System analysis of Pick and Place Control in Education

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Abstract. Pneumatic and electro-pneumatic mechanisms are a necessary component in the operation of production machinery and equipment. Their great development and wide application, especially in the last few years, have contributed to their advantageous characteristics, but also to their affordability. Reliability, safety at work, but also speed of operation together with control issues are such facts which are important to fully respect nowadays when designing assembly. With the progressive development of new processes, more sophisticated automation elements and, last but not least, management and control systems are associated. When designing a pick and place application, it is necessary to analyse the possibility and availability of using collaborative robots. This paper discusses the preliminary stages of the process of optimizing work movements and defines the "pick and place" of collaborative robots with the design of pneumatic and electro-pneumatic control.

1. Introduction

Systems analysis presents a fairly broad set of different methods and procedures. The sequence of individual steps of a system analysis solution in order to achieve the desired result is called the system analysis technology. An important task that arises in the development of the technological procedure is not to omit factors that significantly influence the solution of the problem and at the same time not to burden the process of investigation with irrelevant details.

2. System analysis of directing

In designing individual technologies, it must also be assumed that there are two basic groups of operations that take place in systems analysis: operations of operations and operations of synthesis. These operations can be expressed as processes, activities, or the results of activities. It is also significant that the use of systems analysis can have two basic objectives, namely:
- upgrading an existing system, i.e. improving it and making it more efficient
- the creation and implementation of a system that does not yet exist. [1]

When designing a pick and place management, it is necessary to determine the way of handling the semi-finished product. When designing a workstation, it is necessary to determine the type of workstation whose goal is to work in a certain sequence or to apply a collaborative robot. In pick and place applications, using a UR is sometimes a question of saving space. In fact, not using fencing can make the design of a production line a lot easier. Productivity is always an important point when talking about introducing robots into a plant. Figure 1 [2]

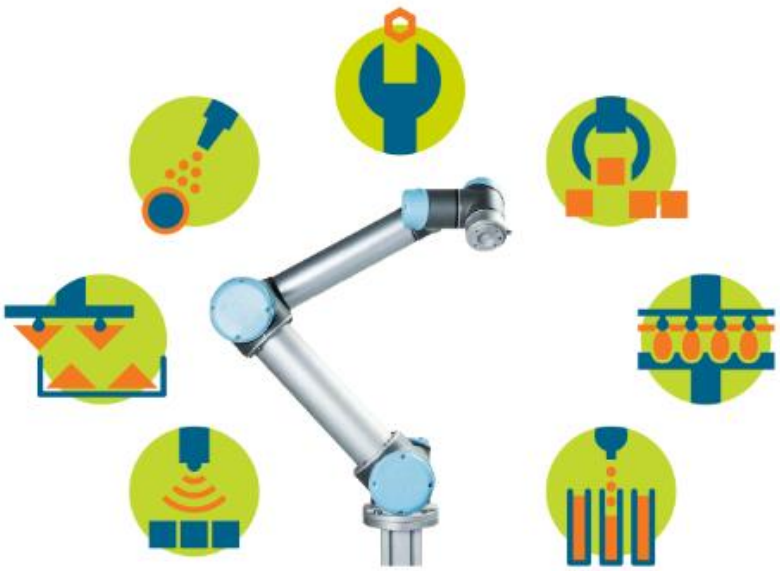

Figure 1 Applications using Universal Robots [2]

Each analysis results in a system model that describes the current status, gaps and a set of recommendations on how to improve the management process. Despite the simplistic explanation of the basic principle and the benefits derived from the implementation of a process analysis, it is clear that the added value from the implementation of a production process analysis is very high.

3. Factors influencing the production efficiency

In the current process of technology development, it is indeed very important and perhaps even strategic for a manufacturing industry with its own development department to come up with technical improvements at the right time so as not to be overtaken by the competition. Today, the issue of timing is often addressed. For this reason, it is also necessary to streamline the innovation of production processes.

In particular, the following five production factors influence the efficiency of the production process:

- Product,
- material flow,
- the nature of the spatial structure,
- inventories,
- production.

These factors are arranged according to their continuity of influence. Production influences inventory, inventory influences spatial structure, inventory influences material flow, material flow influences product, and then the whole influences the efficiency of the production process. In any optimisation, as in the optimisation of the production process, it is necessary to invest sufficient energy and attention in the preparatory phase of the whole optimisation process. The possible environmental influences are outlined in a clear structure. These externalities are clearly classified and indicated in the Ishikawa diagram. Figure 2 [3]

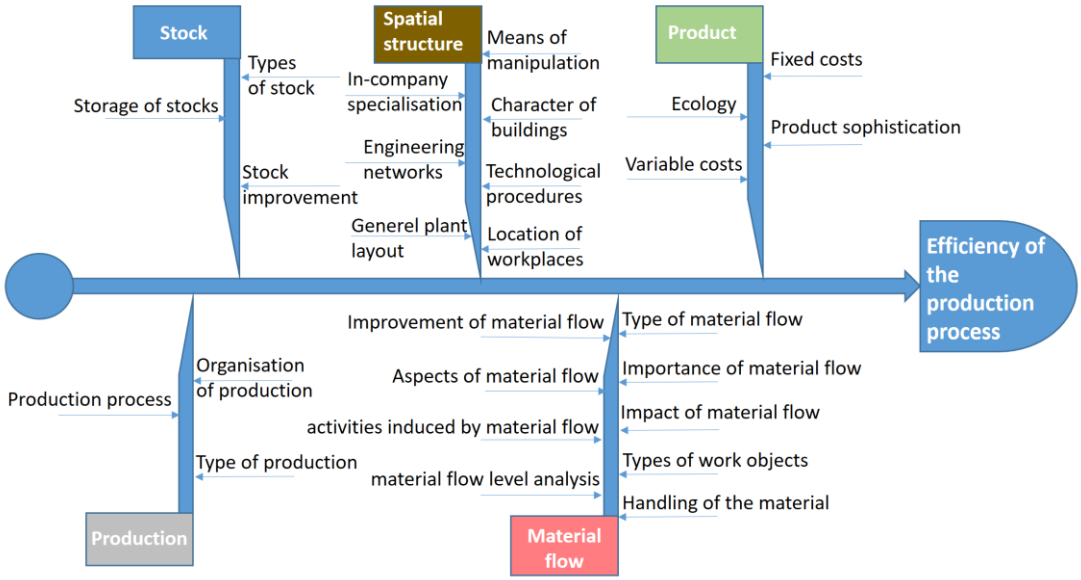

Figure 2 Factory of production process efficiency

4. Preparatory phases of the workflow optimisation process

Planning the work process involves several tasks. One of the first steps is to analyse the way of working and determine the sequence of work operations. By optimizing, it is possible to reduce costs and time. An important part is also the correct selection of the work tools and equipment needed in the handling process. The optimization of the work flow layout (line or workplace), line balancing should be addressed. Based on the results of the planning, the necessary instructions are generated, which are used in the work process by human operators or machines, robots according to the type of manipulation. Nowadays, an ideal material handling system should be able to respond to any kind of disturbances, changing market demands and utilize shop floor real time for best overall performance. By aggregating data and controlling the handling process, the system is able to receive unexpected events and make decisions in real time. [4]

5. "Pick and place" and design of pneumatics and electro-pneumatics directing

Nowadays, the development of products and manufacturing processes are constructed in 3D virtual environments. This new tendency is called Digital Manufacturing. It is defined "Digital manufacturing is the use of an integrated, computer-based system comprised of simulation, three-dimensional (3D) visualization, analytics and various collaboration tools to create product and manufacturing process definitions simultaneously. [5]

To address the control design, a 3D virtual model was developed with subsequent use of the FluidSIM verification software to verify the control theory of the pneumatic motor operation in phases.
The selection of the correct working and control medium "pneumatics, hydraulics, electrical" needs to address the input criteria.
- Force in straight line motion,
- linear motion,
- controllability,
- energy storage and transfer,
- influence of the environment,
- energy cost,
- usability - deployability
- safety.

When solving the method of handling the semi-finished product using 3 pneumatic actuators according to Figure 3, it is necessary to develop technical documentation of pneumatic control. In order to select the appropriate type of actuator, it is necessary to imagine the target components to be handled. Several simple pneumatic actuators are selected to demonstrate the actuator selection criteria. When designing the actuator motion function, the phase motion of the actuators must be determined and the contact elements with the workpiece must be designed. Figure 3

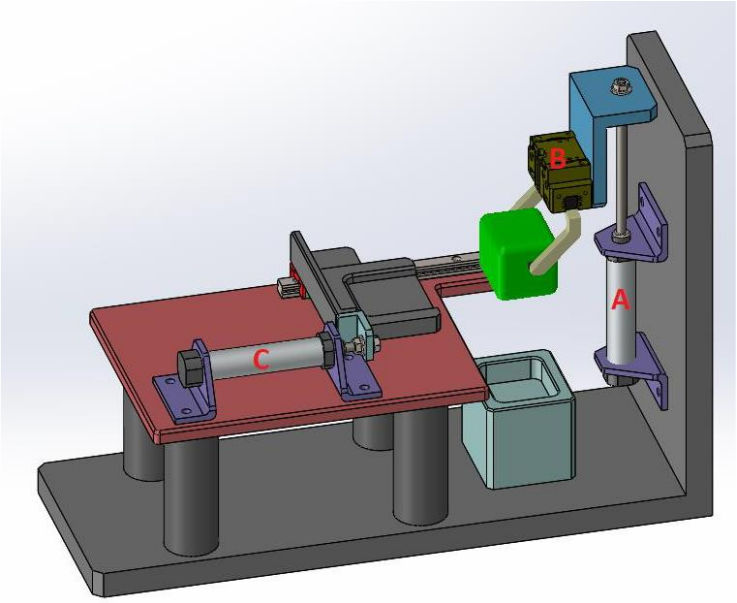

Figure 3 Directing "Pick and Place"

Principle of operation (Figure 4):
Starting position:
Cylinder A - retracted
Cylinder B (gripper) - open
Cylinder C - retracted

1. Insert the part into the jig
2. Gripper closes - grips the part
3. After gripping the manipulated part, cylinder A is ejected
4. Roller A remains extended, then roller C is extended
5. When cylinder C is extended, the gripper opens - releasing the part
6. Roller C retracts
7. Roller A retracts
8. The operation is repeated

Phase sequence of piston ejection B+ A+ C+ B- C- A-

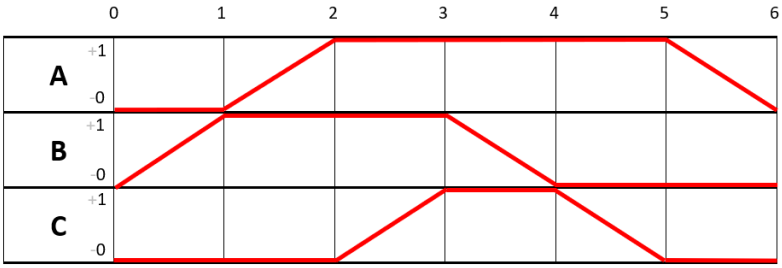

Figure 4 Step by step chart of 3 phases

Table 1 Progress of actuator movements marked A, B, C

	Command	Phase	Operation	Signal
1.	T + 1S1	F1	B+	2S2
2.	2S2 * F1	-	A+	1S2
3.	1S2 * F1	-	C+	3S2
4.	3S2	F2	B-	2S1
5.	2S1	F3	C-	3S1
6.	3S1 * F3	-	A-	1S1

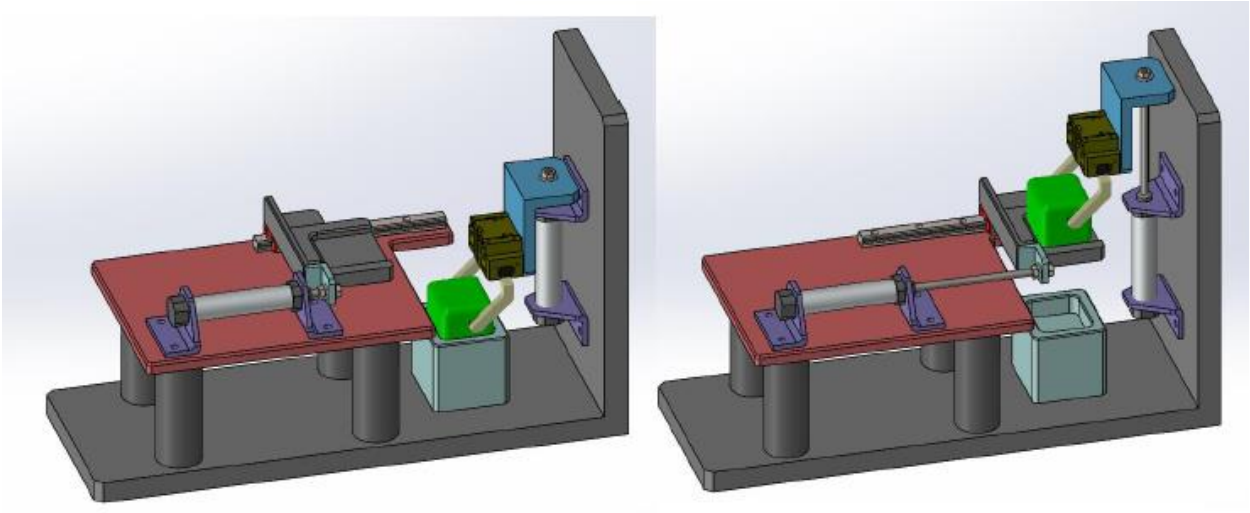

Figure 5 Progress of phase activity of actuators

During the design, the designer must select the working energy, working elements, determine the course of action, the method of control. When designing the pneumatic scheme through phases, it is necessary to ensure that in the determination of the sequence of the individual phases, it is ensured that in each phase the actuator ejection action is located only once. There must not be simultaneous actuator extension and retraction of one actuator in the same phase. Reliable control design requires a thorough knowledge of the instrumentation, of the standard symbols and of the behaviour and interaction of the different elements of the chosen technique. Figure 6 [5]

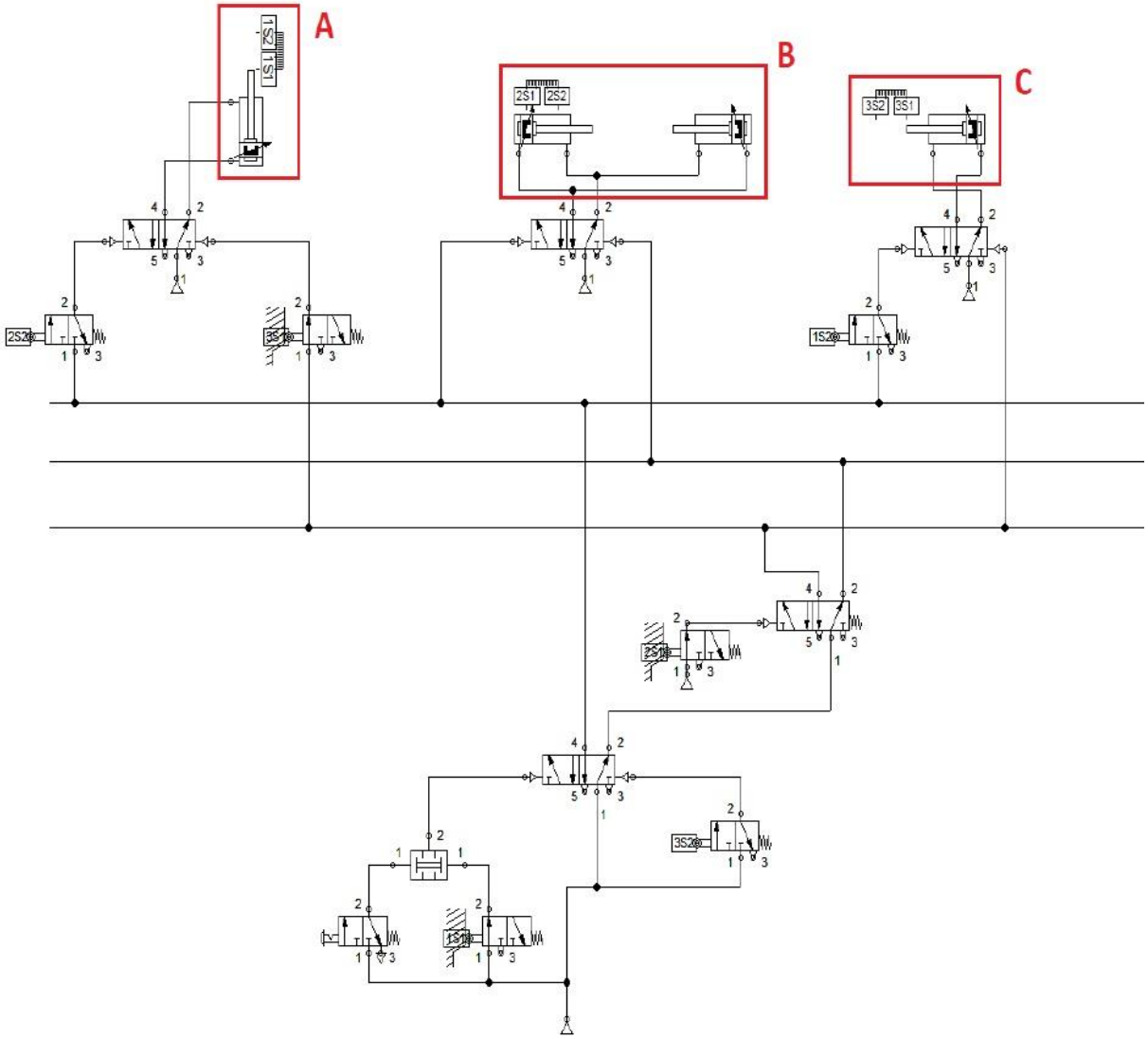

Figure 6 Pneumatic control of Pick and Place operation

When solving electropneumatic control, it is necessary to determine the sensing of the end positions of the actuators. When solving the electrical scheme, it is necessary to determine whether the sensing of the end positions occurs with or without touching. In determining the sensing of the end positions without touching, it is necessary to determine the type of encoder and to design the wiring by indirect control. Indirect control is required for occupational safety reasons [6]:
- The controlled electrical circuit and the main electrical circuit operate with different voltages,
- the coil current exceeds the current allowable for the push button,
- a single pushbutton switches multiple valves,
- extensive connections are required between the signals of different buttons.

The possibilities of expressing the pick and place action through electro-pneumatic control are various, but in this case again the phase electro-pneumatic wiring has to be solved to make the action correspond to the stepping circuit as in pneumatic control. Figure 7

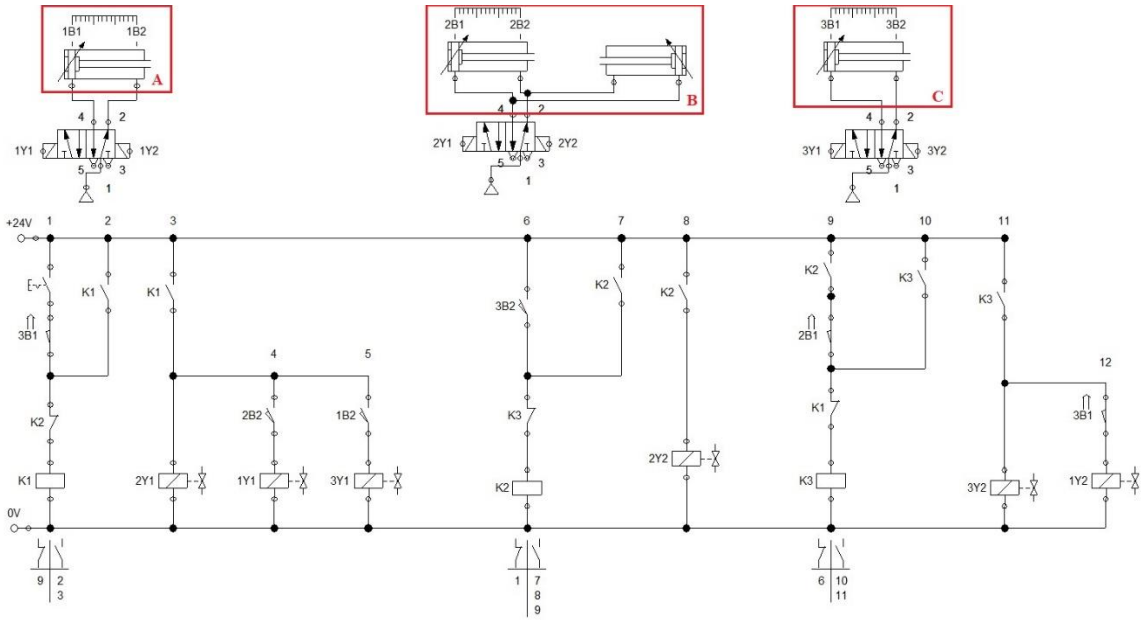

Figure 7 Electropneumatic control via phases

Phase control of actuator operation has advantages for ensuring continuity of signal transmission during actuator operation. It is possible to provide verification of the operation of the previous phase, making the wiring doubly conditional on signal verification.

Electropneumatic mechanisms combine several advantages from the field of electrical control theory and pneumatics. The main reason for the dynamic development of the electric control method is primarily the low operating costs compared to pneumatic mechanisms. (The pressure medium is only delivered to the point of consumption). Other advantages include availability of electricity, minimum dwell time even over long distances, etc. Disadvantages of electro-pneumatic mechanisms are their low stiffness and limitations in terms of deployment in the working environment (relatively high sensitivity to dirt and moisture).

6. Conclusion

The creation of the pneumatic circuit with the connection in phase, is generally to ensure the certainty that every single movement, every single action, is confirmed by means of sensor technology, approved, that it has taken place and is also an input signal so that other, predefined terminations, activities can continue according to the scheme of the pneumatic circuit. System characterization, computer-aided design, virtual environment, virtual environment testing, and virtual environment as a monitoring system allow for a methodology and effective understanding of how to create and use a virtual environment in a manufacturing process. Step by step, students will clarify the functioning of the entire process with a basis on logical and critical thinking and with practical clarification of their knowledge, directly through software or digital porstrations. The aim is to use this methodology, based on logical and critical thinking, in the pre-pedagogical process. Laboratories with adequate software and hardware equipment are intended to develop the technical competences of the pupils with interactive and multimedia means.

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