IDENTIFICATION, CREATION AND ANALYSIS METHODS OF AUTOMATION PROPOSALS

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Abstract: A phased design and review process is advocated in this paper. This is to minimize the amount of skilled manpower resource wasted on a detailed definition and analysis of automation proposals, which are eventually rejected for reasons that could possibly have been identified at an earlier time in the project. This paper will cover the three key preliminary stages required: identification of areas suitable for automation; creation and analysis of an automation proposal. At the end of this process, potential automation applications will either be passed on for detailed design and analysis work or rejected.

1. INTRODUCTION

The implementations of manufacturing automation have an effect on the whole business and will have requirements that can be met by changes outside manufacturing (see Figure 1). There are two actors that must be considered if automation is to be successful in the term in your company: automation strategy, product design.

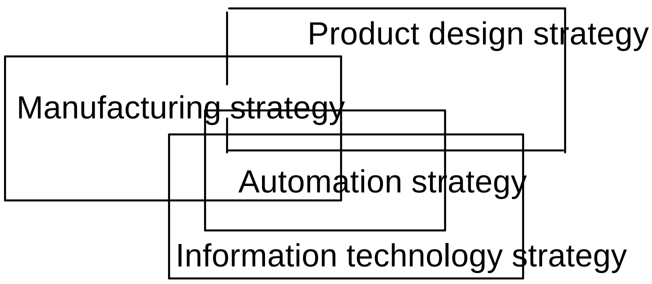

Fig. 1. The implementation of manufacturing automation

In manufacturing, as in any other area of the business, ad hoc actions, in response to problems and requirements as they occur, are not a recipe for long-term success. Proactive planning, as opposed to reactive "fire-fighting", is necessary.

2. IDENTIFYING AREAS FOR AUTOMATION

Figure 2 illustrates the implementation methodology advocated and followed in this paper. Only those proposals that have passed through an initial filter of business, risk and financial acceptance should merit the significant work required to produce a detailed specification and business case.

This paper will cover the three key preliminary stages required, namely:

- Identification of areas suitable for automation;
- Creation of an automation proposal;
- Analysis of an automation proposal.

At the end of this process, potential automation applications will either be passed on for detailed design and analysis work or rejected.

This operation can be divided into two areas of consideration:

- Short-term opportunities
- Long-term opportunities

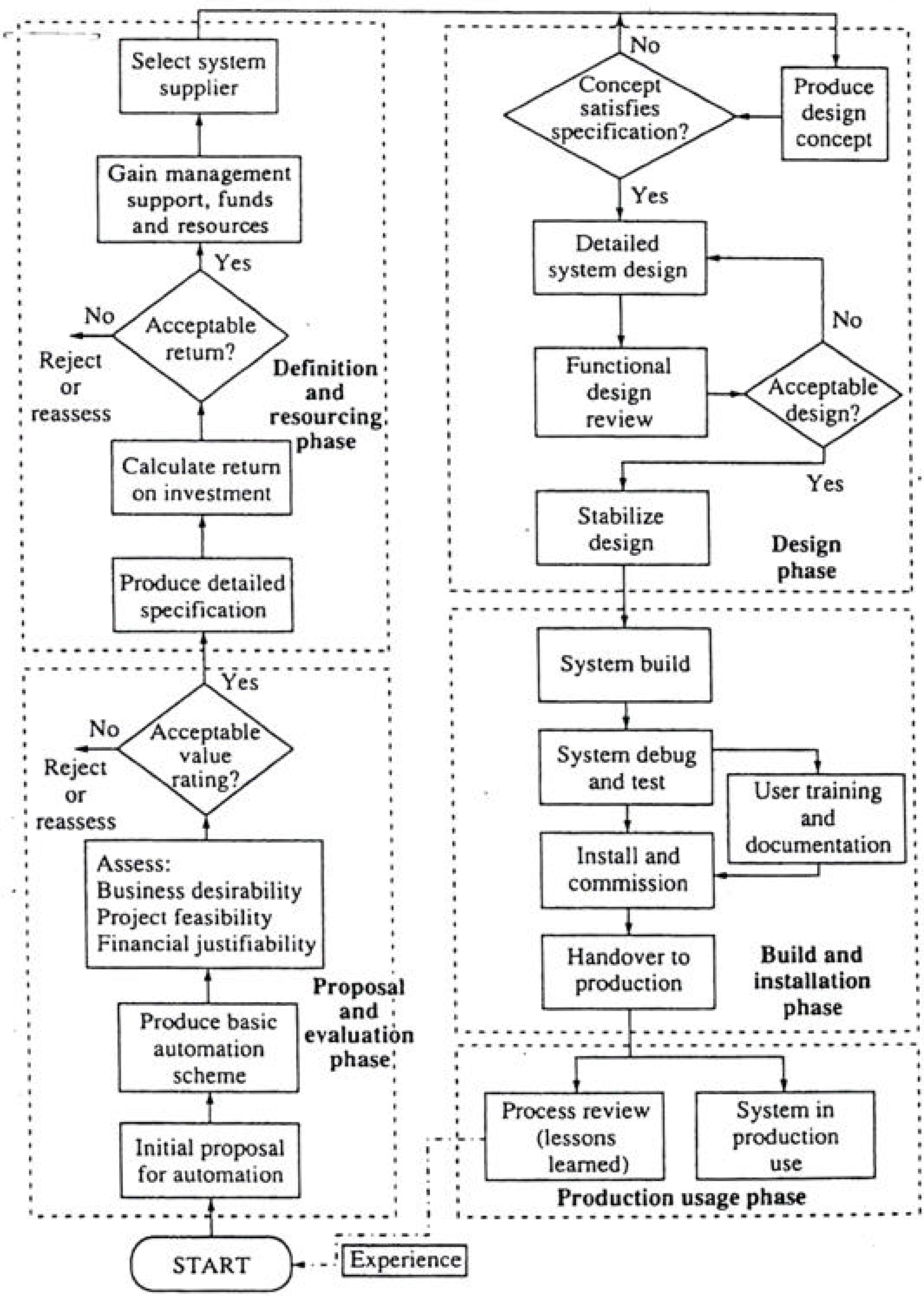

Fig. 2. Identification, creation and analysis of automation proposal

Short-term opportunities are those that are available within your manufacturing plant today.

Long-term opportunities will only be available if you make them happen; they are mainly determined by product design. If you control the design of the products you manufacture, you can ensure that the next product is designed for automated manufacture and assembly. Long-term opportunities might also include areas of opportunity within your key suppliers. If you can encourage and help them to reduce cost and improve quality in the manufacture of your components using automation, your company will also benefit. Your can see that to make the longer-term opportunities attainable the full support of company management is required. The potential benefits of these longer-term opportunities will far outweigh those in the short term, for they are strategic while those in the short term are only tactical. However, they are requiring a significant amount of effort and support to make them happen.

To identify the short-term opportunities, a study or review of the manufacturing operations should be carried out with the objective of identifying operations that have potential for automation.

2.1 Performing the study

Who will perform the study? In carrying out a study to identify the short-term automation opportunities within a manufacturing operation, there are four different approaches that can be taken:

- Investigate using in-house resources.
- Use an external manufacturing consultant.
- Use a factory automation system supplier.
- Use a factory automation manufacturer.

If an outside agency is used to perform this operation, as well as being paid to perform the study, it will require a number of additional resources: the use of someone to act as a guide around the manufacturing operations concerned, the freedom to question/interview operators, managers, engineers and accountants as required, the use of an office on site. The length of time spent on your premises will depend on the size of the manufacturing site to be audited and the nature of the audit required. A report will then be prepared (usually off site) and will be presented to you together with a formal presentation, detailing their analysis, conclusions and recommendations.

If you decide to perform the study yourself, then the following guidelines are set out to help you:

Objectives: Identify areas of manufacturing where automation could be implemented simply with the greatest benefit. Avoid complexity at this early stage.

Study method: A team is required consisting of manufacturing engineering and cost justification skills. A basic level of knowledge of factory automation, in particular its form and potential, is required within the team. This knowledge can be gained by courses or study. Many universities and robot manufactures run hands-on courses or study. The skill level needs to be sufficient to enable the identification of realistic areas of potential within the plant.

Production management should be approached for agreement and support to audit individual areas of operation. Manufacturing engineers and operators should be questioned closely in each production area, as they are the people with the best knowledge of the product and manufacturing operations. The members of the study team mist are aware that people might feel threatened by their study and be sensitive to this. If the workforce and their representatives are to be supportive of an automation programmed, they must be made aware of the reason for the programmed from the outset and be satisfied that no enforced redundancies will result from its implementation.

In contemplating the automation of potential operations, consider the following:

1. A machine should not replicate the manual operation, as this is unlikely to be the most efficient or reliable method.
2. Start thinking in terms of machine attributes – one arm, limited manipulation, poor sensory perception (if this is to be your first robot, then think of a blind robot – keep it simple).
3. Do not be over ambitious. If an operation appears childishly simple to perform, then that is a good operation to automate.
4. Find out if the operator performs other tasks in addition to the basic operation (e.g. machine adjustments, parts sorting, etc.) as a machine may not be capable of performing these.
5. Think about how work and parts would get to the automation and how work would pass to the next operation.
6. How easy will it be for automation to communicate with existing equipment?

Study output: At the conclusion of the study there should be a list produced of the identified areas of potential. These should be reviewed with the production management and engineers concerned to substantiate your conclusions. The next step is to produce basic proposals for the automation of each of the identified operations.

3. CREATION OF AN AUTOMATION PROPOSAL

Once you have determined that an operation has a reasonable requirement and potential to be automated, an engineering proposal needs to be produced. The function of this proposal is to enable provisional analysis of the automation application to be made to determine whether it should be progressed through a detailed scheme and analysis to potential implementation. It may be that while the automation of the operation concerned might have initially appeared possible and desirable, the more detailed examination required to produce an engineered scheme might show technical difficulties in achieving the performance required, or a high implementation cost, or even a dubious benefit of automating the operation at all.

In producing this proposal you should consider two areas:

1. Features of the task
2. Business and product conditions.

The first area requires a technical evaluation of the task requirements and the creation of an automation system proposal that will satisfy those requirements. If your company does not possess sufficient expertise to perform such an evaluation, then an external source of skill (e.g. a consultant) should be utilized. The second area requires an understanding of the conditions prevailing in your business and in your product market, which could influence the type of system to be selected.

It should not be forgotten, when analyzing both sets of conditions, that the solution identified must be consistent with the strategies existing within the business, in particular the manufacturing automation strategy.

3.1 Analysis of business / product conditions

Although you may be temped to immediately focus on to the task-related parameters when selecting the type of automation, as fundamentally the decision would appear to be a technical one, you should be continually aware of the business parameters, which may turn out to be the final arbiter. It is no good deciding that the best solution to your manufacturing problem requires a complex robotic system if your company does not have the funds to implement it nor the level of technical skill to support it in manufacturing. Similarly, it is pointless to decide that the high-volume, short cycle-time operation would be best automated by a dedicated piece of custom hard automation when the product that requires the operation has only 18 months of life left, and the time and cost required to implement the machine would not leave sufficient time for it ever to pay back the investment. Alternatively, if your business manufactures automation components (e.g. robots, shop-floor controllers, etc.), you may wish to utilize your manufacturing lines as a marketing showcase for your products, as well as a production tool. In such a case, the initial system cost and appropriateness of equipment will not be an issue. Therefore, for any automation proposal, always first check that you are fully aware of the conditions upon any automation. Then look at the task itself. The following factors should be considered in this business/product analysis:

- Expected lifetime of process/product
- Time available for implementation
- Funds available for implementation
- Skills available for implementation-user skill base (sophisticated or basic)
- Stability of process/likelihood of change in requirements

4. ANALYSIS OF TASK REQUIREMENTS

Turning to the task itself, within the constraints posed by your business, a number of factors need to be considered in producing a basic automation scheme capable of satisfying the requirements of the task. They include the basic mechanics of performing the task as well as dealing with error conditions. The key factors are listed below, in no order of priority.

- Working environment
- Degree of manipulation required
- Motion control required
- Tools/workload to be carried
- Cycle time
- System intelligence needs
- Communication and electronic interfacing needs
- Programming skill required
- System and cell layout
- Cost
- Complexity
- Flexibility to change

4.1 Cycle time

Consider:

- Maximum time allowed for operation
- Cumulative time of sequential processes
- Changing sequential operations into parallel operations.

Analysis areas. An automated installed on a manufacturing line with a cycle time longer than the slowest operation on the rest of the line will directly restrict the daily throughput rate of the line. It will thus be the line bottleneck station. In such an application, with limited buffering between line stations, the automated system cannot utilize breaks or uncorked shifts to catch up. However, an automated system installed off line and fed with work in batches can be viable even if its cycle time is slower than the process cycle time if it worked through breaks or even three full shifts with the rest of the line on two shifts. However, this means an increase in work-in-progress, which conflicts with just-in-time operation. The seriousness of this depends on the parts logistics strategy within the company and the value of the parts.

Utilizing more than one robot, enabling both to work in parallel, can be a good means of producing an automated system working to a fast cycle time. It can also produce a more reliable system, as griper functions can be shared between robots, to offer two simple units rather than one complex one. Two identical systems used in parallel to perform a process will produce a more robust system, as the failure of one cell will cause a partial, not a total, loss of capacity.

To minimize your cycle time, you must look for parallel operation wherever possible; you must also seek to minimize robot moves. Thus utilizing double or multi-grippers where cycle time is tight enables the robot to pick up unprocessed work while the machine processing the work is busy and then to unload the processed work and immediately load fresh work held in the other part (s) of the gripper. This method also maximizes the utilization of the processing machine. If fitting such a double loading mechanism onto the machine. The robots will then load and unload this mechanism, while the latter interfaces with the machine. This method is obviously not as fast as the former, but is still significantly faster than a system without any parallel operation.

Figure 3 illustrates the various approaches that can be used to divide work between automated cells.

4.2 System intelligence needs

Consider:

- Complexity and variability of task
- Response to error conditions
- Degree of autonomy required by system

Analysis areas: What degree of processing power will the system require? Will it just be basic sequencing of the automation, combined with some conditional logic dependent on the state of input lines? Will complex arithmetic processing be required? Will the system be data driven via a host device? Does the system need to control a very large number of data-in (DI)/ data-out (DO) lines? Questions such as these need to be asked to determine the nature and power of control systems required for an automation application. Control complexity increases with the complexity of a task and the degree of autonomy expected of the automation. The higher the autonomy, the greater is the capability needed by the automated system in recovering from error conditions.

If a robot is to be used in the application, then its controller will be capable of performing certain cell control functions in addition to sequencing the operation of the robot. However, you must determine if it alone is sufficient to operate the cell. It may be functionally incapable (e.g. cannot drive sufficient DI/Do lines or a memory size too small) of performing such a task or not fast enough to perform it within the cycle time required. Or you may consider that the software would become too complex if implemented solely on one hardware modules, with one module controlling the others by running the highest level of control logic and delegating finer detail to the others. Thus, in a multi-robot you may utilize an industrial PC to run the cell, communicate with a host computer, provide an operator interface, store production data and coordinate robot operations; robot controllers to run each and control its end-effectors DI/DO; and PLC to control conveyor indexing and locating pneumatics. Such a modular control approach is shown in Figure 4.

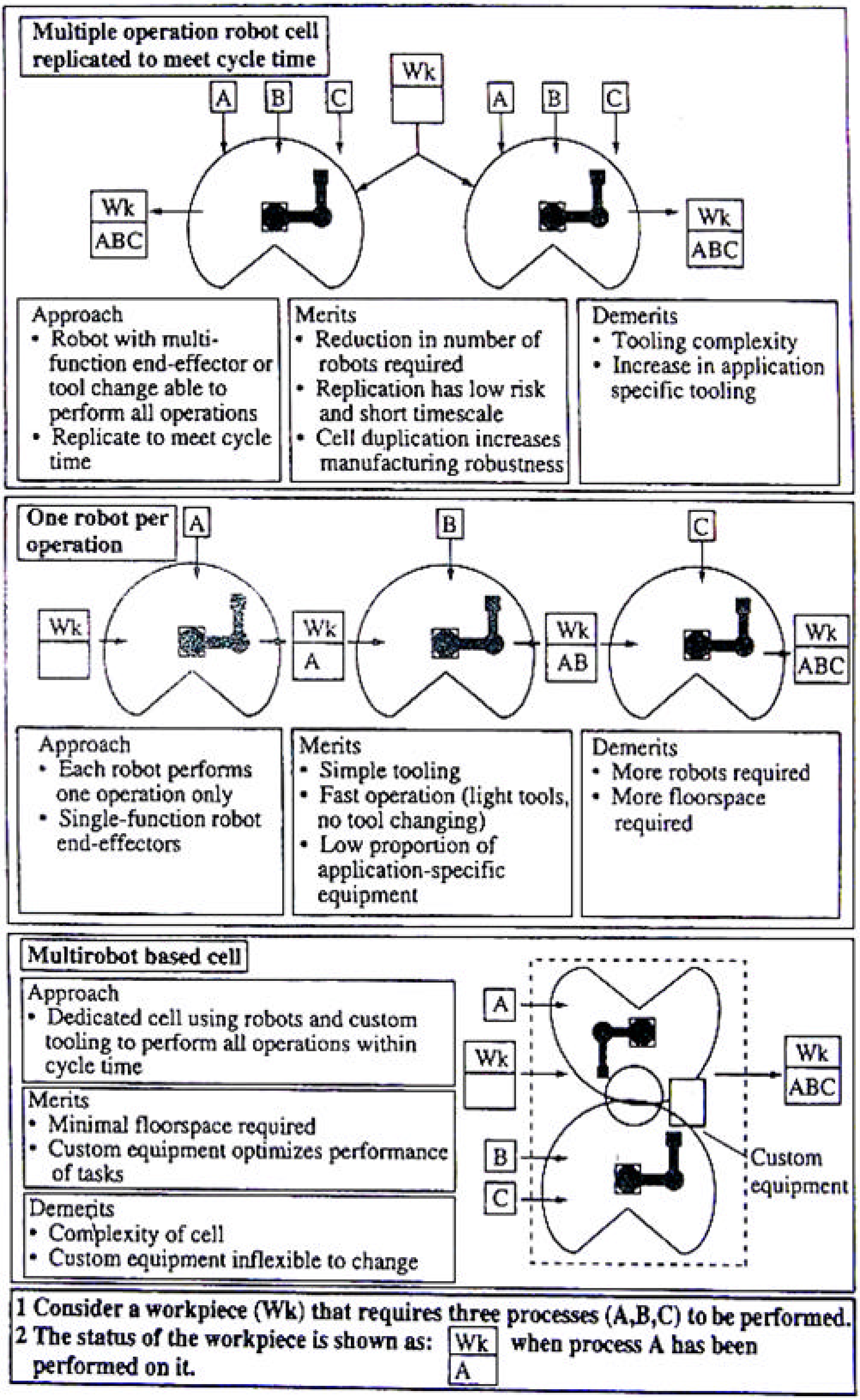

Fig. 3. Approaches to distribution between automated cells

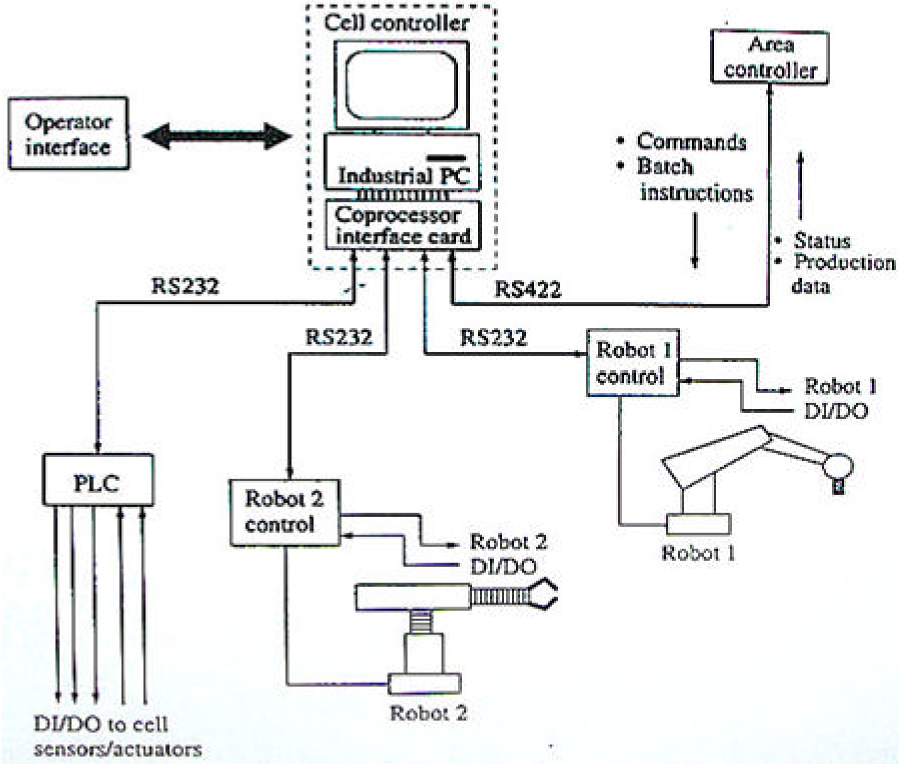

Fig. 4. A modular control approach

5. CONCLUSION

In producing an automated solution to a manufacturing task, the goal should be for a simple solution-simple, in that the solution comprises systems and methods that are well proven and only require a functional, not an operational, knowledge by the implementers of the solution and its users.

It is wise to consider flexibility and the longer term when producing your design and selecting equipment. If the product design is not yet stable, yet you need to make a decision on the type of automation-based system, as this could not cope with engineering changes in the design. This is particularly so if you are using a simultaneous engineering approach to design the product and manufacturing system concurrently. However, if the task to be automated is a fundamental part of your manufacturing process and will remain that way for the foreseeable future, you should consider a dedicated system of hard automation.

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