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FPS CONTROL REQUIREMENTS

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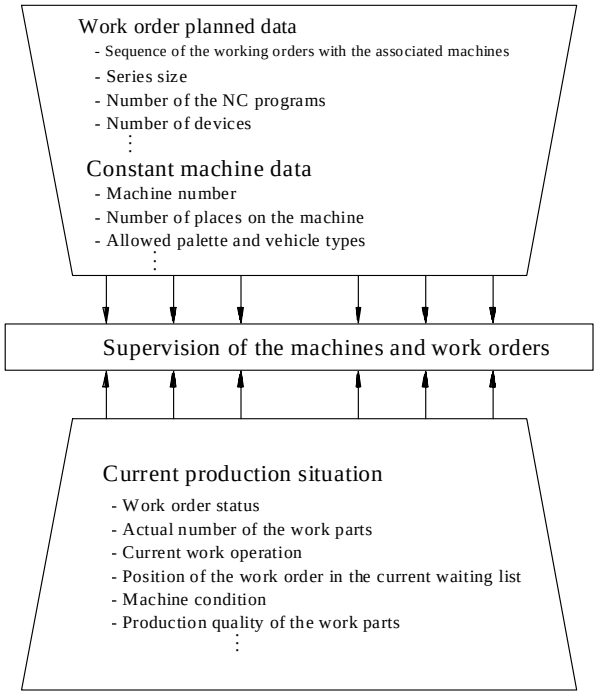
ABSTRACT
Realisation of flexible production systems and flexible automated material flow depends on analysis of its components and requirements that puts before control system. Attention of this article is focused on modular control system in FPS level and on requirements analysis of process supervision, communication with subordinate control level and communication with personnel.
Keywords: Flexible production systems, material flow, process supervision, control planes.

1. INTRODUCTION
While developing the controlling software widely applicable for FPS, we should take into account development criteria which, on the one hand, stem from the needs which are set out in the programming process by such software, and on the other hand from the analysis of the control needs independently from different system configurations.

2. PROCESS SUPERVISION REQUESTS
Need for supervision of the automated process originates from intention to avoid disturbances by the use of precautionary measure and prevention care. Additionally, appropriate countermeasures (avoidance strategies, service personnel actions) can prevent mistakes and greater damages on the machines and work parts. Furthermore, regular reception of information regarding disturbances and their processing enables localisation and removal of the cause of an error.
Supervision during the process: Problems on system components generally occur during some work process (transport or processing process). Reception of the work data and data from machine is a usefully additional means of how to better utilise a resource and manage production with the aid of system status analysis. Problems, which usually occur during the work process and cannot be avoided, may hinder the set production plan. Reception of the work and machine related data enables the control computer to get the clear picture of the status of production and the system.
On the basis of their causes and ability of how to recognise them the problems can be divided as follows:
a) *Inaccurate starting conditions:* Investigation of the preconditions prior to the work process can be used to avoid a bigger portion of mistakes which occur during the work process and which partially come as a consequence of the personnel mistake or wrong function of the machine during the previous work operation. Under this category we can find, for example, investigation of the readiness of the machine for the work or identification of the work part prior to the manipulation operation. After the problem is removed by the personnel intervention or, depending on the problem, by the automated response strategy in the case of disturbances, the interrupted process can continue without problems.
b) *Work station and machine component failure:* Technical failure of an element is a more frequent cause of the problems during some movement process. Failure can be detected by simple sensors. Because of that many controls supervise the machine during a work process, and this will take care of

shutting down the machine if the problems occur. Control of the machine, apart from CNC usually has PA control as well, which can shut off the drive in the case of a problem and can notify the control computer which will react correspondingly.
c) *Problems in the logical flow:* Investigation of the logical conditions is necessary, especially regarding transport operations which require synchronisation with the other components during the process. Causes of the logical problems may be incorrect serving, errors in the control program or the wrong function of a peripheral component.
d) *Equipment failure:* Fracture of a tool during the processing can cause the process to be restarted and can cause additional expenses for reparation, loss because the machine was not utilised and this is a separate subject of investigation.



Picture 1. Data for the work order monitoring

Supervision and monitoring of work orders: For the assessment of the work order status, i.e. production, there has to be information regarding the current production situation. Picture 1 shows the information regarding the monitoring and supervision of machines and work orders.
Provision of quality through the integration of instruments for the measurement of work parts: In order to control the measures and in order to investigate surface roughness (quality control), the work parts should pass measuring operation after processing. System-integrated supervision of the work parts and tools can be conducted both inside and outside the processing machine. Measuring within the work space of the machine goes onto the account of the main processing time. Integration of the control of measuring into the machine control makes the information flow simpler. Corrective data obtained from the measuring may be processed directly in the machine control, so in is not necessary for them to pass through the superordinated computer. In the advanced flexible production systems, in order to provide quality, measuring machines with multiple NC control are integrated into the process flow. Physical and IT connexion of the measuring instrument is envisaged through the control computer.

3 COMMUNICATION WITH THE SUBORDINATED CONTROL LEVEL

Requirements regarding subordinated controls of devices can be formulated as follows: 1) Controls have to be able to autonomously perform complicated functions and cycles; 2) Controls have to have interface through which functions can be initiated from the outside (i.e. by the control computer) and through which the programs in control can be saved; 3) Interface should be enabled to call up information regarding the process flow (for example performance of a function) or regarding the status of control and component.

Ad 1: Control autonomy: During the production each process is composed of smaller parts, which are performed in parallel or sequentially, and these parts are composed of smaller functions. The more the functions, that a control can perform autonomously, (i.e. without the influence of the control computer) are complex the less is the strain onto the control computer and data transmission systems. For the performance of a function more than one of system component can be active and in that case their actions have to be coordinated. If all of these actions were coordinated individually by the control computer it would be hard to imagine manual performance of such process without the control computer, for example in the test phase. Direct connexion of controls at the lowest level (CNC- or PA-level) increases modularity and decreases response time.

Ad 2: Remote serving of control: With all controls which are integrated into some production system it is necessary that, during the automated work, programs could be saved through the appropriate interface (DNC-work) and that the functions which have to be performed could start. Information is structured in the form of a block on the basis symbol-serial transmission. Each block (telegram) is composed of multiple bytes and is secured from disturbances through data transmission protocol.

Ad 3: Data exchange through DNC-interface: Intelligence decentralisation i.e. autonomous performance of complex functions by the control of devices has some advantages: computer release, separation of time critical tasks and release of data transmission system. However, there are some disadvantages as well. Namely, direct supervision of the status of process is possible only if the strain is put onto data transmission system and control computer. In order to reduce such disadvantage controls have to be able to perform self-supervision. In the case of some disturbances, they can through the internal diagnosis notify the control computer about the type, cause and time of disturbance. Status report is delivered by the autonomous device control on the basis of problems, or the control computer (server) can, at any time, register them within the scope of data acquisition.

Device controls can differ in functions which they can perform. Here the decisive role has the component type (transport device, procession machine, storage etc.), but also there are great differences in the scope of functions even with the same type of controls of different manufacturers, and even of the same manufacturer. The next difference with the same functions can be seen in the manner of calling up the functions. Then, the controls differ in the manner of data telegram shaping, in the scope of signs and in data transmission procedures. The sign scope and data transmission procedures generally depend on data transmission system for which the control is conceived.

As a link between the control computer and subordinated control level, data transmission system (PP-Production Planning systems) has the role of conducting the information through in a fast and safe manner. While the control system can be adapted to different device functions and data telegrams through the changes in the control software, adaptation of the control computer to the different PP-systems creates additional expenses for hardware. Many computer manufacturers offer hardware for PP-systems which are most frequently used, like for example, V.24 and V.11 or Ethernet. If onto the PP-system older controls or controls with inappropriate interface, there is a connexion through DNC-extension. The use of such extension is recommended in the following cases: with the controls which have no possibility of safe data transmission through a standardised interface and with NC-controls without autonomous program memory as memory at the machine. With the unification of the interface and PP-procedures it is possible to reduce costs of the control adaptation at the control computer level.

4. COMMUNICATION WITH THE SERVING PERSONNEL

Apart from the communication with the subordinated system level, in automated production plants we have data exchange between the control computers and the personnel that perform serving and supervision. This data exchange takes place at the main table and is included under the name of serving communication.

Defining the serving communication tasks needs the investigation of different phases which can occur during the work of some FPS. Apart from the phase of setting into motion, we generally make difference between the following phases: automated work and test and attendance.

The more precise division of the automated work leads towards the following phases:

a) Phase of setting into motion: Before the first setting into motion and after each longer pause the system is in the state which is unknown to the control computer. The phase of setting into motion is, as far as the service communication is concerned, marked with the operation of initialisation, where the control computer acquires the status of the system components, arrangement of the work parts and palettes etc.

b) Work phase: Automated flow of material and information is typical of this phase. Personnel at the control table have to have function for the deliverance of new work orders, management of the data status, supervision of the process and for the reactions in the case of disturbances has to be available (see Table 1). On the places for clamping and supply the service personnel will be provided with the appropriate communication media (monitors, function keyboards) in order to be able to take certain measures which have to be appropriately reported to the controlling computer.

TABLE 1 Tasks of the service communication

Data entry for production control	• Deliverance of the new work orders • Deliverance of the urgent work orders • Termination of the work order
Informative issuance of data for the system supervision and acquisition of the work data and data from the machines	• Presentation of the component status • Storage busyness • Transport means status • Presentation of the sequence of the transport order • Presentation of the waiting list on the machine • Protocol activities and disturbances
Data deliverance when there is a problem	• Confirmation regarding the removal of a problem • Deliverance of the newest status after the manual action in the case of disturbance • shutting down (component logging off)
Manual management of the material flow	• Deliverance and start of the transport orders
Change of the changeable status information	• Change of the folder content • Busyness of the stations and palettes • Component and the work parts status

Server has to have the possibility to stop or terminate automatic work in order to resupply certain machines or in order to be able to reach a definite state at the end of a shift. Contrary to the phase of setting into motion, at the restart the new initialisation is not necessary, provided that the system status during the termination was not changed.

c) Closing phase: Before the start of a longer pause (for example drive pause) the defined output status can be reached by the targeted closure of the processing phase. Current work orders will be finished and the system will be automatically unloaded.

The work in the test phase and attendance is specific because of a complete or partial manual control of the information and material flow. In such manner certain components and control software can be tested separately, especially in the system construction phase. Because of this the phase of setting into motion will be significantly reduced.

In order for the serving personnel to be able to accept one highly-automated system, the function understanding and easy service are of vital importance. Dialogical system based on menus makes entering easier, and with them the use of large handbooks is not necessary.

Prevention of the wrong serving, for example by investigation of the acceptability during the entry, is of vital importance for the functional safety of the plant. Under no circumstances the wrong serving may lead towards the system failure. Control orders which may lead towards the blockages in the material flow must be recognised and reported to the server prior to their deliverance to the controls of devices. Server will react correspondingly.

Apart from the number of functions which has to be performed, media for input and deliverance affect the software for the serving communication as well. Properties of the different devices with monitor (for example controlling by cursor, functional buttons, graphic possibilities, etc) requires significant modularity during the program creation.

Modular realisation of specific functions is necessary for individual setup of the possibility for intervention and supervision, according to the wish of a user. Different shaping of the mask on monitor or change of the information which has to be issued requires some changes in the software.

5. CONCLUSION

Quality analysis regarding FPS control requirements, and FPS components as well, are requirements for the creation of the control system which will be reliable, simple, modular and adaptable to different control tasks as well.

Data processing represents the bottleneck when it comes to controlling. Data processing architecture is nowadays directed towards technical and work requirements.