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CAPITAL INVESTMENT PLANNING FOR NEW TECHNOLOGIES - A SYSTEM DYNAMICS ASSESSMENT ON ECONOMIC EFFICIENCY

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Capital investment planning for new technologies a System Dynamics assessment on economic efficiency

Abstract

Technological investment planning is of crucial importance for industrial enterprises. Successful investment decisions and the right process technology increase the companies competitive strength. If the wrong technology is applied this leads to high fixed costs diminishing the return on investment. Methodical long-range planning is required.

The necessity to introduce new technologies is emphasized in numerous publications. For evaluation of such strategic investments the classical methods of project calculations are not sufficient due to nonconsideration of specific economic parameters changed by modern process technologies.

A holistic view will be developed, considering all effects of new technologies on the enterprise. The proposed System Dynamics approach simulates the changes of cost relations due to the introduction of a Flexible Manufacturing System (FMS) in an industrial enterprise.

The handy SD model can be easily adapted to individual circumstances. Therefore, it offers practical support to demonstrate the economic efficiency of capital investment already in the planning stage of preinvestment analysis.

The model of an industrial enterprise

Research and development over the last fifteen years on the field of information-intensive processing technologies enables today`s manufacturing industry to reach productivity and flexibility as well. However, besides high investment costs for acquisition of hardware for flexible automation, the enterprise`s economic setup has to be changed.
This dynamic process of integration is going hand in hand with the changing of cost relations, determined by a complex system of management decisions, these showing non-linear relations to the costs. Vice versa the cost relations are the basis for many entrepreneurial decisions, such as investment decisions or the calculation of prices. Therefore, the character of an information feed-back loop can be recognized.

System Dynamics - based on the investigation of networks of information feed-back characters to understand non-linear complex systems seems to be suitable to support investment decisions for information-intensive process technologies.

The SD model shows the changing economic setup of an enterprise manufacturing capital goods after having installed a FMS. Typical for the factory is

- the order-related production
- the small economic lotsize and
- the complexity of handling and tooling demands.

The FMS is installed - as usual step by step. Meanwhile the qualification and instruction of labour is realized in continuation- and training courses. To describe the effects of the FMS on the enterprise the model analyses several sections, reflecting the (Fig.1)

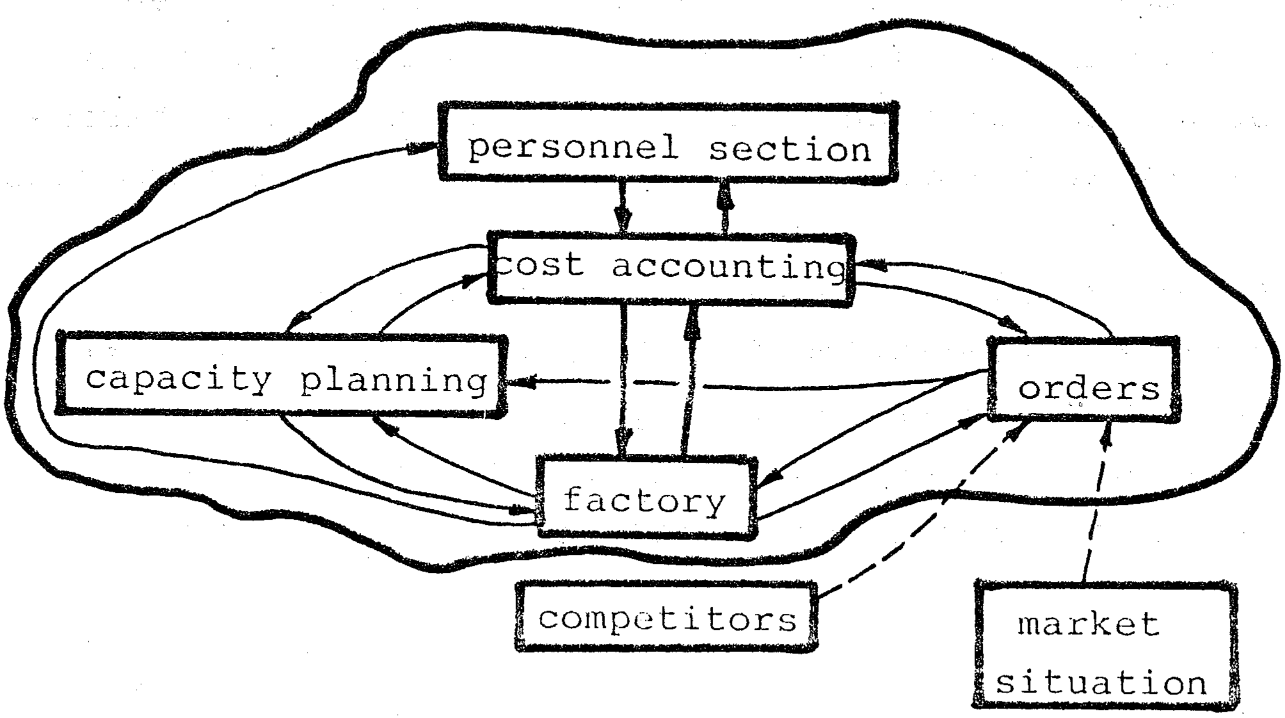

Fig.1: The model`s sections

- personnel and labour department
- the factory and production
- the capacity planning
- cost accounting, and the
- demand according to the market situation.

In the personnel section the investment`s implication on labour forces is reflected. The SD model recognizes in two sub-sections the
- machine operators in the workshops and the
- operational staff.

The general policy in the labour section ensures that the machine operators being cut back will be trained and qualified so that they can be transferred to members of the increasing staff of the operational subsection. This is necessary to avoid dismissals as far as possible, according to the "Kündigungs-schutzgesetz", the law against dismissal in Germany from 1985. This transposition of labour forces requires extensive arrangements to develop the average labour qualifications.(Fig.2) During the time of training, these staff members cannot be assigned for the production process. Therefore the staff level is reduced by the necessary rate of training.

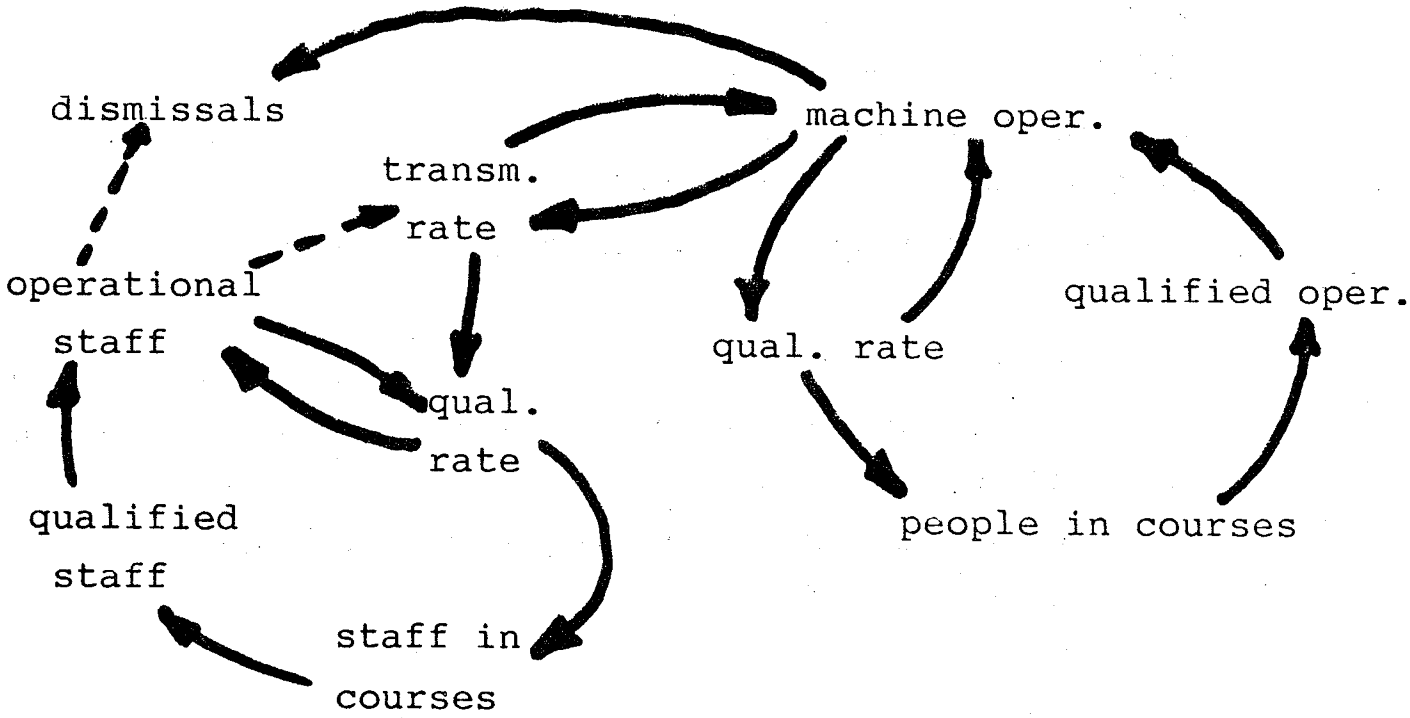

Fig.2: Feed-back loop personnel section

The models second section shows the factory and production. The production is assessed as a multilevel (3-levels)process. The level of orders is increased by the order rate and diminished by addition of the production rate and the rate of lost orders, these representing the orders that cannot be manufactured. The size of this rate in relation to the total number of orders is an indicative number, expressing how the factory`s flexibility in production rises due to the increasing experiences in flexible manufacturing.

The proportion of lost orders declines during the time of simulation, finally the enterprise can satisfy almost every order of the market.(Fig.3)

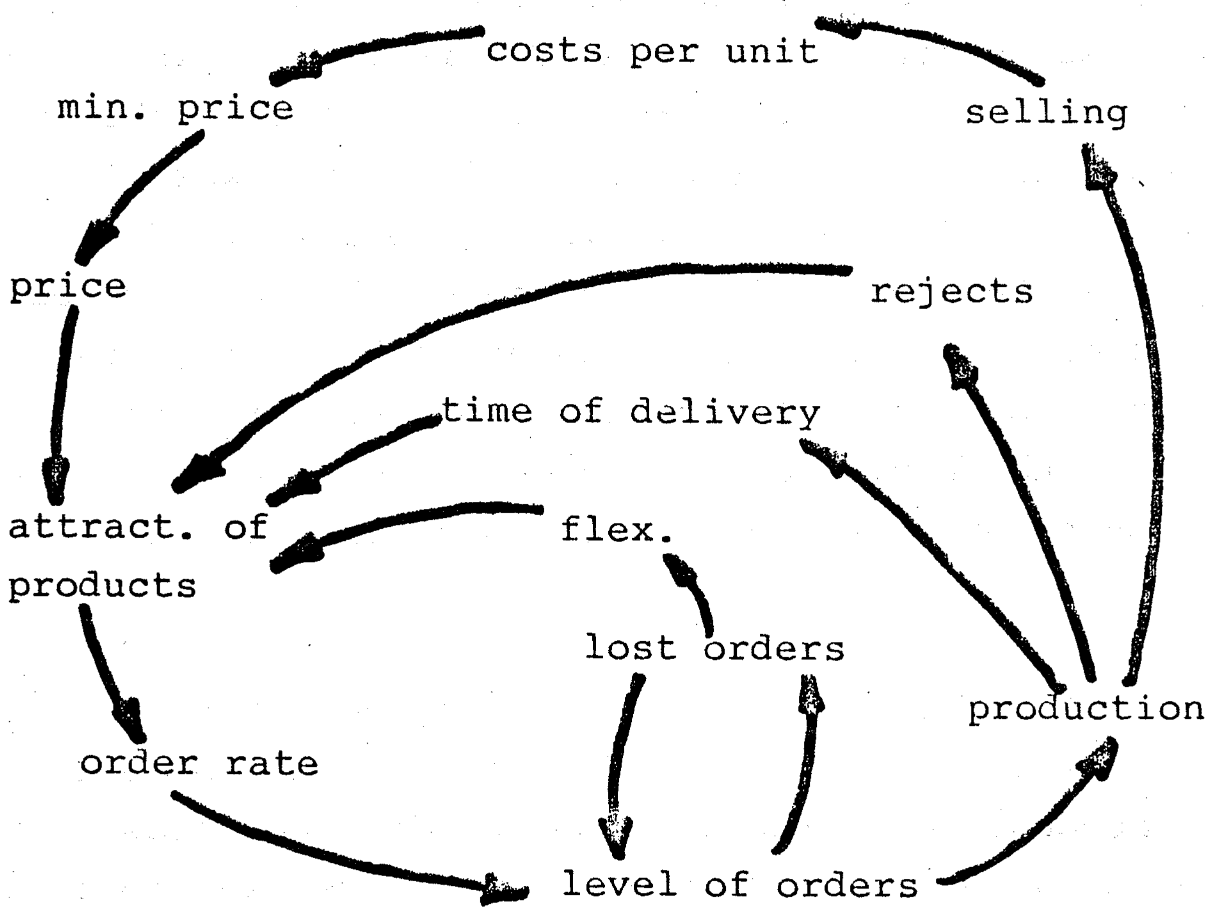

Fig.3: cutout of feed-back loop production, demand and selling

In the section of capacity planning the factory`s most probably required machine capacity for the following month is calculated. Depending on the actual use of capacity the speed of production is determined by the following policy: On condition that the capacity installed is covering the one required according to the order level, the production is done at the optimum speed, which is characterised by lowest defective rejects and a minimum of abrasion. If requested the speed of production can be accelerated to the maximum, leading to higher costs of rejects and abrasion. The information generated here are used in the section of cost accounting to calculate the costs per unit and the corresponding minimum price.

The relation of costs and it`s changing after the introduction of the FMS is displayed in the models cost accounting section. The model distinguishes between "direct costs" and "indirect overhead costs". The decision is depended upon calculations on actual costs. Accounting is founded on full-cost principle, accepting the disadvantages of this method, respecting the models degree of aggregation.

The section of demand for the enterprise`s products is determined by the general situation in the market and the attractivity of the products, compared with the average of the competitors. While the market situation in the SD model is generated by the mathematical overlapping of economic trend, business cycle and law of chance, the attractivity represents the arithmetical result determined by the time of delivery, the price of products and the flexibility in production, compared with the competitors.

Simulation and results of the model`s experiments

For the simulation the period "TIME" was chosen as being one month, corresponding to the usual phase of accounting. The simulation`s "LENGTH" represents ten years, an adequate period for investment planning. The model displays how the crucial changes in the enterprise`s economic formation are enforced in the first two years. During the time of simulation the level of productive labour is reduced from 40 to 15 workers. On the other hand there is a considerable accession of manpower in the operational section, increasing by 50% of the initial level.

According to Fig.4, by introduction of the FMS the productive factor "(manufacturing)labour" is reduced through the productive factor "capital". In the operational section, the company needs more highly-qualified staff, for example in software-engineering and other operational functions. This process of labour transposition requires considerable expenditure for instructive continuation- and training courses.(Fig.5)

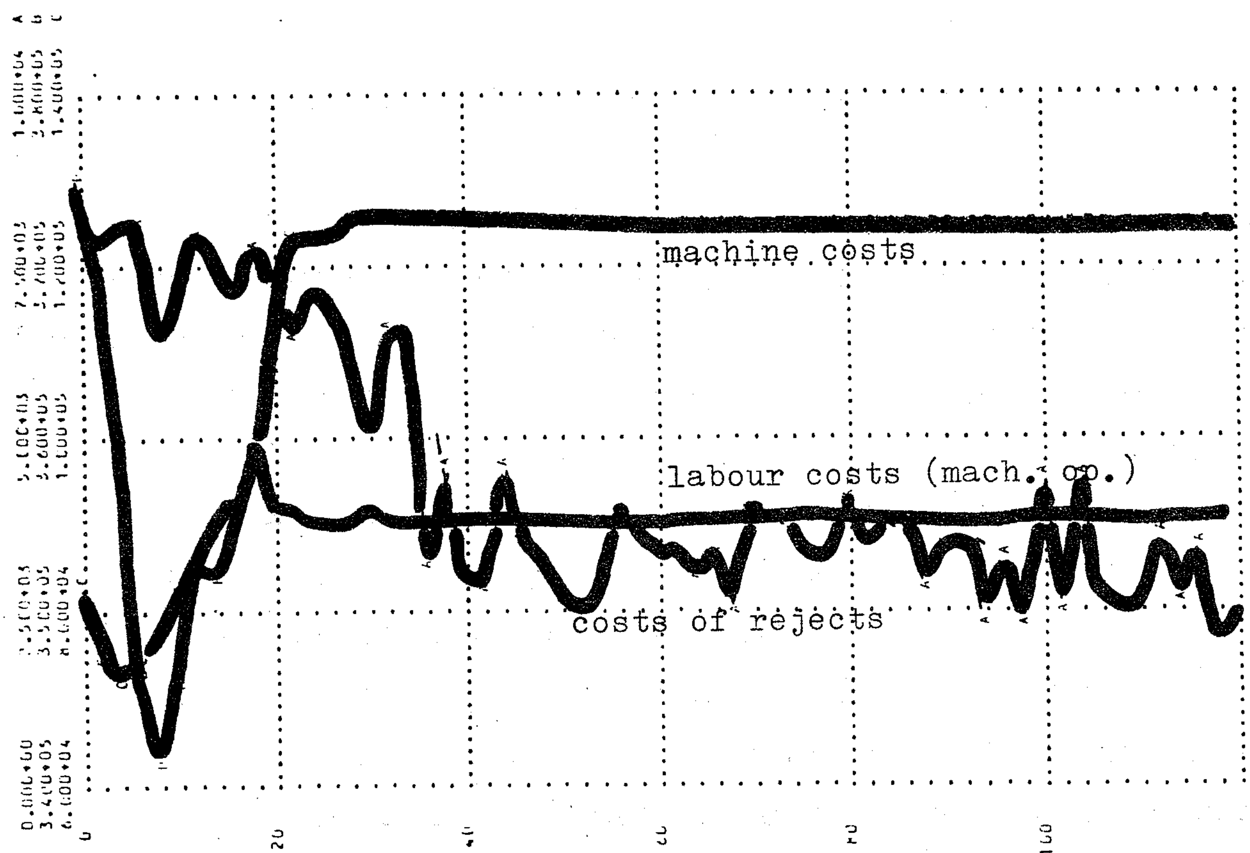

Fig.4

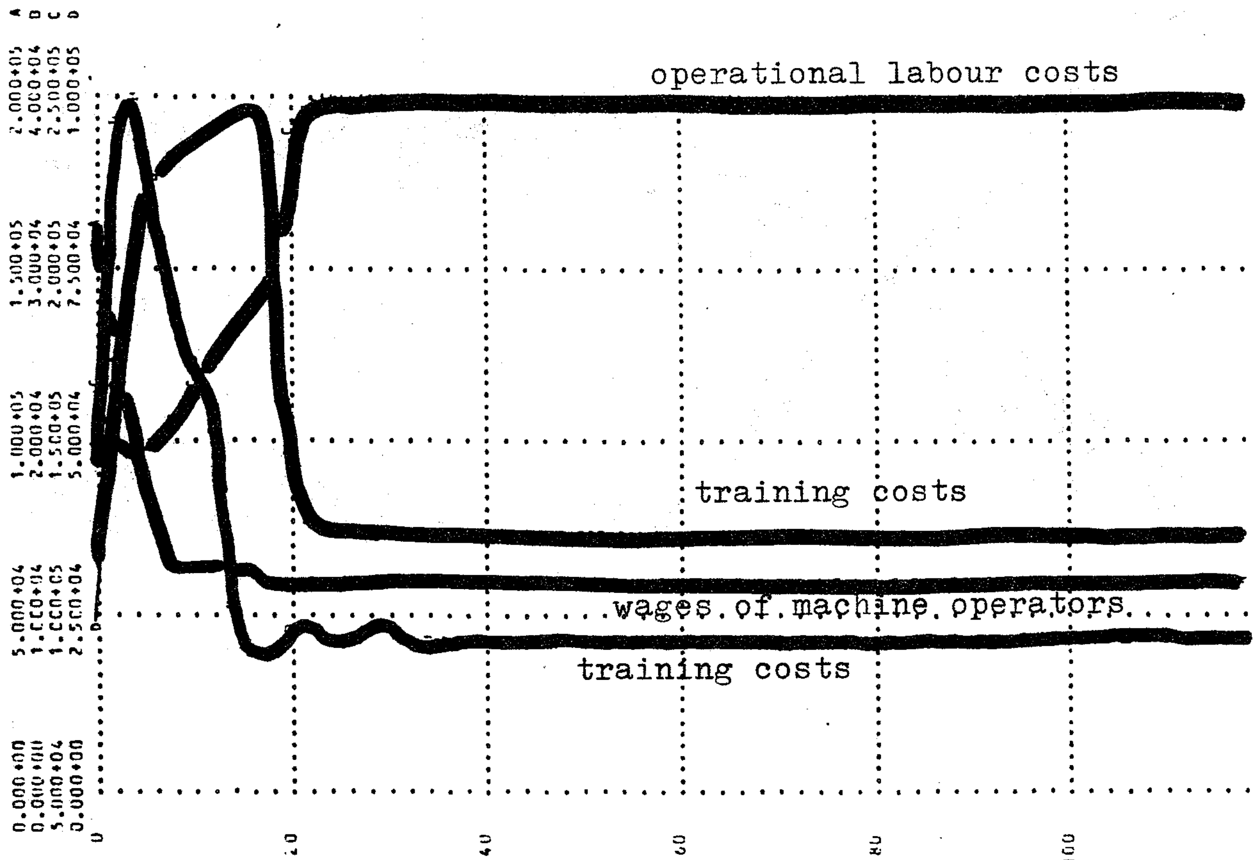

Fig.5

After roughly two years of experiences the initial problems are solved. Fig.6 shows, the manufacturing system`s break-down time is significantly reduced, which increases the systems use of capacity, reducing the overhead costs such as machine hour rates and capital costs per unit. Further the number of defective rejects decreases by 60%, leading to lower costs per unit as well as the higher use of capacity, raising the enterprise`s competitive strength. Due to higher flexibility in production,

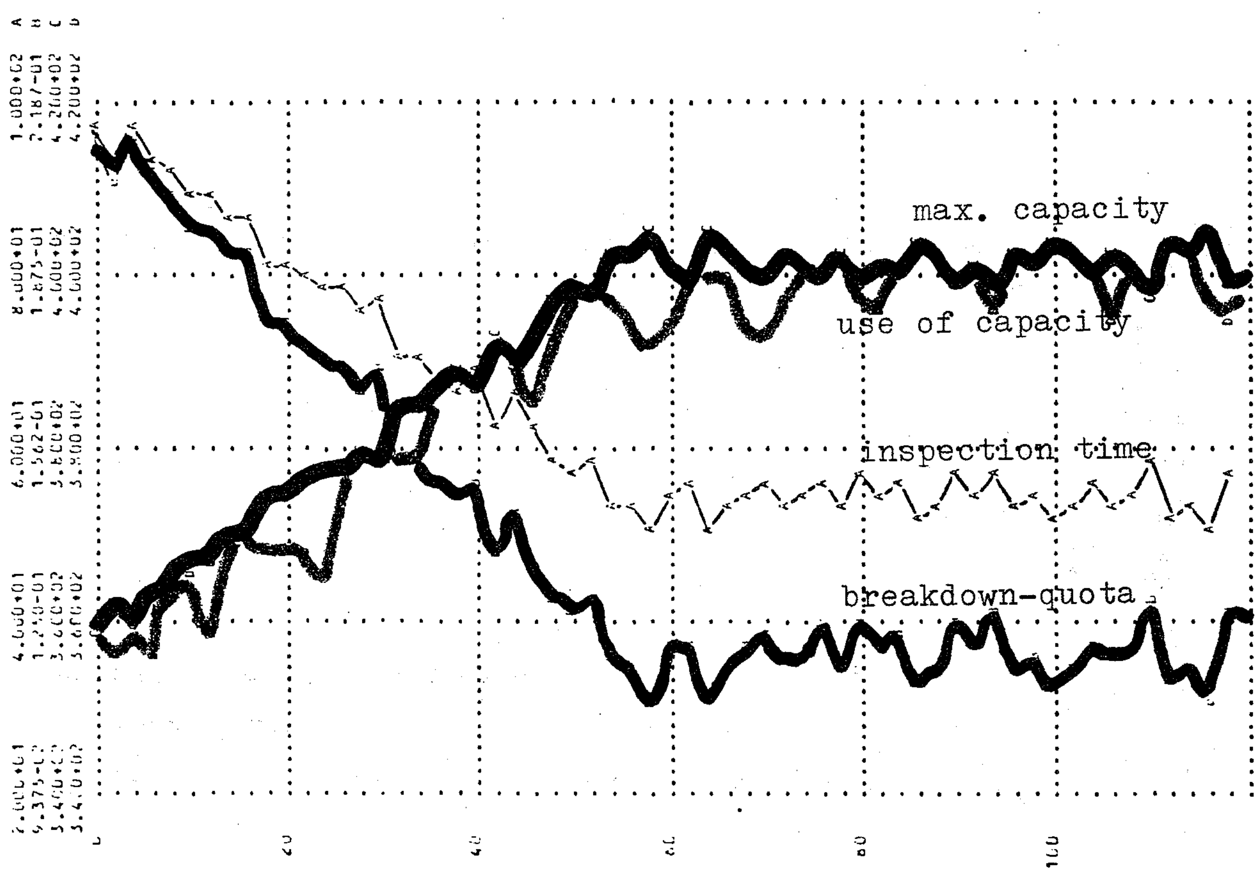

Fig.6

the number of lost orders can be diminished. The result is an increasing attractivity of the enterprises products, responsible for the remarkable rise of orders after the 40th period.(Fig.7) Depending on the high level of orders, the speed up of production becomes necessary, causing a higher quota of rejects after 80 periods of simulation. Fig.8 is finally giving a general view on the proportion of capital costs, compared with labour costs and the ratio direct to indirect overhead costs, is changing during the simulation time of investment planning.

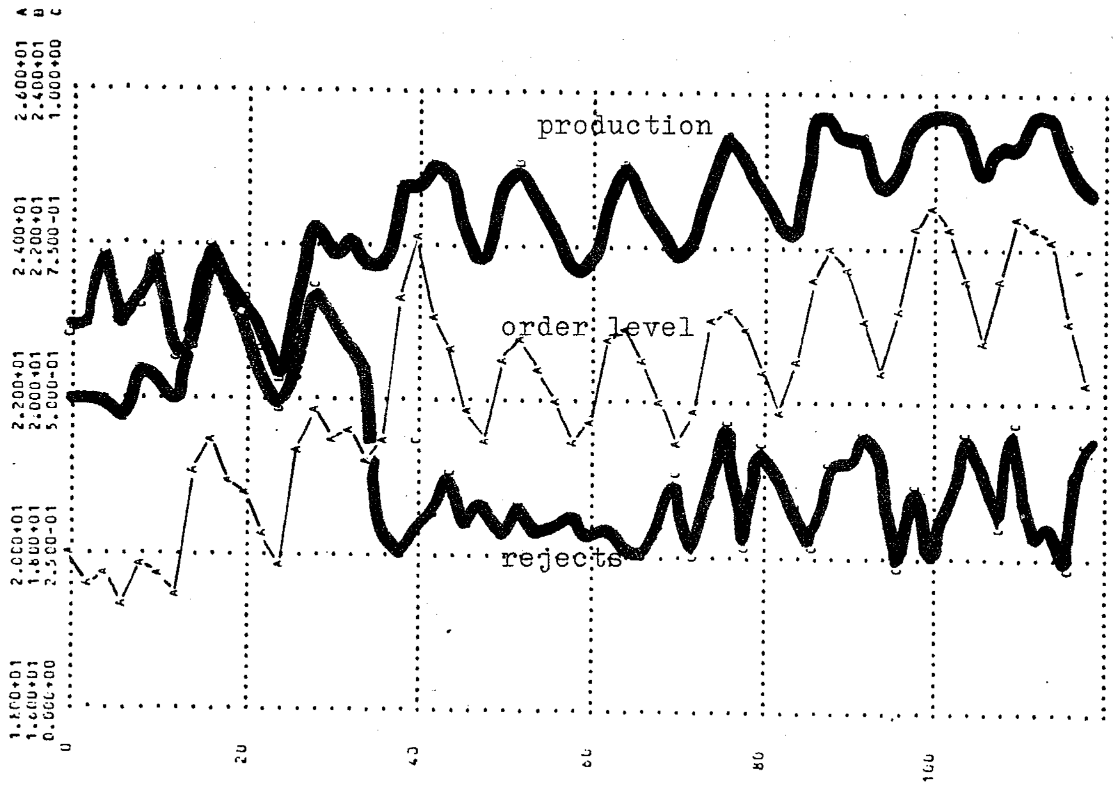
production
order level
rejects

Fig.7

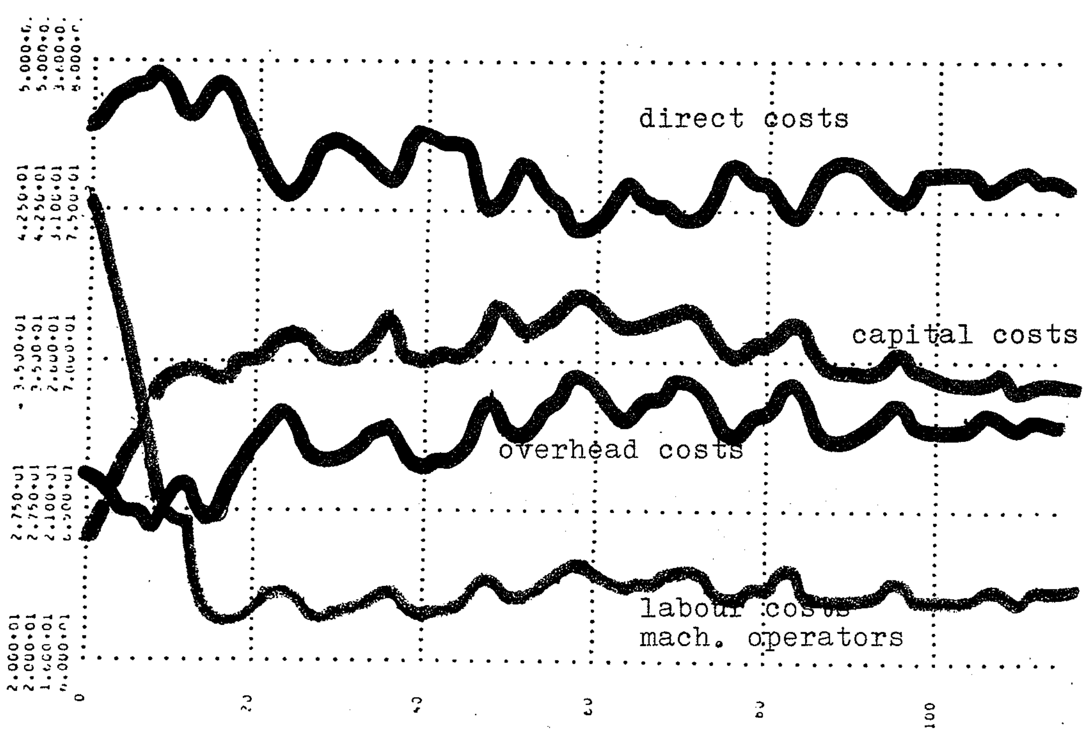
direct costs
capital costs
overhead costs
labour costs
mach. operators

Fig.8