V. Sgurev, *Logical Process Management*, Sofia, Bulgaria: Technical University, 2001 [А. Тодоров, С. Йорданова, С. Джиев и В. Сгурев, *Логическо управление на процеси*, София, България: ТУ, 2001].

[9] S. Suwannarongsri, T. Bunnag and W. Klinbun, „Energy Resource Management of Assembly Line Balancing Problem using Modified Current Search Method“, *International Journal of Intelligent Systems and Applications (IJISA)*, vol. 6, № 3, pp. 1–11, 2014.DOI: 10.5815/ijisa.2014.03.01

[10] A. Guendouz and D. Bennouar, „Software Product Lines Composition through Partial Derivation“, *International Journal of Information Technology and Computer Science (IJITCS)*, vol. 9, № 10, pp. 47–58, 2017.DOI: 10.5815/ijitcs.2017.10.05
[11] M. Rizwan Jameel Qureshi and N. Farraj, „A Proposal of Expert System to Select Components for the Product Line Software Engineering“, *International Journal of Information Engineering and Electronic Business (IJIEEB)*, vol. 5, № 4, pp. 1–7, 2013.DOI: 10.5815/ijieeb.2013.04.01
[12] *Simatic Programming with STEP 7*, Germany: Siemens, 2006.
[13] *Simatic Working with STEP 7*, Germany: Siemens, 2006.
[14] *Simatic WinCC Flexible*, Germany: Siemens, 2006.

Authors' Profiles

Dr. Gergana Kalpachka is a Chief Assistant Professor of Computer systems, complexes and networks at the South-West University „Neofit Rilski“, Blagoevgrad, Bulgaria, since 2008.

Gergana Kalpachka's research interests include Computer Science, Computer Engineering, Computer Educational Technologies, etc.

Gergana Kalpachka is a participant in several national and international scientific and research projects. She has published articles in refereed and indexed scientific international and national journals.

Georgi Kotsev has a Bachelor's degree in Computer Systems and Technologies at South-West University „Neofit Rilski“, Blagoevgrad, Bulgaria, since 2016. He is a computer engineer.

Georgi Kotsev's interests include Computer and Software Engineering, Databases, Visual Programming, etc.

How to cite this paper: Gergana Kalpachka, Georgi Kotsev,"An Approach for Software Development for the Management of an Assembly Line", International Journal of Education and Management Engineering(IJEME), Vol.8, No.5, pp.1-10, 2018.DOI: 10.5815/ijeme.2018.05.01