MANIPULATION AND ASSEMBLY OF SMALL COMPONENTS : HISTORY, TRENDS AND FUTURE

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ABSTRACT

Construction processes involving the manipulation and assembly of small components are very ancient. These traditional processes, among which masonry is the most developed (but not the only one) have undergone very slight progress until the last decades. Improving the efficiency of the process was the main incentive to such progress. The growing concern about the improvement of work condition and the availability of robotics techniques gave a new impulse to the developments of these processes. New design of components and of automatic machines have been made. This paper draws out the main lines of the historical perspective and underlines the trends of these developments. Economical perspective are outlined through this information and from experimental work carried out at the laboratory of robotics of the CSTB.

1. Introduction

The erection of a wall with bricks is a millenial technique. Modern bricks are either in clay or in concrete but basically, the technique is the same than thousands of years ago. This is at least a proof that it is a very relevant technique but can't it be improved ?

Though these small components are designed to be handled manually, the repetitive task is very tiring and occupational diseases result from this activity.

Other processes using small components are currently used in the construction industry. For example, some piping processes, curb-stones, waste water or cables troughs installation use such components.

The mechanization of some of these processes is being studied and some industrial machines are already available on the market.

These mechanized processes mainly intend to assist the human worker in his efforts during the manipulation and the assembly phases.

For instance, arms with self-locking grips are used to assist the workers who place the curb-stones.

The automation of the mechanized tools is limited because the component has not been changed. The component is the same for the manual process and for the mechanized process.

This paper intends to analyse the full handling and assembly process. Both mechanisms and components are considered. The analysis is focused on the wall erection process but conclusions are to be extended for other processes.

2. Previous attempts

2.1 The mechanisms

The automation of the wall erection process looks to be an existing subject when it is refered to cartoons and comic strips.

More seriously, a look at a patent data base offers an important source of information.

Figure 1 to 4 give a summary of such a bibliographical research.

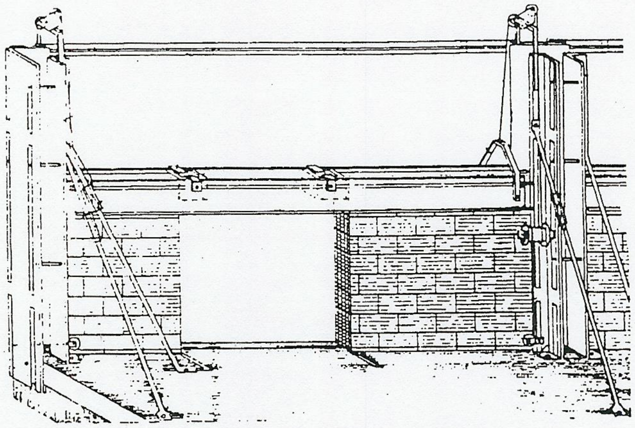

Figure 1 (Patent n° FR 2487411)

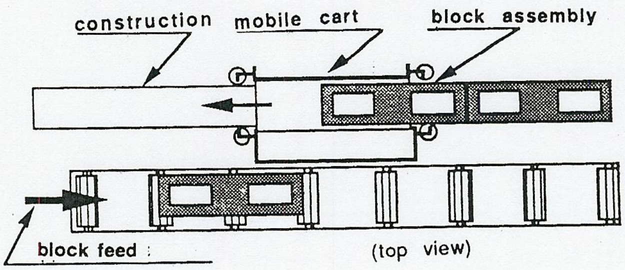

Figure 2 (Patent n° FR 2507654)

It is clear that none of these machines can compete with the traditional manual process. The reason is that they mainly try to reproduce the manual movments.

A special attention should be taken to system of Fig. 2 which is essentially a brick distributor. The worker is assisted in the handling phase but carries out the assembly task in the traditional way.

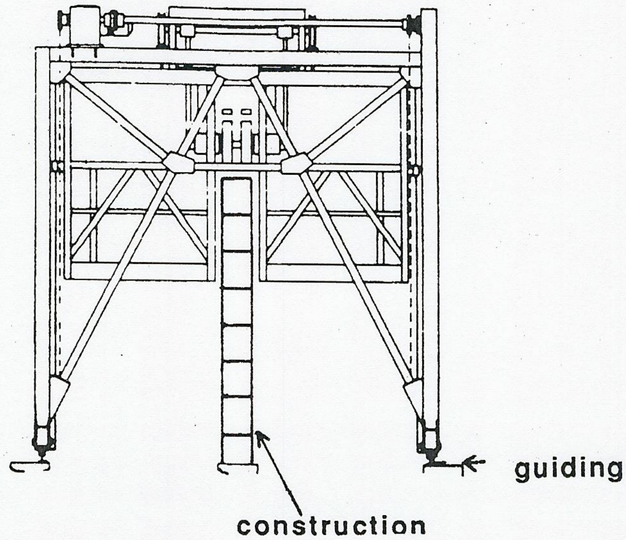

Figure 3 (Patent n° DK 2283284)

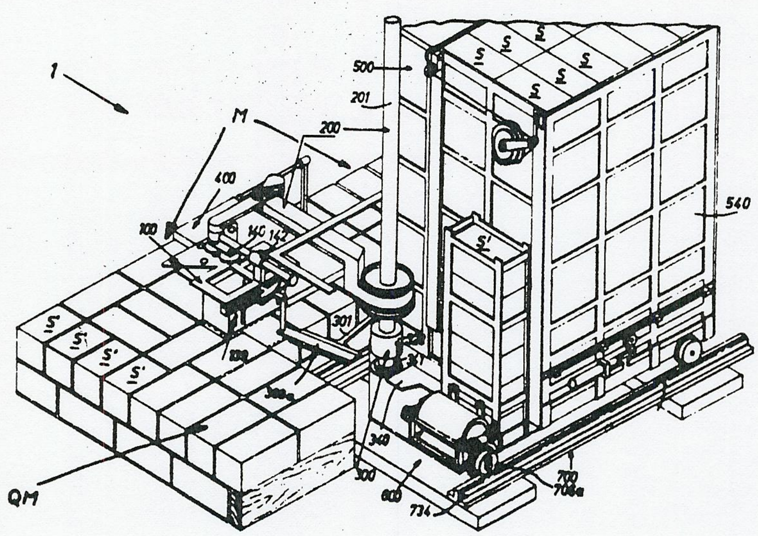

Figure 4 (Patent n° D 2200383)

A review of automation attempts must include the communication presented in the frame of previous ISARC Symposiums ([1] to [5]).

Some of these studies propose new designs of blocks ([1], [3]) after considering that the reproduction of the manual process leads to unsatisfactory solutions.

2.2 The blocks

A specific phase of the manual process is the laying of mortar. Human skill allows a precise positioning of blocks on a mortar layer. The reproduction of such a skill by a machine would require ... human capacities !

Dry assembly has been proposed as a more simple solution in the way it avoids the mortar. Up to now, it has not been very successfull mainly because of the too low tolerance of blocks manufacturing. After three of four layers of blocks, it becomes impossible to place new blocks without getting some troubles with verticality.

The development of polystyrene blocks gives a higher geometric tolerance and the flexibility of the material allows a more precise assembly.

All this experience and the bibliographical research is patent data bases and technical documentation leads to classify existing or proposed block designs as shown in Fig. 5. The ideal block which would be self positioning and self-locking is still to be found.

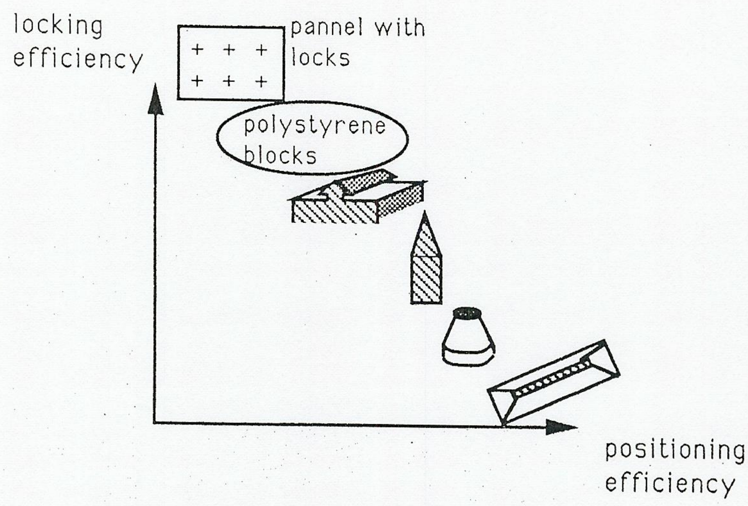

Figure 5 : Classification of blocks

3. The economical limits

Refering to present economical conditions, it is worth evaluate the cost limit of both the mechanism and the blocks.

This is done taking into account the following assumptions :

- the "robot" is n times more efficient than the man ;
- the blocks cost m times more than traditional blocks ;
- the pay off period is p years.

The reference conditions are as follows :

surface of wall	thickness	time	cost of manpower	cost of blocks	total cost
1m2	0.2 m (normalized concrete blocks)	1.2 h	65F/h	100 F	180 F

From these informations and from additional data (effective work period per year (1 700 h/year), benefits (11%), cost of maintenance of the robot (15% of the investment per year)), some situations can be studied.

The maximum investment for the robot results from these situations :

n	1	2	3
m	1	1,25	1
p (years)	4	4	4
maximum investment for the robot (F)	472 000	924 000	1 132 000

These are rather rough figures but it means that the order of magnitude of the robot could be 700 000 FF (100 000 Ecus or 115 000 US dollars).

This cost would correspond to a slightly more expensive block (20% higher) with a significantly improved efficiency.

Which block design and which automated machine could be consistent with such figures ?

4. The choice of a system

The system includes both a block design and a mechanism. The aim of this mechanism is to handle these blocks which are designed to be assembled according to a "simple" process.

We have compared systems according to a set of twelve parameters as shown in Fig. 6.

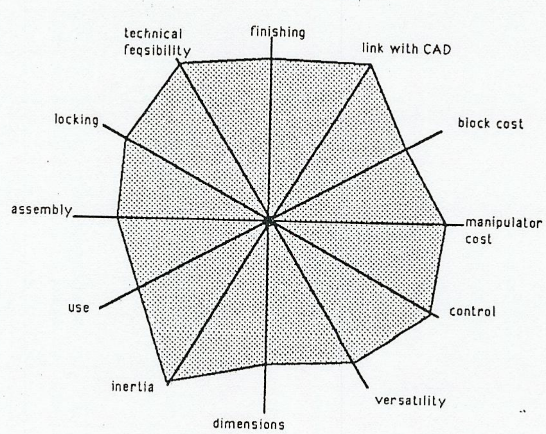

Figure 6

These parameters characterize the ability of the system to be included in a fully automated construction process.

The higher the value of the parameter, the better the ability.

A system consisting of a cartesian coordinate manipulator and of blocks with slots has been choosen.

This system is the nearest from the "ideal" system as presented in Fig. 6.

5. Experimental system

Experimental blocks have been made of wood and of polystyrene. Each block weights 1.5 kg and the dimensions are : 36 cm (L) x 10 cm (l) x 15 cm (h)

the manipulator consists of :

- a x-axis actuated with a stepping motor ;
- a y and a z-axis actuated with air jacks ;
- a grip with air jacks.

The dimensions are indicated in Fig. 7

This manupulator is controled by a micro-computer.

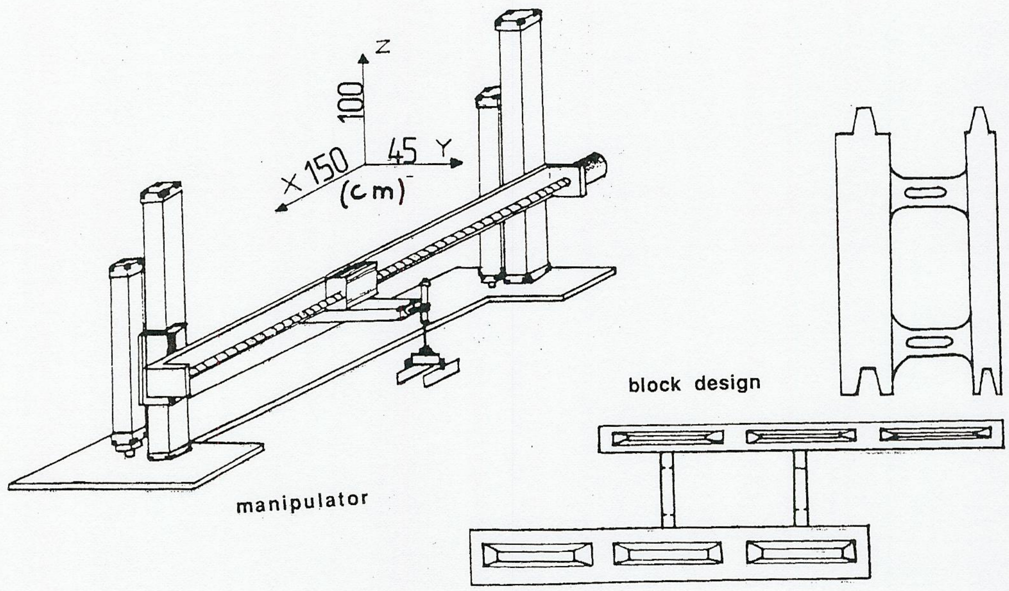

Figure 7 : Artist view of the block and of the manipulator

Preliminary tests have confirmed that the mechanical design was satisfactory for the situations to be encountered.

An experimental program is now being carried out to gather informations about the behaviour of a full scale manipulator and about the possible problems which are likely to raise during the use of such a "masonry robot".

6. Conclusions

It is now clear that a system for the handling and the assembly off small components must include both the design of blocks and the design of the (automated mechanism).

The cost of such a manipulator is now expensive but the order of magnitude of the acceptable cost is not a deterent.

The proposed design results from assumptions which sound reasonable but a full experimental program will give more reference data.

From this experience and from previous experiments, we think time is ready to begin an interactive discussion with end-users, block manufacturers and machine manufacturers.

Similar studies have to be undertaken for the other kinds of processes mentioned in the introduction.

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