Applications of programmable handling-units in contracting companies

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1. Introduction

Following the quick entry of robotics in production engineering during the last dec ade the state of the art of the current robot technology has reached a level which might open thoughts for new applications in other branches.
Such a branch could be civil engineering. Productivity nearly reached stagnation in Federal Republic of Germany after the introduction of machines like cranes, hydraulic excavatores, mobile concrete mixers etc.
At the moment we are standing at the very beginning to introduce robotics into the reality of modern contracting companies. From the technological point of view two general approaches are possible :

- development of an intelligent autonomous system
- step by step development of already existing machines with the aim of increasing automation or implementation in civil engineering

After a brief review of the present state of the art in production engineering concerning industrial robots some case studies are presented. The aim of this paper is to think about the possibilities and the problems of advanced handling-units in civil engineering for specified examples.
A joint project KFK/IPA is currently in process to cover the above mentioned task. The present paper gives the first results for the branch civil engineering.

2. Industrial robotics-state of the art

The current state of the art is described for example in /1/ and /2/. With handling units (according to VDI-guideline 2860) we distinguish :

- o manual operated machines (for example manipulators)
- o machines with fixed sequences (for example pick and place units)
- o free programmable machines (for example robots in different versions : playback, NC, intelligent ...)

Let us take these existing categories of machines as starting point. We can sum up the state of the art as follows :

o Mechanical design

Problems with the inverse transformation keeps the number of the programmable axes in certain limits. Figure 1 shows the most often used kinematic chains for industrial robots (excluding playback type) - only three types can be considered as very important. Furthermore robots have to be very stiff (and heavy) in order to get the required position-accuracy in the automatic cycle. With manual operated manipulators we don't have the above mentioned problems.

o Mobility

In production engineering the number of applications for mobile robots are limited. In most cases we have a structured environment and high batch numbers - factors ruling out mobility. For certain applications we might introduce mobile sytems as shown in Figure 2. Here we have a system including an inductively guided vehicle, robot and magazine for a tool change application. Remote controlled mobile manipulators are now used quite often in nuclear reactors, as shown in Figure 3 .

Looking onto the current boom of walking mechnisms for robots we have to consider carefully possible applications and the costs. Many similar devices have been developed more than twenty years ago for dredgers etc. In the long run the wheel and chain-drive succeeded for various reasons.

o Control and programming of movements

The major problem of modern robot controllers can be found in the fast data processing and interpretation of the sensor signals. A short term solution does not exist, but for longer term projects we can expect suitable fast process computers. The manually operated cycle with manipulators on the other hand is very slow. For each automatic cycle we have to consider new approaches for the generation of movement data. This process is very expensive now and rules out the use of robotics for small batch applications.

o Artificial intelligence

For certain well defined environments applications are known. Artificial intelligence is very important for the automatic generation of movement data in order to approach the autonomous system some time in the future.

3. Situation of contracting companies in the Federal Republik of Germany

In this chapter the current situation of contracting companies is shown related to possible innovations :

- o the federal and private building constructions has almost cut in half during the last twelve years (see Figure 4). Most of the buildings are new, the population is declining.
- o prices for housing grounds are very high, especially in larger cities. Therefore the price increase for an individual solution is less important - an industrial mass production of houses comparable to solutions in the USSR are unthinkable
- o during the next five years more than 20 percent of the turnover in building construction related to repair and modernization is expected.
- o the aim of federal orders (subways,highspeed trains) is to balance this trend. But with these new orders also new technology has to be introduced.
- o in Germany bigger contracting companies are very flexible and interested in new machinery. Trained staff is available.
- o it is most common to lease expensive machinery from machine pools.

Considering these facts we meet good conditions for applications of robotics (or similar machines) in certain well defined areas.

4. Procedure for the identification of new applications

The application of robotics in contracting companies can be evaluated from the following parameters :

- o economy
- o humanization
- o accident hazard
- o inaccessibility

In most cases more than one of these parameters are influential. If we consider robotics in construction companies we can not think about economy alone. For example the efforts to put the human in a hazardous environment can be very expensive. Keeping the fact in mind that almost all new machinery was developed for specific needs of potential customers /3/, the IPA and KFK started a project to identify new applications for robotics, also in contracting companies. The following procedure was tested with success :

- o foundation of a mixed team of experts from the robotics, manipulator and technology side in order to set up specifications for the questions to the industry expert and for the worksite analysis.
- o after a telefone contact to clarify the situation there is a meeting with the industry expert. The aim of the questions is to find new applications and setting up together performance specifications for the new system.
- o if a robotic solution seems likely to the experts a worksite analysis of the present system follows.

Experience has shown that only the worksite analysis gives a fair answer whether or not the robotic solution has any chance.

5. Case studies

Now we would like to discuss several applications in civil engineering with regard to a possible robotization :

a) Rock drilling machine (Boomer)
This mobile machine, consisting of several booms is used to drill holes in pre-specified pattern in the rock for tunnelling.
Typical taskes which might be automated are:
- o positioning of the machine in the tunnel
- o positioning of the arms, drill control to a programmed depth, return and move to the next hole position
- o change of the sectional drill rods

For automation we have to consider:
- o bad or no view for the operator
- o manual positioning and drilling very slow and difficult

A machine for this task was developed by Furuholmen company in Norway. Here the human can override a specified programme.

b) Demolition
A remote guided vehicle BROOK 250 was developed for :
- o excavation of bricks in steel converters
- o demolition of concrete walls etc.

This mobile vehicle with an arm quite similar to an industrial robot is equipped with an hydraulic chisel.
Factors like :
- o accident hazards
- o high noise level
- o bad or no view

encourage a robotic development of that system, especially if we consider the environment of a more or less defined steel-converter. Similar applications can be found with some hydraulic excavator missions.

c) Repair of reinforced concrete

In the last years many reinforced concrete buildings had to be repaired and many more will follow. Many reasons, especially a polluted environment caused corrosion of the reinforcement. A principle to remove concrete without damaging the building and the reinforcement is the CONJET-method from Atlas Copco. Here high-pressure water (1000-1200 bar) cuts the brittle concrete (distance is a variable). A three wheel vehicle, remote controlled, was developed for the application on horizontal surfaces. In order to achive a wider range of applications a device is needed where more positions and orientations of the nozzle can be realized.

Factors like :

- o strong accident hazards
- o high noise level (120 dB(A))

are influential in this case.

d) Repair of shuttering panels

The repair of shuttering panels is a common problem in many contracting companies. The most important sequences in the repair work are :

- o grinding, cleaning and oiling of the form
- o or, if the panel is damaged, removing the old panel and assembly of a new one (see Figure 5)

In this case we have a structured, fixed workplace. For a robotic solution we can sum up the following parameters :

- o repeating cycles in a structured environment
- o variable dimensions of the workpieces
- o small batch number, so fixed sequence machine not suitable

6. Conclusion

The future development of robotics in contracting companies will be task oriented. The case studies show a variety of different tasks. The combination of already existing systems with a more or less modified robot control (including sensors) should be taken as a first step forward.

References

/1/ Warnecke, Schraft : Industrial robots, IFS Publications, Bedford,1981

/2/ Köhler : Typenbuch der Manipulatoren, Karl Thiemig Verlag; 1981

/3/ Hippel : Users as innovators, Technology Review, January 1978, page 31-38

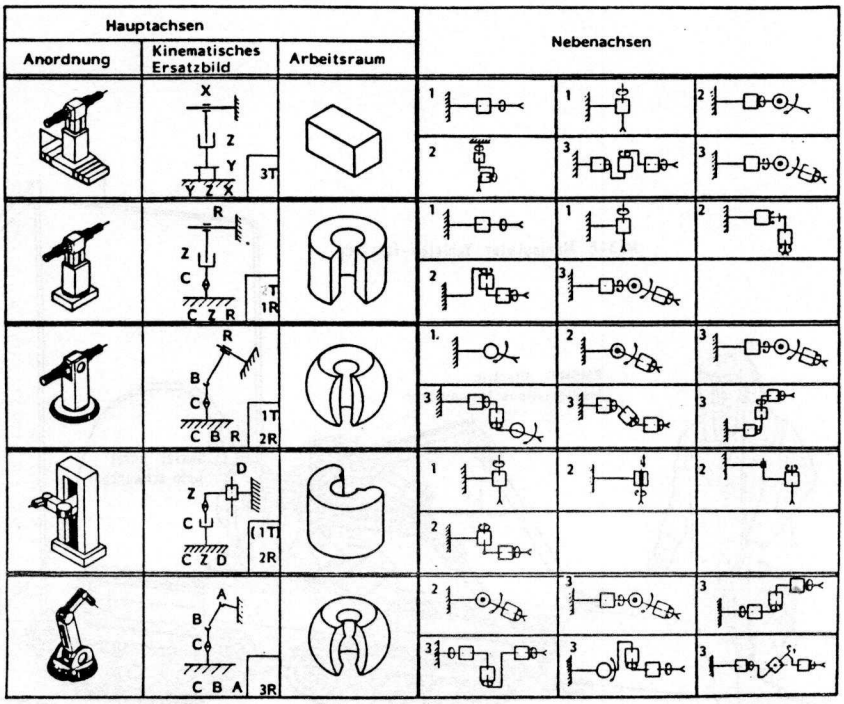

Figure 1 : Kinematic chains of industrial robots (IPA)

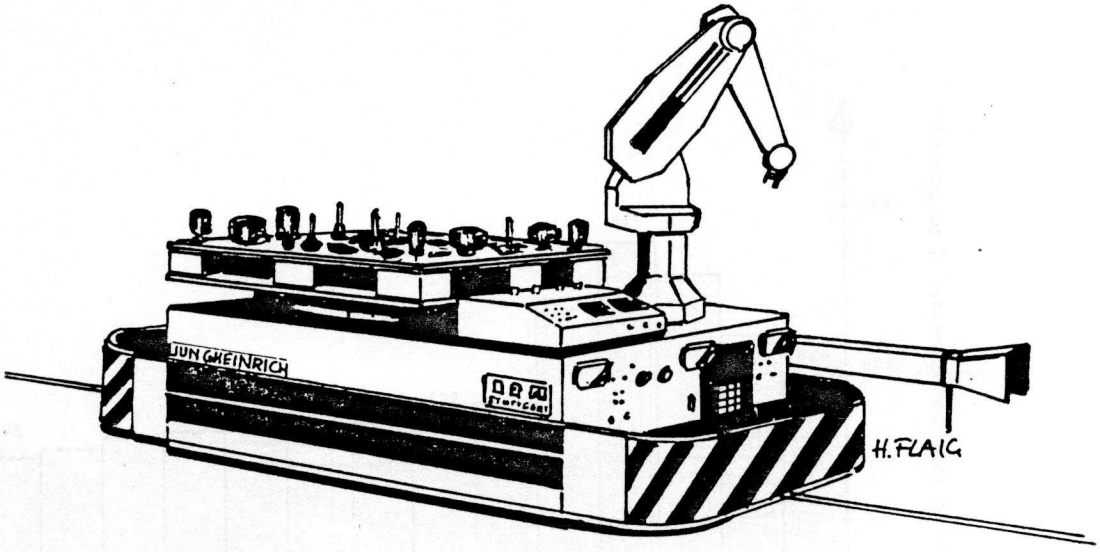

Figure 2 : Mobile robot system (IPA)

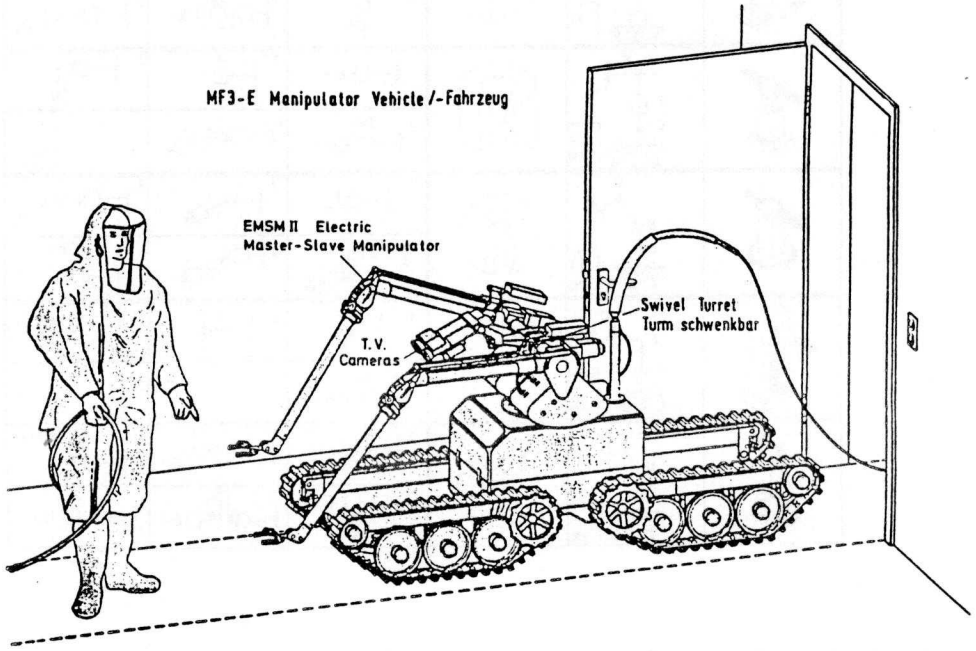

Figure 3 : Remote controlled mobile manipulator (KFK)

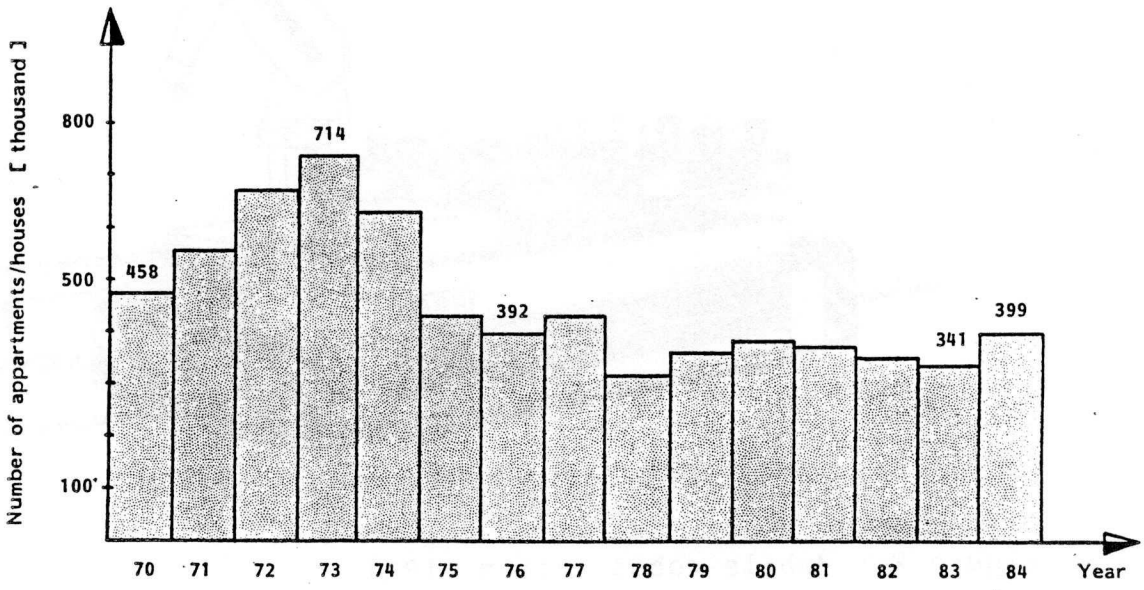

Figure 4 : Number of appartments/houses completed in the FR of Germany 1971-1984

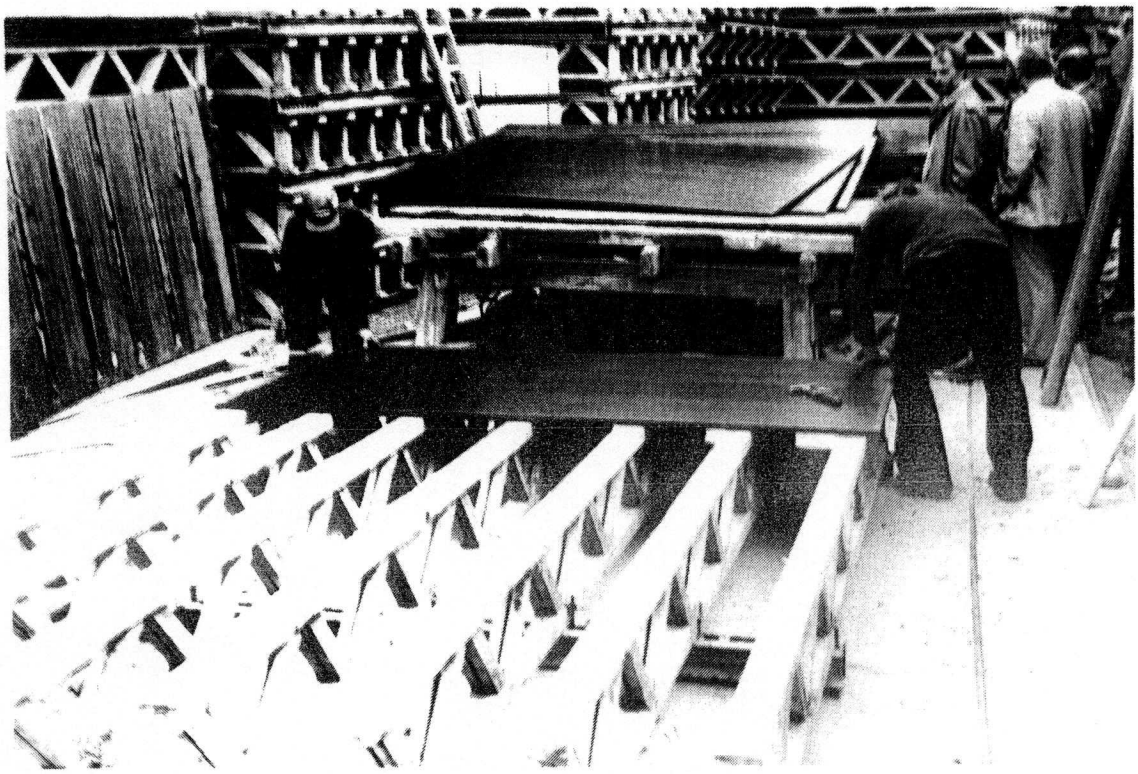

Figure 5 : Repair of shuttering panel - manual workplace (IPA)