AUTOMATED SYSTEM FOR CONTROL AND MANAGEMENT OF A MACHINE FOR AUTOMATIC ASSEMBLY OF CURTAIN BRACKETS AND HOOKS

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Abstract: The automated system for control and management is intended to assemble curtain brackets and hooks by a predefined movement sequence, registering each of the details “roll” or “bracket” with their subsequent assembly. In the work the way of choosing of a technological scheme for control and management of the executive devices is pointed out, for selection of the primary measurement transducers, for optimization of the assembly time cycles taking into account the proper productivity of the whole system. The invention is implemented by "KMS Engineering" LTD - Plovdiv in "UYUT" LTD - Sankt Petersburg.

Key Words: fiber optic converters, logic controller, pneumatic distributors, ejector nozzle.

1. Introduction

The target of automation is an automatic assembly machine which joins together two plastic parts - "hook" and “roller". This features the following processes:

- Initial check of all default positions of actuators
- Presence of all start conditions related to the automatic mode;
- Start of automatic mode;
- Stop of automatic mode;
- Control of all mechanisms in manual mode;
- Control of each of the two vibratory bowl feeders depending on the signals from the sensors for minimal and maximal parts quantity;
- Control of the signal lamp tower with red and green lights;
- Control of the sequence of actions, which take part in the assembly process;
- Tracking of statistical parameters - "productivity", "number of errors for a period of time", etc.

The main tasks are related to the design and assembling of the described system, based on standard components, writing of control algorithm for the technological process and the creation of a simulative laboratory unit demonstrating the various process activities. [1, 2, 3, 4]. The machine control system if based on a programmable logic controller, which accepts signals from fiber optics sensors for detection of parts presence in assembly position and controls four pneumatic valves through relay outputs.

2. Networks of possible variants

Fig. 1. Network of the possible variants for project realization

Fig. 1 shows a network of the possible variants for project realization based on the main functions which are required from the control system. An optimal solution must be found among these variants. Some devices are able to do more than one operation or to fulfill two functions simultaneously. The process of decision taking is connected to a complex analysis of many factors and for each solution there are various advantages and disadvantages:

- the system is designed with maximal usage of standard components of famous suppliers;
- to create ModBus communication;
- A presence of a convenient display of the controller, suitable of daily change of the parameters and other settings;
- Usage of programmable controller with physical buttons and the presence of a touch screen;
- Free supplier software
- Flexibility in programming

- Possibility for upgrade
- The platform must have the necessary usage certificates in industrial environment (low work voltage and good electromagnetic compatibility); safe for the working staff, reliable for an environment with specific factors: dust, high temperature, moisture, presence of electromagnetic fields;
- Low price

Green dots in Fig 1 mark the taken decisions for this specific task.

3. Cyclogram of the machine process

The assembly process is cycle-based, where each cycle takes 1,5 seconds. Fig.2 demonstrates the time for the working stroke of every of the four pneumatic cylinders (lifting, assembly, opposing cylinders as well as a blowout nozzle). In the event of anomaly in the working cycle or in case of other emergency situation, the control system activates light and sound signals to attract attention of the site personnel.

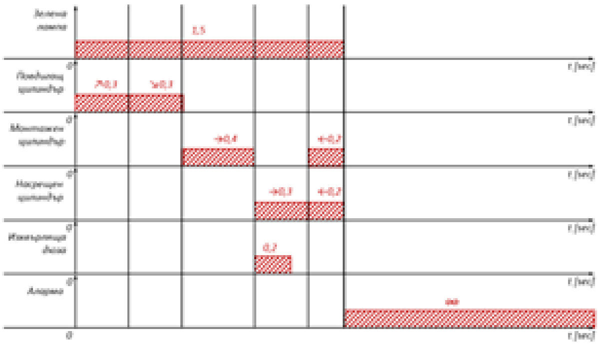

Fig. 2. Cyclogram of the machine process

4. Working algorithm

It is based on several modules - preparatory, subroutines calling module, module for delaying fiber-optic sensors' signals, control module for vibratory bowl feeders and alarms handling module. All modules are written in LADDER language and each module does not surpass 30 program steps.

Taking onto account the orientation of the parts‘ (hook and roll) position in the lead of the vibratory bowl feeder, tracing their movements in the leads, time synchronization of both types of details and optimization of their transfer from vibratory bowl feeders to the assembly device, algorithm for increasing the transfer precision of the parts, working as moving objects can be applied [6]. It is based on the Kalman filter. Its purpose is to provide high measurement accuracy for the full range of changing of the measurement quantity and the influence of the interferences as well as to eliminate the influence of a number of interference sources, each of which is of secondary significance. However, their total effect can cause considerable distortion of the measurement signal [7]. This theoretical survey will be a subject of further investigations in the subsequent contractor orders.

5. Experimental analysis

5.1. Experimental analysis on the productivity of the vibratory bowl feeder for hooks

The vibratory bowl feeder for hooks is a critical part of the whole system. Depending on the number of arriving and properly oriented parts, the machine will either have minimal presence of parts for normal work cycles, or will need to wait until this quantity is attained. The following statistical information was acquired based on 10 trials. (table 1):

Table 1

	TESTS FOR HOOKS FEEDER PRODUCTIVITY				
Parts quantity	76				
Duration for the above quantity:					
Minute	**Seconds**	**Total: (seconds)**	**Parts / sec**	**Parts / min**	**Parts / hour**
1	30	90	0,84	50,67	3040,00
1	40	100	0,76	45,60	2736,00
1	25	85	0,89	53,65	3218,82
1	15	75	1,01	60,80	3648,00
1	20	80	0,95	57,00	3420,00
1	32	92	0,83	49,57	2973,91
1	45	105	0,72	43,43	2605,71
1	15	75	1,01	60,80	3648,00
1	20	80	0,95	57,00	3420,00
	AVERAGE:	87	0,89	53	**3190**

Based on the results, the average feeder productivity is 3190 parts / hour. However, the assembly mechanism is able to work faster.

In case the bowl feeder could not feed enough parts, its own feeder rate is the maximum possible productivity value for the machine.

5.2. Experimental analysis on the productivity of the vibratory bowl feeder for rollers

- after 10 trials the results show that the rollers feeder has higher feed rate than the hooks feeder. This is easily explained with the smaller roller dimensions and the easier orientation in general.

The results are shown in Table 2:

Table 2

TESTS FOR ROLLERS FEEDER PRODUCTIVITY

Parts quantity	40				
Duration for the above quantity:					
Minute	**Seconds**	**Total: (seconds)**	**Parts / sec**	**Parts / min**	**Parts / hour**
0	38	38	1,05	63,16	3789,47
0	43	43	0,93	55,81	3348,84
0	45	45	0,89	53,33	3200,00
0	45	45	0,89	53,33	3200,00
0	40	40	1,00	60,00	3600,00
0	42	42	0,95	57,14	3428,57
0	43	43	0,93	55,81	3348,84
0	45	45	0,89	53,33	3200,00
0	45	45	0,89	53,33	3200,00
	AVERAGE:	43	0,94	56	**3368**

5.3. Experimental analysis on the PLC scan cycle - a "scan cycle" by PLCs is the time needed to execute the following sequence of operations:

- check of states on every input - logic "0" or logic "1"
- program execution
- update of output signals based on the changes in the current PLC cycle.

The PLCs from the XINJE XC3 series have a scan cycle from 1 ms to 10 ms, depending on the program complexity and the number of additional expansion modules, connected to the base PLC. During the phase of PLC program creation, the following statistical information was acquired (table 3):

Table 3

Number of steps inside the PLC program	PLC scan cycle (ms)
100	0
200	1
300	1
400	1
500	2
600	2
700	2
800	3
900	4

The following additional research on the scan cycle has been conducted independently from the system with a resulting scan cycle of 20 ms:

- Base PLC XC3-60PRT-C with 36 inputs and 24 outputs
- 7 additional expansion modules (a total of 140 inputs / 100 outputs)
- 5000 program steps inside the program

6. Conclusion:

1. The experience gathered from the project for automatic assembly of hooks and rollers could be applied in many other projects having similar parts. During the development of a specific manufacturing process, a detailed research activity related to industrial sensors used in industrial environment, automation components and innovations in IT and communication technologies is to be done. Additionally, analysis on the application of programmable logic controllers for industrial automation projects and other areas, based on the end user's inquiry has to be researched;

2. The design of the electrical and pneumatic schematics for system control is connected to choice of a clear boundaries regarding the number of input/output parameters of the assembly process;

3. Economical parameters are to be taken into account when making decisions on the choice of automation components.

4. To ensure a good system performance it is necessary to ensure dynamic precision of the measurement system, defining the parameters of the moving objects on the predefined curve.

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