ORGANIZATIONAL MODEL OF NC MACHINE INSTALLATION

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Summary

This article analyses the organizational aspects of NC machine selection. It deals with the conditions of site selection and preparation, installation, maintenance and instrumentation. The tasks of the individual organizational units are listed as well. In the end proposals are made for the organizational promotion of continuous NC operation.

Introduction

One of the main development trends in the machine industry is the increasing use of numerical control techniques. There has always been a general requirement to eliminate the quantity of produced goods, as a limit of automation, and this need called NC machines into life. Additionally, with NC machines operational elements can be concentrated to a very high degree; e.g. components, difficult to fit in may be produced economically. The integration of components is really a functional integration. The more complex is a component, the more functions it can perform, and this has been made possible by sophisticated technical methods—like the NC technique. Numerical control means consequently not only a higher degree of automation, but rather a higher organizational niveau in preparation: in the processes of planning, construction and technology, as well as in creating the technical-organizational conditions of production.

This article adresses first of all those firms, managers and specialists, who want to use NC technique for the first time. They all should know that introducing NC machines requires quite new, non-traditional conditions in technical preparation, as well as in production and control. It is a general experience that management does not take the above mentioned facts into consideration, i.e. the organizational questions are always in the background, or their solution is delayed.

NC machines are installed mainly in a traditional production environment. Through the installation of these machines the original production system changes to a great extent, requiring new kinds of connections to other parts of the system.

To fit NC machines into a given production system is always a difficult task, even if the system has modern machines, sophisticated material handling, management and control. Here it should be emphasized again that only a preparation/organization work of high level can provide for harmonical fitting, which is a precondition of economical operation.

Next we show an organizational model, which promotes all the aspects of NC machine installation, concentrating on technical and operational preparation.

When installing a new machine, the main aim is always to make the most of its benefits. The achievement of this aim depends on two groups of criteria:

1) To what extent the workshop is ready to receive the new machine:
— which aspects were used in machine evaluation and selection,
— which were the methods of installation, how carefully it was done, how the new machine fits into the former system and organization etc.

2) To what extent the maximum utilization of the new machine is possible:
— whether the workshop is well supplied with production tasks,
— whether the management is of a high level,
— whether the workshop has an efficient production control system, etc.

Proper selection, careful installation and unbroken fitting ensure efficient operation. Methodically a manifold approach is needed, including among other the organization of mixed working groups and the application of creative methods to raise their efficiency.

The structure of the model

Aspects of NC machine selection

Classification of components

— aspects of component selection
— classification of components
— definition of technical data (basic data and additional surface elements)

Installation of NC machines

— conditions of installation
— activities of installation
— logical and time sequence of activities (network)

— analysis of sub-processes
— analysis of machine transportation
— analysis of tool supply
— analysis of programming activities
— analysis of maintenance activities
— analysis of warehousing

Adaptation to the present system and organization

— analysis of activity-organization relationships
— analysis of continuous operation

Main organizational aspects of NC machine selection

Two main aspects are to be considered when selecting NC machines:
1) The available working time should be fully utilizable;
2) All the technical features of the machine should be fully utilizable.

Experience shows that installation is easier and more reliable, when NC machines are already in operation in the workshop. In this case, many conditions (technological, programming, etc.) are fulfilled, and the necessary experience is given. Installing an NC machine in an environment of low technical level is quite another case, since experience in receiving and installing the new machine is missing. It is therefore the very first step to take to create the necessary environmental conditions (setting up a programming office, training technical, maintenance and programming staff, etc.).

Component classification system

The acquisition of a NC machine should always be started with the analysis of components to be produced.

There is a *first, rough* classification, when components are classified according to technology and machine size.

The aim is always the maximum utilization of machine size and time.

There is a *second, fine* classification, concentrating more on the necessary harmony of machine characteristics and component requirements.

In the case of lathes for example, the following aspects may come into question:
— l/d ratio,

— external and internal cone different from 45°,
— external and internal cone of 45°,
— threading,
— number of steps (external and internal),
— number of radiuses.

Other, additional aspects should also be taken into consideration, when installing other types of NC machines: for drilling machines the number of holes and plate thickness, for drilling-milling machines the number of surfaces to be processed, the number of holes and hole-groups and the number of turnings are of importance.

Based on the above mentioned characteristics a technical score can be defined, based on which one can deside whether the component is suitable for NC machine processing or not. The respective data are collected on "machine data sheets"—one sheet is used for each component.

This sheet has a number:
1 for drilling
2 for axle-lathe
3 for disk-lathe
4 for drilling-milling

The NC technological office defines the proposed machine, or it refuses NC processing at all. In the "Proposed machine" field the following code is used:
∅ — rejected
1 — accepted for drilling
2 — accepted for axle-lathe
3 — accepted for disk-lathe
4 — accepted for drilling-milling

The NC office processes machine data sheets in four copies. It agrees with the NC programming on the production starting point, and defines accordingly a suitable programming period.

The *first copy* is for the Programming Office, the *second* for NC production programming, the *third* for the ordering workshop, and the *last* copy serves as documentation.

The technical score of drilling, milling-drilling machines and lathes is the sum of all the technical scores of the "NC order-forms". In order to raise the efficiency of NC processing, one has to deal will components of high technical score.

Taking the capacities and demands also into consideration, a minimum score is to be defined. It is not a static value; it depends on the workload. Components of simple shape, i.e. of low score must not be processed by NC machines.

The standard hours on the sheet are those of NC machines (previously calculated, or precise values).

The data sheets are suitable for analyzing capacities, machine-utilization, based on standard values. The results of these analyses show over- or under-utilization, the demands of other workshops, and call attention to the measures to be taken.

Locating NC machines

Installation conditions

The conditions to be fulfilled when receiving NC machines may be divided into two parts:
1) technical conditions,
2) organizational conditions.

Technical conditions include all the activities needed before installation:
— site preparation, foundation,
— ensuring energy supply,
— machine transportation, assembly, installation,
— producing accessories,
— providing for tool supply,
— providing for preproducts,
— fulfilment of programming conditions,
— programming documentation,
— education, internal programming course,
— warehousing problems,
— tests, etc.

Organizational conditions include personnel questions, organizational structure, working order, operational processes.

Grouping and logical ordering of installation activities

The first logical order of the activities mentioned in the previous point are shown on the figure. Those main activity groups are shown, which provide for a continuous process—from contracting until installation, through their logical interdependence.

These conditions may be divided into three groups, according to the diagrams:
a) conditions of installation (Fig. 1)
b) conditions of transportation (Fig. 2)
c) conditions of operation (Fig. 3)

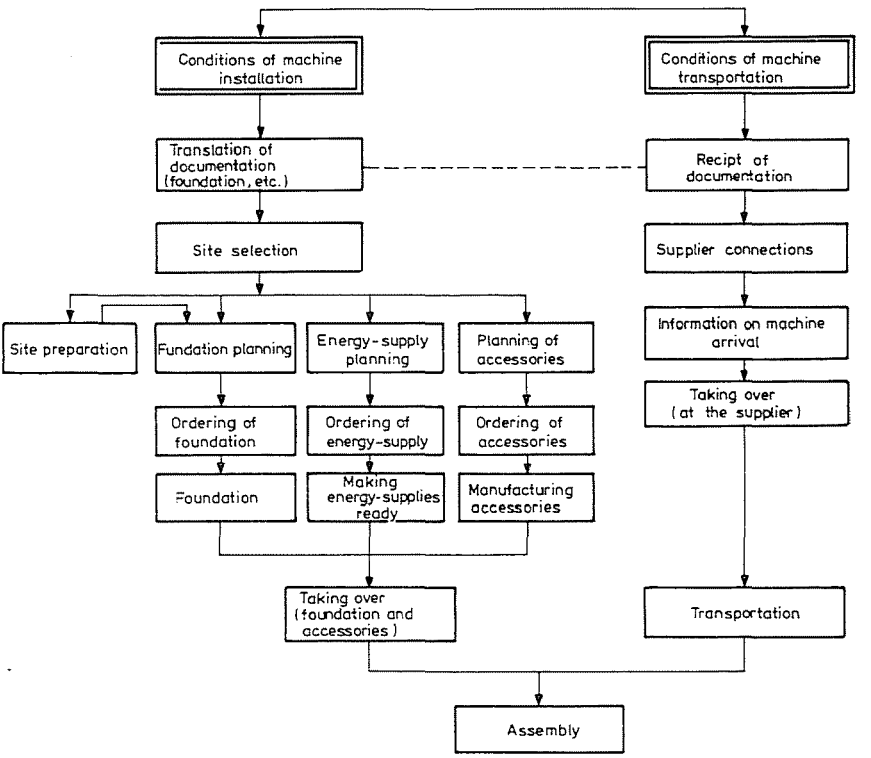

Fig. 1. Conditions of machine installation

The latter has further subconditions:
— personal,
— programming,
— technology,
— instrument-supply,
— maintenance.

Conditions of machine transport and installation

There are no special activities needed to support the machine's production and transport. To have a good connection to the manufacturer is important: one should always have information on the progress, and on the estimated term of delivery. The latter is an important point of the process. Before delivery there is an on-site inspection. The deadlines of all th(e preparatory activities (founding, operational preconditions etc.) should be kept.

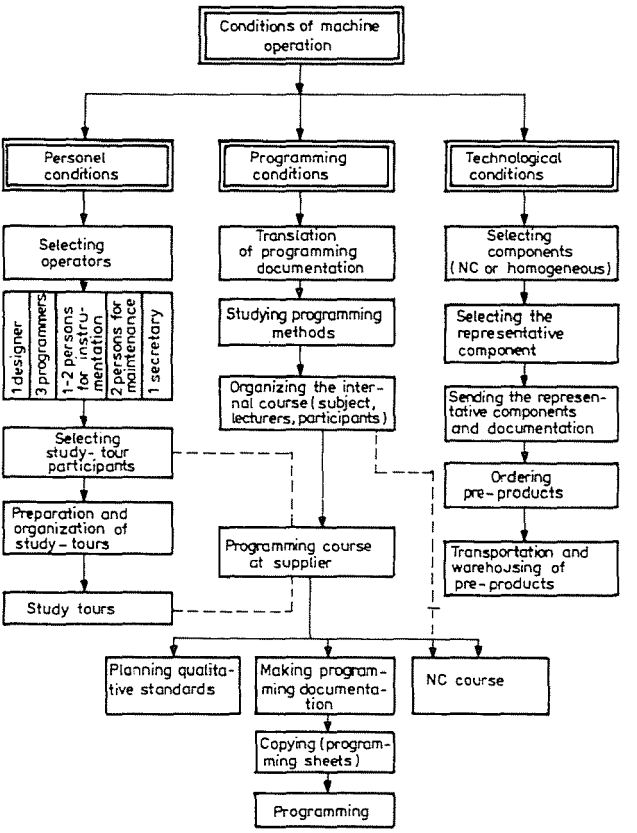

Fig. 2. Conditions of machine operation

Note, that most of the belongings are castings, and their manufacturing (making wooden casts, casting, processing) takes a long time (1.5 years). In the case of an incidental faulty casting, there will be no time to produce a new one; consequently the final deadline is in danger. This comment concerns first of all the foundation, energy supply facilities and belongings, because these are on the critical path of the net diagram. The activity, which is to begin as soon as possible, is the translation of documentation, contracting with subcontractors, and ordering. The cooperation partners are very important, since due to their eventual delay the starting and final deadlines of founding and assembly cannot be kept. The manufacturer generally gives a deadline for the inspection of the belongings, foundation etc. Obviously there should be a time span between this deadline and the deadline of the production. This time span is ordinarily 2 weeks, which is long enough for occasional corrections.

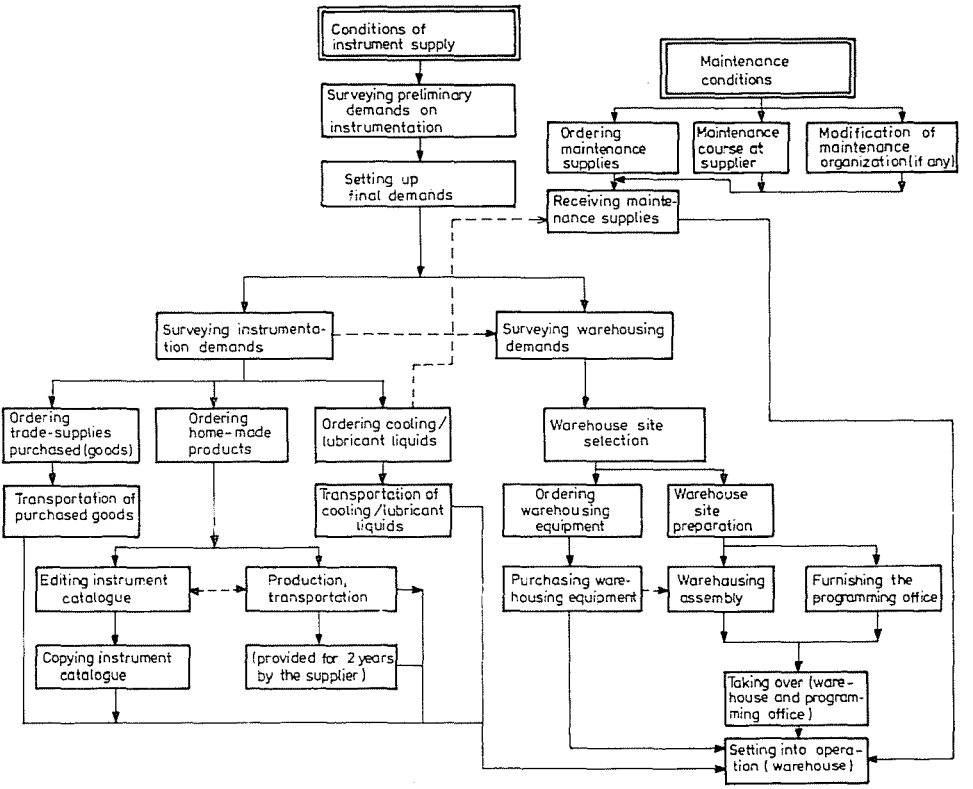

Fig. 3. Conditions of instrument supply and maintenance

Instrumentation, instrument supply

Under usual contract with the manufacturer, instruments needed to normal operation are delivered in 2 years. Thus there is no problem with instruments at first. Later it is very important, however, to set up an appropriate instrument catalogue for instruments and technologies, with exact data and material qualities. The proposed deadline of this activity comes from the net diagram. A delay of 30 days is allowed. (Warehousing activities are discussed later.)

Starting *programming work* is of high priority.

The first step here is to translate and learn the programming documentation. The suitable composition of the programming office (for the first period, for 3–4 machines):

1 person: office manager
3 persons: programmers
1 person: secretary

Their tasks before installation are: writing and copying the programming documentation, setting up instrumentation and impacting plans and providing for all the preconditions related to technology, pre-products, and pieces of work. Additionally, they take part in the course of the manufacturer (2 persons), based on which programs are to be written until installation.

The process of maintenance

NC technology means new knowledge and new tasks for maintenance organization and maintenance people. The maintenance problems of numerical control are quite different from those of traditional machines, especially from the electrical maintenance's point of view. There are also new electrical parts of these machines (step motors, electromagnetic clutch) and their fixing should also be learned.

The maintenance people should take part in an intensive course of the manufacturer, in order to acquire the necessary knowledge. Additionally, exact statistics are to be given by the manufacturer on the frequency and characteristics of electrical failures. The needed amount of spare-parts are to be provided for. Mechanical maintenance people get on-the-job training. Consequently, they should play an active role in machine assembling. They also have to get acquinted with new structural elements and their assembly. Failure statistics are also to be asked from the manufacturer, and spare-parts have to be purchased. In the inventory of spare-parts different amounts are needed of parts of long durability and those of rapid wear.

The process of warehousing/storing

The tasks here are twofold: processing instruments (regular inventory and circulating items), and the edging of instruments. Edged instruments should be transported to machines, according to the instrumentation plan. Unnecessary instruments should be brought back, received and occasionally sorted out. For transportation home-made rolling cars are to be used; with prismatic trays for drills and boring bars.

Manufacturers generally provide for a stock of two years. During this time exact inventory statistics should be made. At the same time the purchasing-manufacturing possibilities are to be estimated, and the stock should be replenished according to shrinking. Precise edging is of utmost importance: inaccurately edged instruments cause inaccuracy of the final product. All types of clamping apparatus should be suitable for various working tasks, to make use of the flexibility provided by NC machines. It is

great advantage of NC technique, that belongings and equipment are mostly simple, can be home made.

Since the NC system is not closely connected to equipment-manufacturing, the time of production may be reduced. This statement is related first of all to drilling and drilling-milling machines. Appliances could be produced within appr. 3/4 years by the appropriate workshop, but in our case this time falls out, and even the costs are positively influenced. That is why an exact catalogue is to be made on working piece holders (after analysis) and the problems of their storage should be solved. The case of instrument holders is simpler. Since these holders are of the same type, one should only concentrate on their replacement and efficient use.

Summing up, the tasks of this activity group are the following: allocating free storage-area, establishing warehouses, storing incoming instruments and preparating the form use according to plans and programs. Additionally, one should start with the instrument catalogue as well. This catalogue should continuously be updated according to instruments used up.

Problematic work-phases

Those activities and processes have to be mentioned here which are carried out neither by the manufacturer, nor by the receiving firm, but by inland cooperation partners. For example:

— foundation
— energy supply
— belongings.

(The situation may be more complex, if belongings are not only moulded, but even processed afterwards.) From the deadlines' point of view outside building firms are rather unreliable.

In the production of belongings, the following problems/tasks should be solved:

— looking for production capacity
— ordering
— production of belongings:
  — cast-making
  — moulding
  — processing
— receiving of belongings.

This sequence of activities is critical from many aspects:

— the delay in this process directly causes a delay in the assembly and installation;

— moulding takes a long time (appr. 1.5 years) and there is always a danger of making mistakes which may result in delay and extra costs.

The available time is generally 6 months. Within this period should all these cooperative items be made without mistakes and they should be processed with the required accuracy. It is advisable to shorten the preparatory phases, in order to have enough time for moulding and eventual error-correction.

Setting up activity-organization relationships

The NC *technical manager* is the main promoter and coordinator of the NC installation. He is at the same time responsible for the whole process. The main process of installation (thick arrow on the figure) and the utilities supporting it, should all be carried out within his sphere of activity and should be his sole responsibility.

The tasks of the NC technical manager are:

— co-ordination of all the installation conditions, including-underline—the technological conditions;
— providing for instrument supply and related co-ordination;
— working out and providing for maintenance conditions;
— receiving the machine, supervising the installation and assembly;
— supervising tests, measurements and putting into operation.

The NC technical manager receives assistance first of all from the department of operation (building, production), and from units, listed under "other departments" (services, technical support).

The *investment department* is responsible for the tasks connected to machine-transport, translation of documents, outside relations, travelling etc. These are all supporting the technical manager's task.

The NC workshop appears in the focus of all the tasks and conditions. It is the place, where the taking over of foundation, belongings, instruments and of the machine itself takes place and where assembly, testing and installation run.

The continuous operation of NC machines

In the above points we examined the installation conditions of the NC machine. Having installed and taken over the machine, the NC technical manager has no more tasks and the machine becomes an organic part of the workshop's everyday life. From this point on all the working pieces, which can be efficiently processed on NC machines, should reach the NC workshop (within the normal technological process), and after processing they should get

back to the original point. All the activities of NC processing between these two poles are shown on the next figure.

The activity chain shown starts with *technological processing*, on *workshop* level. If there—on this level—arises a demand for NC processing, then it should be sent (with appropriate documentation) to the NC *technological group*, operating the NC machine.

The above mentioned group accepts the task (or refuses it; in that case the working piece and documentation is sent back) and elaborates the NC technological program (responsible: NC machine operator + NC workshop manager). Further preparatory tasks—impaction plans, instrumentation plans, program sheets, punched card, standards etc.—are carried out by the *NC production control group*, based on instrument- and equipment-ordering.

The basic calculations and documentation having been done by the production control group, the task is sent to the fine programming section—if loads and capacities are balanced. (When there is a lack of capacity, program modification—assigning another machine—is needed. In the case of underload, additional tasks can be accepted from outside, as job work.)

If all the conditions of the technological program are fulfilled, according to the fine schedule, the program should be tested (and modified, if necessary), and executed (under the control of NC group manager).

Ready-made working pieces and documentation should be sent back (to the ordering department and to the NC technological or production control group, respectively.

The activities described above bear consequences on the organization to be set up, and/or on the necessary analyses and organizational modifications to be made.

Proposals for NC organization

a) It is proposed to appoint responsible persons within the technological department(s),* who are in charge of selecting and transmitting working pieces intended for NC processing and of communication with NC people. These persons should attend NC courses before being appointed.

b) It is advisable to set up an *NC technological group* somewhere within the present organizational structure (e.g. within department/major department of technical development). This group is working under hierarchical control, and has the following tasks: working out and providing for technological conditions of NC processing; working out storing and transmitting impaction and instrumentation plans, program-sheets, punched card, standards.

* In the case of more plants than one

c) It is advisible to set up an *NC production control group*, somewhere within the present organizational structure (e.g. within department) major department of production control). This group is also working under the appropriate hierarchical control and has the following tasks: working out and providing for conditions of production control in NC processing; working out and transmitting schedules, net diagrams and loads/capacities for fine programming.

d) It is advisable to appoint one person NC programmer, and one NC workshop dispatcher.

e) It is advisable to appoint an NC workshop manager as well. He is to control the NC group and is to be responsible for the NC stock, i.e. for instrument supply, for communication and co-operation with support of fine programming.

f) The NC workshop manager is proposed to be under the hierarchical control of the cutting manager.

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