Specification of technical information system dedicated to a reorganizable and reconfigurable microfactory.

Eric Descourvières, Dominique Gendreau, Philippe Lutz, François Kiefer

SPECIFICATIONS OF TECHNICAL INFORMATION SYSTEM DEDICATED TO A REORGANIZABLE AND RECONFIGURABLE MICROFACTORY

Eric Descourvières[1], Dominique Gendreau[1], Philippe Lutz[1], François Kiefer[2]

[1]Laboratoire d'Automatique de Besançon (LAB),
ENSMM, UFC, UMR CNRS 6596, France, http://www.lab.cnrs.fr
24 rue Alain Savary - 25000 Besançon - France
[2]Laboratoire d'Ingénierie de Conception, Cognition et Intelligence Artificielle (LICIA),
INSA de Strasbourg, France, http://www.insa-strasbourg.fr/licia
eric.descourvieres@insa-strasbourg.fr, dominique.gendreau@ens2m.fr,
philippe.lutz@ens2m.fr, francois.kiefer@insa-strasbourg.fr

Abstract

This paper shows, in a global solution of the control of a microfactory, a dedicated and perennial structure of a technical information system. Our objective is to allow the realization of a reorganizable and reconfigurable production microsystem. The manufacture framework is located in the production of small and medium batches of different microproducts with a relative great autonomy, as well for the phase of setting in production as to ensure the follow-up of the production, in spite of the risks related to the microworld particular physics. For this reason and because the human intervention is limited to this small scale, data, information exchanges and the automatic generation of scenarios take a particular importance, and are different from those of the macroworld.

Introduction

To assemble these very small products, called microproducts (about some hundreds of μm^3 for the volume), the use of traditional technology and traditional size assembly systems leads to important difficulties which can be hardly overcome because of the scale effect and of the complexity of the microworld physics. The solution for the future is to have production system, which the dimensions and the cost are in relation with the microproducts: the solution is the microfactory.

Because of its double experiences in microrobotic and in the design and control of assembly systems, the LAB associates some sharp forces of these thematic to develop a research area on microfactory and to produce new approach in opposition of miniaturization approach.

We wish to consider the problem of the design and the control of the microfactory through a modular solution. Unlike the existing prototypes, we apply the modularity concept since the design and we address the resources and the control. As that is generally considered ([1], [2], [3]), a microfactory will comprise a significant number of production stations made up of modular elements allowing at the same time a great flexibility and an easy re-use of the resources.

Until now, it appears that the solutions suggested are relatively restrictive because they are quickly oriented towards material solutions. That has favours to allow fast experimental validations ([4], [5], [6]), but our main direction of work is the analysis of the specific need to the micro factory and on the conceptual definition for the control architecture from the point of view of the technical information system. This first

approach wants to be independent of currently available technology, nevertheless, an experimentation on a platform demonstrator will be developed in parallel.
According to us, the production microsystem is composed of three parts: It is based on a "PlatForm of Production of Microproduct" (PFPM) on which are laid out of the "trade stations", specialized stations necessary to the transformation of the microproduct, the whole being controlled by an "organization system" (Figure 1). The technical range of production (ordered list of the manufacture and assembly operations) as well as the mode of production management dictated by requirements of volume, of time, of balance of work, will allow the qualitative and quantitative choices of stations to be integrated on the platform. Various types of stations (storage station, assembly station, traditional or laser machining station, station of forming or separation of the matter, selective laser sintering station, etc), which can be with controlled environment, are, for this purpose, available in a store. These stations will have to be configured in order to achieve specific tasks for microproducts realization.

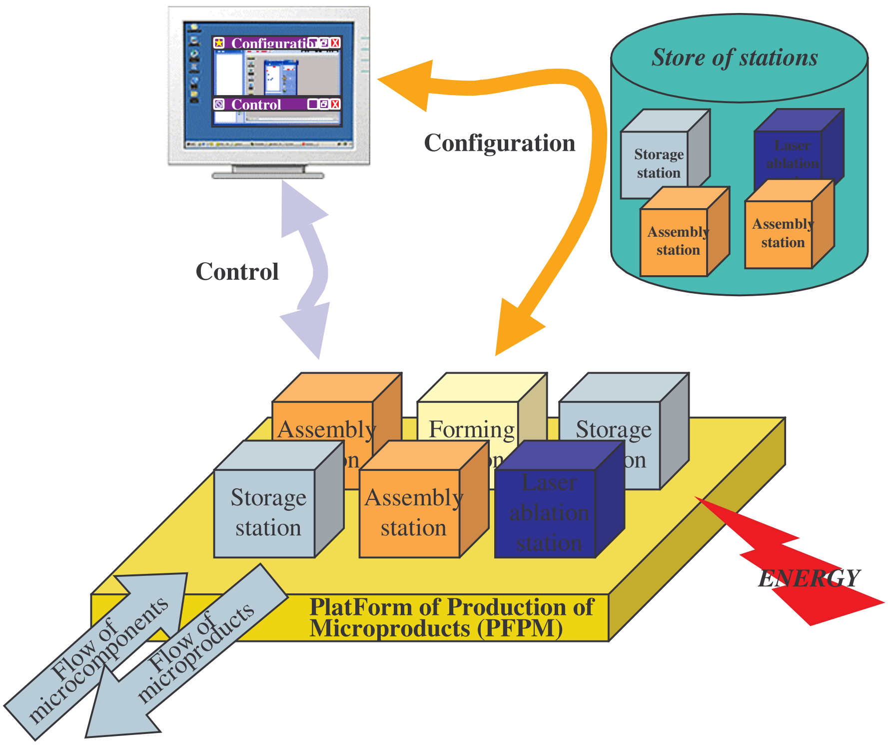

Figure 1 : Presentation of the microfactory structure

Like any production system, this microfactory must be able to manage flows allowing its operation and its provisioning. The entry of the rough material is characterized by a flow of microcomponents and the exit of the manufactured material requires the management of a flow of microproducts (result obtained by the assembly of microcomponents). Necessary external energies (electric power, pneumatic energy or laser beam, etc.) are conveyed at the various stations of the microfactory. All the management of the various stations and their synchronizations are supported by a technical information system in continuous relationship with an intelligent "organization system" in charge of the functions of parameter setting, supervision, production reporting and maintenance.

It appeared fundamental to us to focus firstly on the flexibility aspect in order to satisfy the context of various microproducts treatment in small and average batches. Then, the modularity brings a particularly interesting dimension on the organization, management of flows, and maintenance aspects. The whole can then be integrated in an easier way while bringing an adapted control architecture. The various axes of this approach bring reorganization and reconfiguration properties very interesting for this production framework. Lastly, the very specific technology of the microworld is largely taken into account through studies undertaken on the vision and feeding systems. Once integrated within a microfactory, in production, all this technology must remain accessible to the operator; that also forces to conceptualise a specific technical information system able to support this data category.

The concept of reorganizable and reconfigurable microfactory

Because the human reasoning is not accustomed to the microworld physics where surface efforts (electrostatic, Van Der Waals, surface stress effects) are as significant as volume efforts (gravity, inertia, pushed of Archimede effects), it is necessary to support the use of the microfactory by an assistance which automatically generate production scenarios. Thus, it will not be essential for the operator to follow a specific training to configure the microfactory and to produce small or medium batches at a moderated cost.

Thus, faced to the request of a microproduct manufacturing, the microfactory must have the capacity to propose an organization of its production platform in order to respect specifications the best possible. This organization will result from operator proposals and also from capitalized knowledge, resulting from former productions, but adapted to the new microproduct and its microcomponents.

However, even in production, the microworld physical constraints don't make possible the guarantee of reliability of an operation. So it's necessary to integrate productivity indicators, which must make possible the detection of the decrease of station efficiency. Then an alternative with the initial scenario of production must be automatically studied. Insofar as the entirety of the production platform isn't called into question, this step corresponds to a reconfiguration with a probable modification of the station parameter setting, or with minor material exchanges (tools change, etc). During a change of microproduct, there is a full reorganization action, which is taken by the "organization system". Nevertheless, a reorganization can also happen for a same microproduct, but in the case of a more consequent reconfiguration, having an impact raised on the initial weakening production scenario; for example with addition, removal or exchange of stations which impacts flows of rough material.

Because of all these reasons, the concept of reconfigurable production microsystems is more and more adopted by the international scientific community ([6], [7]). But the current publications generally treat material problems. However we think that it is necessary to go further in this direction by generalizing the reconfigurability to the organization system by an intelligent control which must be based on a structured and evolutionary technical information system, and especially long-lasting to guarantee the concept viability. Thus, in production job and for different microproducts, the control algorithms of a microfactory will evolve permanently. This method has the advantage to not privilege the architecture choice upstream. In fact, recent works show us that several different architectures are compatible with the microfactory operation ([2], [5], [7]).

Finally, according to the need, a microfactory will be able to adopt a centralized architecture, decentralized architecture, Web type architecture, etc. This new way of prospecting must arouse an additional interest near the international scientific community.

Specificities of the technical information system

It is important to specify the apparent necessity to dissociate two types of control into the microfactory: the supervision and organization control ensured by the "organization system", and the local control inside a station charged to ensure material operation (generation and followed trajectory [8], analyses measurements, etc.). In fact, the information conveyed by each one of these controls is probably not comparable in terms of volumes, data types, nature and time processing. The organization system processes

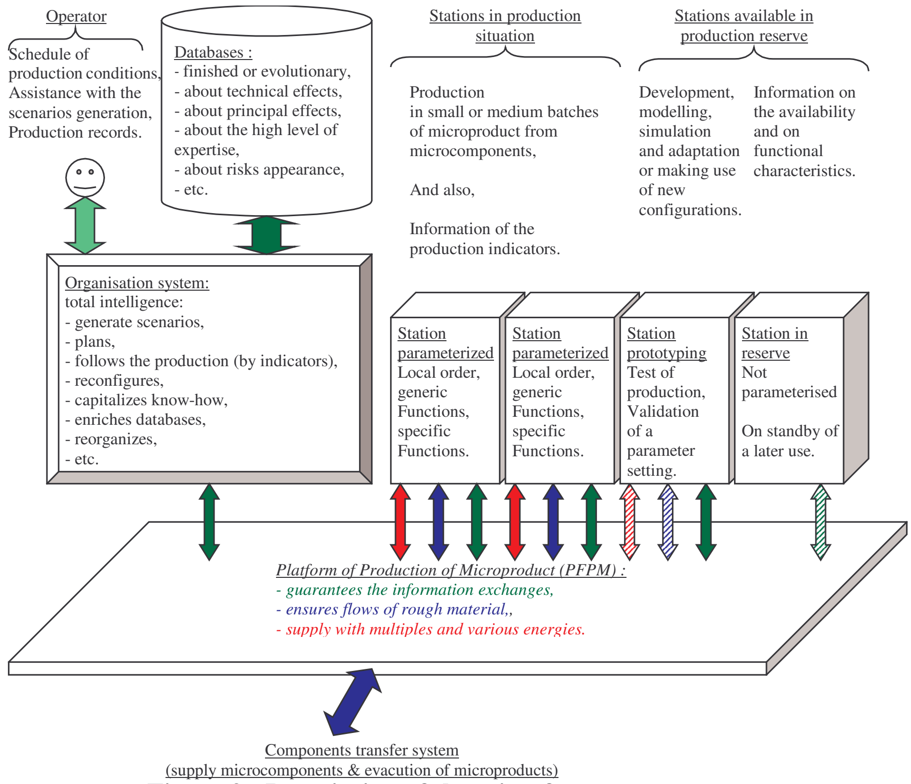

Figure 2 : Description of the microfactory components

production data whereas the local station control acts primarily on articular parameters. The Figure 2 described a réorganisable and reconfigurable microfactory. Its structures turn around the following constitutive categories:

- an "operator",
- several "trade stations",
- a "platform of production of microproduct" (PFPM),
- several "databases",
- an "organization system".

Thus composed, the production microsystem works according to the following principle:
A “(tele) operator”, since he can neither act nor observe the events of the microworld without assistance, undertakes at least the data entry of the production schedule. Then, to accelerate the generation of a optimum production scenario, he can assist the “organization system” either in the scenarios development, or in the choice of a particular scenario among several scenarios generated and proposed by the intelligent organization system. Lastly, the operator receives production reporting and status control, which inform him the flow of work and also the efficiency of the adopted production scenario.
Several "trade stations" are resources available for the microproduct production. Each station has two types of functionalities; some, called specific, are proper and define its speciality trade (for example: laser microwelding), others, called generic (for example: micropositioning [8]), are identical to several stations to minimize the development cost and to improve the application of modularity concept. According to the use or not of the stations, we dissociate their membership of the production platform or of a reserve. When they take part directly in the microproduct realization, they are considered in the production state; they were parameterised by the organization system and they are always observed by this same system thanks to the productivity indicators. The stations in reserve are requested by the organization system in case of defect productivity, which appear due to the random events of the microworld. Then they take part in possible reconfigurations with the organization system through the development of new scenarios, which are modelled, simulated, adapted and implemented on a small batch to test their efficiency.
The role of the “PlatForm of Production of Microproduct” (PFPM) is passive according to the point of view of the scenarios generation. Its principal task consists to guarantee the information exchanges between the stations, and between the organization system and the stations. In term of technical and material, the support of these exchanges could be electrical wires, electromagnetic, chemical, etc. In addition, the PFPM allows also the supplying of the stations in various energies, and it takes part in rough material flows between the stations and during the transfers with outside.
Several finished and/or evolutionary “databases” capitalize the possibilities offered by the stations. At first, in each local station, there is a census of the achievable “technical effects” during the piloting of the articular parameters. Then, the intelligent coordination of “technical effects sequence” makes it possible to obtain a directly exploitable “principal effect” to provide beneficiation on the microcomponents. Principal effects are a priori unlimited, but their development can also have a negative impact on the microproduct by supporting the appearance of the risks; that defines a “constraint effect”. Thus, each effect has properties of volume, time, and various physical sizes, which will be listed and will allow the generation of a resources library.
Possibly in relation with the operator, an “organization system” takes care of the generation of production scenarios starting from the production schedule, available stations and their capacity in term of technical effects. It must be associated with intelligent algorithm to have the capacity to generate new principal effects faced with new production situations. During the work-in-process, it takes care on the production efficiency thanks to the data coming from the productivity indicators. If necessary, if the output is not acceptable, the organization system is brought to reconfigure or also to reorganize the stations. For that, it considers new scenarios in collaboration with the whole of the stations; those in situation of production and those available in production

reserve. Lastly, the know-how of each station coming from the multiple productions of various microproducts, and coming from reconfiguration simulations unaccepted, is capitalized in the form of databases so as to reduce the scenarios generation of future microproducts manufactures.

At end, the technical information system must however be dedicated to allow to the operator an access to the microworld. Indeed, it is not possible to act manually or visually within a station. It will be necessary to provide to the operator a communication with the local stations control to enable him to operate directly, and with a great dexterity, the actuators control and to reach in real-time sensors measurements.

Conclusion

This first stage in the description of the specifications of technical information system dedicated to the control of a reorganizable and reconfigurable microfactory reveals two major aspects to be taken into account in the continuation of our work. On the one hand, to ensure the concept perenniality, it is significant to preserve a high level of abstraction during the architecture development of this technical information system, which is the "spinal cord of the microfactory". On the other hand, we will give one's whole mind to the concretisation and the technological means to allow the realization of an Experimentation platform of Modular MIcroSystems of Assemblage and Production (the LAB's EMISMAP project).

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