6
DECEMBER '71

metaalinstituut communications TNO

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Introduction

Communications, all over the world, are gaining in coverage and speed. It is but a few years ago that a satellite, 'Telstar' first ever enabled us to look 'live' at other continents. Today we are no longer surprised that, via a permanent system of satellites, we can watch astronauts working on the moon.
By comparison it may seem a minor achievement that in Chicago a computer is fed with a programme for N.C. metalworking machines developed by the 'Metaalinstituut TNO', and similarly, that staff of this Metaalinstituut TNO in Delft, Holland within seconds receive the data need straight at a computer terminal.
A minor achievement, comparativily, though an indication that even for 'everyday' technology boundaries and distances no longer exist.

Metal Research Institute TNO

Institut TNO pour la Recherche des Métaux

Institut für Metallforschung TNO

Director:

Prof. Dr. Ir. C. A. Verbraak

Departments:

Applied Basic Research
Physics
Testing and Heat Treatment
Friction and Wear
Surface treatment and corrosion
Welding, soldering and brazing
Technical Foundry Centre
Technical Centre for Metalworking
Special subjects

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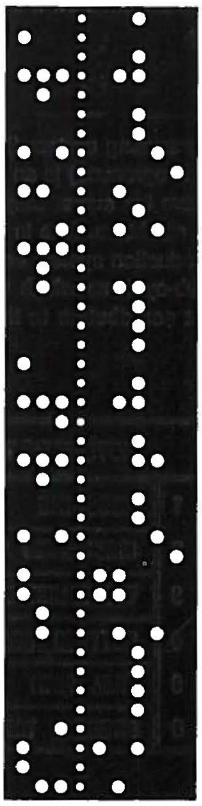


TNO miturn

from tape to product

Centre for Metalworking
Group Production Automation

The MITURN programming system for lathes

621.941.234-503.55

Summary

In the Netherlands, too, metalworking industries start using numerical control for automated information processing, and thus promote further mechanized production cycles.
Accordingly, the entrepreneurs and their specialists are enabled to focus on management proper; computer facilities ensure improved processing of appropriate geometric and technological information.
'Miturn' stands for: the Metal Research Institute TNO-s Turning Programme; it is a programming system developed by the Institute's Technical Centre for Metalworking. The system facilitates a reliable, fast and relatively inexpensive preparation of tapes feeding numerically controlled metalworking machinery with precise information supplied on a certain time-sharing basis.

Introduction

The MITURN programming system (Metal Institute TURNing Programme) is an efficient programming system for numerically controlled turning machines. It is in fact a comprehensive production system composed of a number of sub-systems which together make an important contribution to the optimum utilization of numerically controlled lathes (NC lathes).
In MITURN, the achieving of maximum lathe capacity is coupled with simple programming and a high degree of automation of the punching of the control tape: this is because MITURN is designed so that, after programming of the geometry of the starting material and the workpiece, the following operations are carried out automatically:
— the optimum sequence of operations is determined,
— the optimum depth of cut, feed and cutting speed are determined per cut or per part of a cut,
— the programmed surface quality is reached,
— the best tool for each operation is selected from the stock of tools,
— the operating instructions for the machine are formulated,
— the expected machine time for the programmed workpiece is specified,
— the tape is punched for the machine.

Processing of geometrical and technological information

In contrast to a general programming system, which can be used to control operations of various types, MITURN is

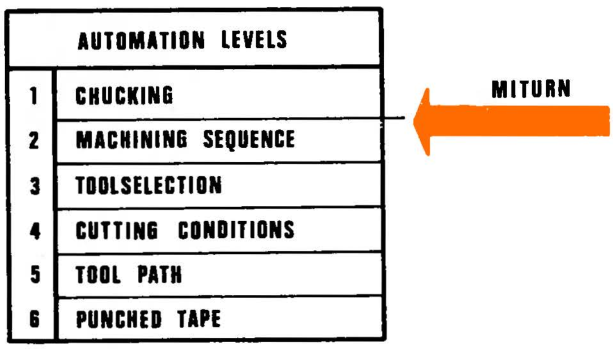
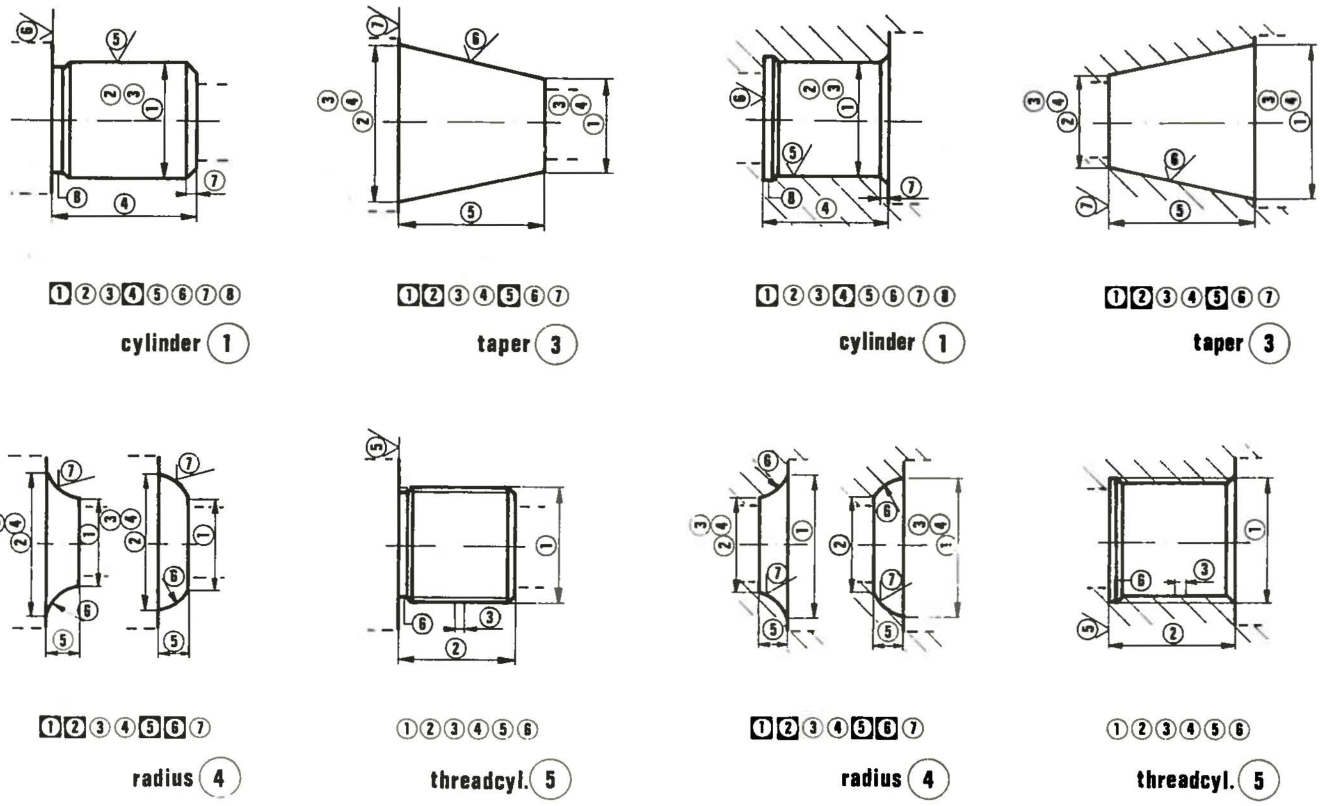


Fig. 1 The high automation level of MITURN reduces partprogrammer's efforts substantially

TNO miturn

basic elements



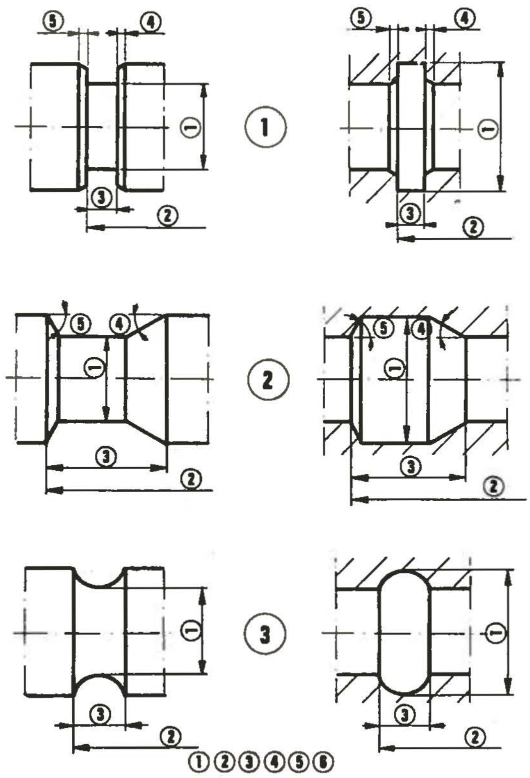
□ parameters for rough elements
○ parameters for machined elements

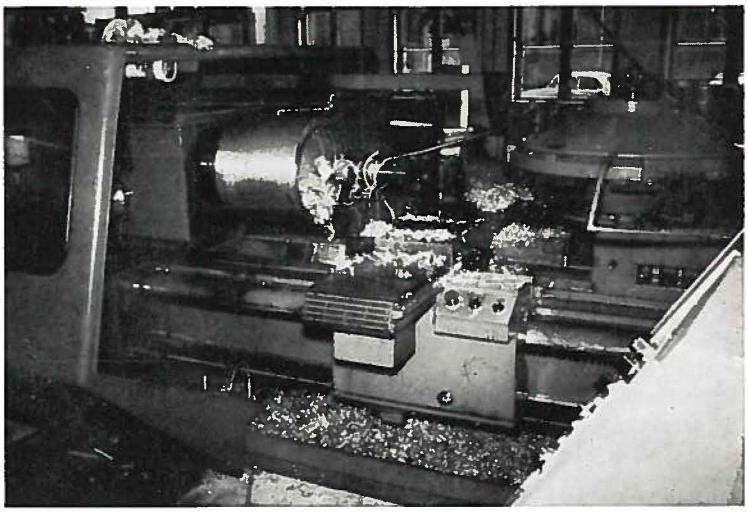
□ parameters for rough elements
○ parameters for machined elements

Fig. 2 Definitions of the standard elements for discription of the rough and machined (final) workpiece. As one can see, the definitions for the internal and external elements are the same

TNO miturn

superimposed elements





example part

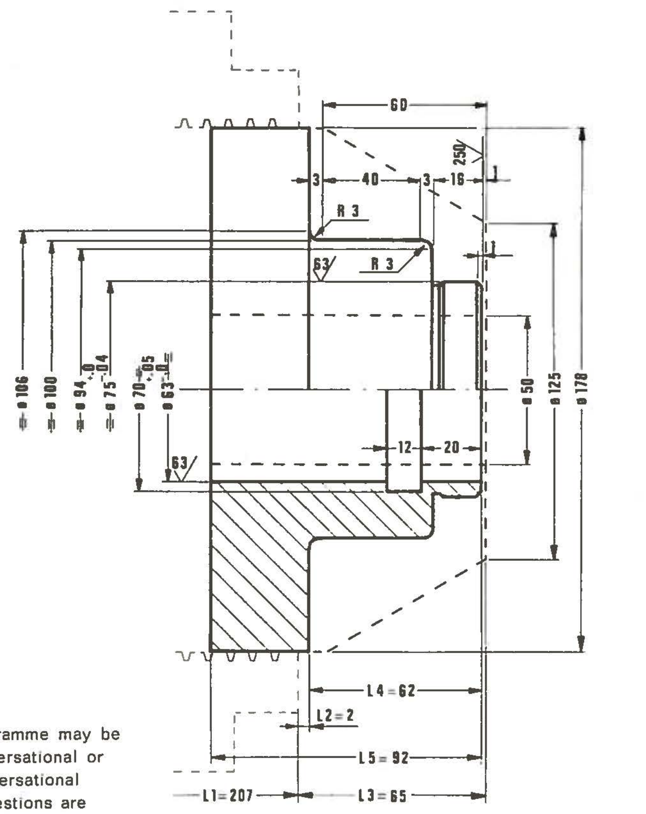


Fig. 3 The part programme may be optionally either conversational or direct file input. Conversational means that all the questions are typed out by the computer and the programmer answers these questions. The programme input is underlined in the example part programme

part programme

MITURN PROGRAMMING SHEET

```
* * * * * * * * * * INDENTIFICATION * * * * * * * * *
PROGRAMMER AND DATE?  MI TNO
DRAWINGNUMBER?        EXAMPLE
DRAWINGSTANDARD?      MM
WORKPIECEMATERIAL     MEEHANITE G
MACHCAT, CATNO?       CAT111   4
* * * * * * * * * * SET-UP SPECIFICATIONS * * * * *
MACH, CYCLE, MAT, MAC, MAS, RIC
  4     10     2    1    10    1
L1, L2, L3, L4, L5, L6
207  2  65  62  92  3
* * * * * * * * * * BLANK * * * * * * * * * * * * * * *
NUMBER OF EXTERNAL ELEMENTS?  2
EL. CODES?  3  1
EL1?  TPR  125  178  60
EL2?  CYL  178   3
NUMBER OF INTERNAL ELEMENTS?  1
EL. CODES?  1
EL1?  CYL  50  93
* * * * * * * * * * MACHINED PART * * * * * * * * * *
NUMBER OF EXTERNAL ELEMENTS?  4
EL. CODES?  1  4  1  4
EL1?  CYL  75  .0  -.04  16  63  125  1  1
EL2?  RAD  94  100   0   0   3   -3   125
EL3?  CYL  100  0    0  40  125   0   0  0
EL4?  RAD  100 106   0   0   3    3   125
NUMBER OF EXTERNAL GROOVES?  0
NUMBER OF INTERNAL ELEMENTS? 1
EL. CODES?  1
EL1?  CYL  63   05  0  92  63  0  0  0
NUMBER OF INTERNAL GROOVES?   1
GR1?  GR   70   32  12  0   0  1
FACE ROUGHNESS?  250
* * * * * * * * * * COMMENTS * * * * * * * * * * * * *
EXAMPLE PART PROGRAMME
FIRST SET-UP
```

(so far) restricted to turning operations. Thanks to this ,,specialization", the MITURN programming system actually allows very comprehensive control of the turning process, and can handle technological as well as geometrical information (Fig. 1). The imput is short and simple: the programmer merely has to specify the initial and final forms of the workpiece, and give some details concerning clamping up and the material used. These data are passed to the computer. MITURN now determines from these data which operations must be carried out, and what tools should be selected for this purpose.

High degree of automation

The operations which at present can be carried out with MITURN are facing, drilling, centre drilling, internal and external roughing and finishing, plunge cutting and thread cutting.
The path of the tool is kept as short as possible for each of the operations, and the cutting conditions are calculated a new for each cut or part of a cut. For this purpose, an operational model is set up for each operation; standardization of these models allows a high degree of automation to be achieved during programming. The programmer specifies the initial and final forms, and all the intermediate steps are determined by the operational model. This reduces the programming time to a minimum, while ensuring that cutting conditions are optimum. Moreover, the operational model ensures that the tool can never collide with the workpiece or the machine. The high degree of automation has led to very short machining times per workpiece.

Programming based on group technology

The input for the programming in MITURN is very simple. It is designed so that the data occuring in a normal working drawing as regards form, dimensions, tolerances and roughnesses do not need to be translated into a machine language. All that is needed is a few simple rules for determining the sequence of the numbers occurring in the drawing. This is possible because MITURN is based on a grouptechnological approach to manufacturing processes.
Group-technological investigations showed that about 80 % of lathe workpieces were of such a simple form that in principle these workpieces can be described quite simply by imagining them to be built up of a combination of a few standard elements, viz: cylinders, cones, radii, threaded cylinders and grooves. Grooves can in their turn be subdivided into three types: straight grooves, reliefs and profiled grooves. The programmer now describes the initial and final form of the workpiece in terms of these standard elements (Fig. 2), and adds some further information about clamping up and the material (Fig. 3). From these specifications, MITURN determines what operations must be carried out, and what tools are required for this purpose. In this way, the input of informations is reduced to a minimum.

Quick, cheep and reliable programming system

When the programmer has finished the workpiece specifications, these are passed to the input of the computer. On the basis of this input information, MITURN now determines all the steps required between the initial and final forms. For this purpose, MITURN makes use of information stored in the computer in the form of files (Fig 4). With the aid of these data and the input information, an instruction sheet and a punched tape for the NC lathe are prepared. In principle, we thus have two different kinds of information: that used for the workpiece description, and that in the files. The data in the files can be adapted to meet the needs of the individual MITURN user, so that special operating conditions can be taken into account. Since MITURN is available via a time-sharing computer, all that the MITURN user needs to have is a telephone and a terminal; no individual computer is required. Waiting times are practically eliminated. All this means that the possibilities of the computer can be made use of without having a computer of one's own; and the user needs to know very little about a computer, and about programming lanquages. In this way, punched tapes for NC lathes can be made quickly, cheaply and very reliable.

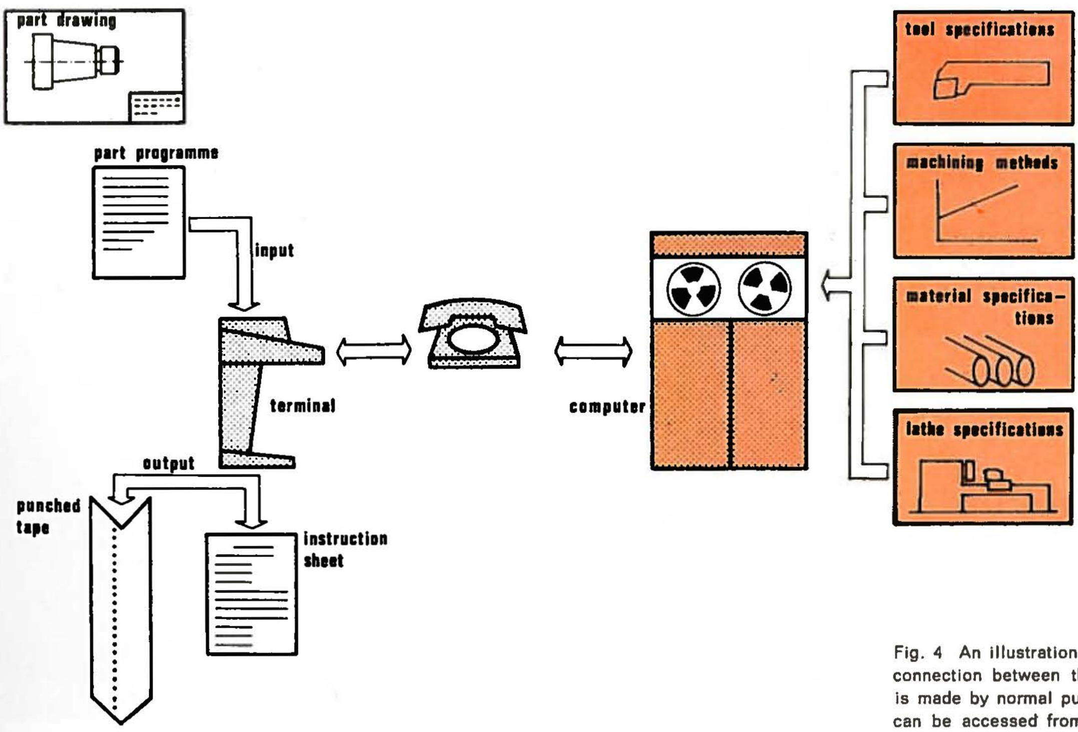


Fig. 4 An illustration how MITURN operates. The connection between the terminal and the computer is made by normal public telephon so that MITURN can be accessed from everywhere

H. BOSWINKEL

Shrinkage and hot-tearing of diecast brass

621.746.019; 669.35'5-143

In the manufacture of brass castings by gravity diecasting, inconvenient difficulties are sometimes encountered with unaccountable shrinkage effects and/or with hot tearing, often occurring suddenly. In consultation with a group of Dutch gravity diecasting and some ingotmelting firms a study has been made to determine the influence of the alloy composition on the above-mentioned effects. To study the relationships between the composition and the shrinkage tendency and the susceptibility to hot tearing respectively, a conical test piece (Tatur cone) and a ringshaped test piece were used.
It was stated that brass cast in chill moulds shows spongy-dendritic solidification if the copper content is relatively high (fig. 1). Alloys which solidify in this manner are difficult to feed, and the chance of non-tight castings due to interdendritic microporosity is great, specially after machining when the tight surface skin is removed. Brass cast in chill moulds which has a relatively low copper content shows an endogeneous and shell-forming compact solidification (fig. 2). Such alloys are relatively easy to feed; there will be hardly any microporosity, if at all.
The copper content critical for the type of solidification lies, depending on the aluminium, tin and lead content at about 63 %. An increasing content of aluminium and/or tin shifts these critical levels to a higher copper content; however, an increasing lead content moves them to a lower copper content.
The shrinkage cavity of a Tatur cone shows clearly whether the copper content of the alloy is too high as regards the type of solidification (fig. 3 and 4). Trials conducted in various foundries have demonstrated the usefullness of the Tatur cone as a melt quality control test (fig. 5, 6).
The susceptibility to hot tearing of brass cast in chill moulds is lower the smaller the amount of copper contained in the alloy. In low-tin and low-lead alloys the material is not susceptible if the copper content does not exceed about 65 %. Lead (up to 2 %)

Fig. 1 Spongy-dendritic solidified brass, with 65,7 % Cu and 0,26 % Al. 12x

Official Netherlands exchange paper, 37th Intern. Foundry Congress 1970, Brighton, Great-Britain. Also published in the 'Giessereiforschung' No 2, 1971 and in the 'British Foundryman' No 5, 1971.

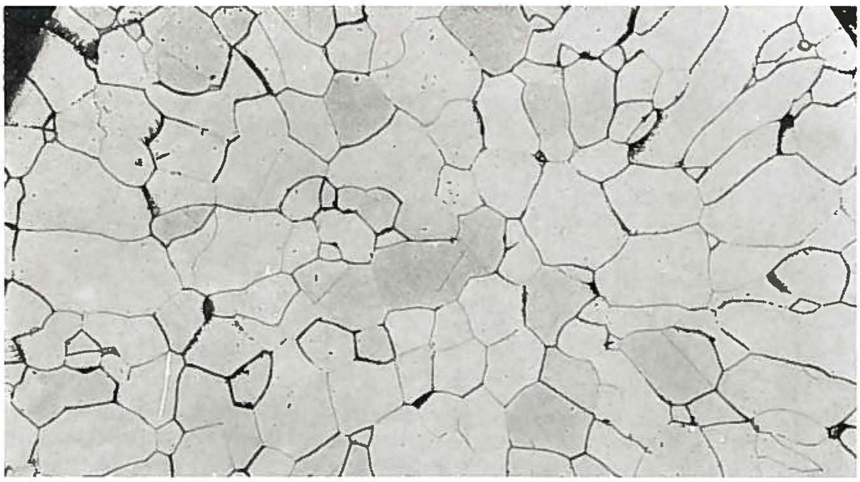


Fig. 2 Endogeneous compact solidified brass, with 56,1 % Cu and 0,27 % Al. 12x

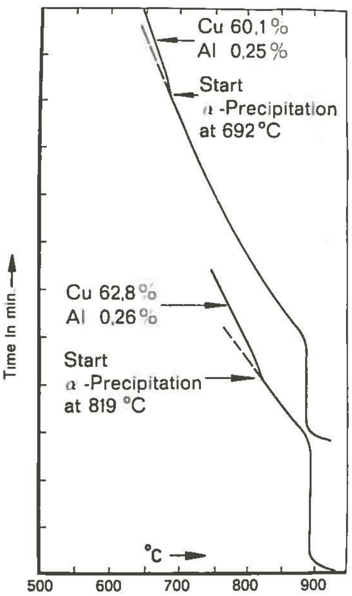


Fig. 7 Two cooling curves from brass with different copper-content.

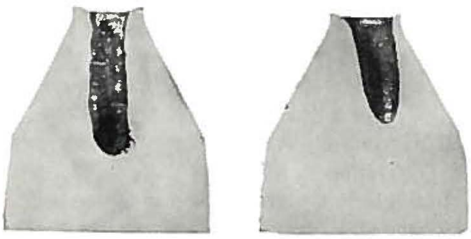


Fig. 3 Shrinkage cavity of a Tatur-cone with 68,0 % Cu and 0,33 % Al.

Fig. 4 Shrinkage cavity of a Tatur-cone with 63,0 % Cu and 0,33 % Al.

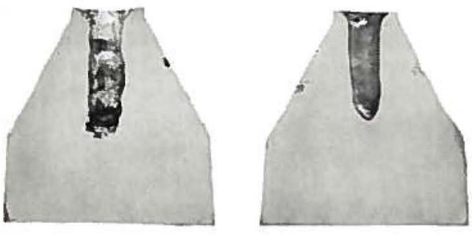


Fig. 5 Shrinkage cavity of a Tatur-cone with 64,3 % Cu, 0,58 % Al, 0,49 % Sn and 1.61 % Pb. Castings made from the same melt were unsound.

Fig. 6 Shrinkage cavity of a Tatur-cone with 63,3 % Cu. The cone was cast from the same melt as the test piece in figure 5, but after zinc-addition.
Castings made from this melt were sound.

has no detrimental effect on this. Tin, however, increases the susceptibility, and considerably more so as the copper content increases. In tin and lead containing alloys (about 0,75 % and 1,65 % resp) the susceptibility to hot tearing is negligible if the copper content does not exceed about 60 %.
If the copper content is too low stress cracking may occur at 450 ° C, very likely related to the conversion of $\beta \rightarrow \beta'$
For practical purposes, the ring test also provides a reliable indication about the susceptibility to hot tearing of brass cast in chill moulds.
As the copper content can be attributed a very important influence in the kind of solidification and in the development of hot tears it is important to know exactly the copper content of the melt before casting.
There is no purpose in recording a cooling curve with a view to determining the copper content as a function of the liquidus temperature because the latter is very much influenced by the tin lead and aluminium content, though hardly so by the copper content (about 2 °C/% Cu). Only appreciable deviations of the copper content can be demonstrated by this method.
An arrest point in the cooling curve however (fig. 7), indicating the temperature at which the α-precipitation starts is a rapid and reliable way of showing what type of solidification occurs and giving details of the structure, which are both determined by the composition.
If the α-precipitation starts at 800 °C or less, the alloy will not show spongy-dendritic solidification. On the other hand it is desirable for the α-precipitation to start not lower than 600 °C as otherwise for instance the elongation would be too small and the susceptibility to stress corrosion would be adversely affected. The susceptibility to hot tearing is lower according as the α-precipitation starts at a lower temperature. The lower temperature limit is likewise 600 °C, as otherwise the alloy will become susceptible to stress cracking.

A. W. J. DE GEE

Materials research and tribology*

621.89+539.6.

Problem areas

In discussing the organization of multi-disciplinary materials research and, in particular, the requirements for successful tribological research, it should first be tried to explain and, in fact, justify the existence of specially formed friction, wear and lubrication research units.
Such a justification can be based upon an analysis of various problem areas, with special regard to their tribological aspects.
Table 1 shows five different machines or machine components which have as common denominator that their reliability or endurance depends on a successful solution of the wear problem.

Journal bearings

In lubricated journal bearings, the first and foremost challenge of the engineer is to stimulate the formation of a fluid film that completely separates the relatively moving surfaces of journal and bearing. Any measure that leads to a more complete fulfilment of this objective pays off in practice. A fine example of this rule is the development by Dr. G. G. Hirs of the Institute for Mechanical Constructions TNO of a bearing for the sodium pump of the fast breeder reactor. This bearing, which is shown in Fig. 1, is fed with sodium, bypassed from the main stream on the pressure side. It has no external restrictions, but by virtue of shallow axial grooves in the journal surface, differences in pressure are generated along the circumference of the shaft. This guarantees a good load carrying capacity. As an insurance policy against unforeseen trouble and to overcome safely starting and stopping operations, surface coatings are being developed, which have superior running characteristics under conditions of metal to metal contact. As in any other bearing development programme, however, material selection is not the first and certainly not the only approach.
In more conventional, oil lubricated bearings, the last line of defence is the boundary film, which is formed by adsorption of polar compounds from the lubricant on the bearing surface. Under such conditions of boundary lubrication, wear of the bearing has a mild character, and is mainly associated with the abrasive action of the asperities on the surface of the steel journal. If the temperature in the friction interface reaches a critical value, large scale desorption of surfactant molecules occurs, the uncovered metal surfaces touch locally, and adhesion and heavy metal transfer from the bearing towards the shaft may occur.
By approximation, self acting journal bearings act according to the Stribeck curve, shown in Fig. 2.
This curve relates the coefficient of friction f to the dimensionless number $\frac{\eta\omega}{P}$, which contains the dynamic viscosity of the oil (η), the number of revolutions per min. of the shaft (ω) and the projected bearing load (P). At decreasing viscosity or speed of rotation or at increasing load, hydrodynamic film thickness and, with that, viscous friction losses decrease until, at some critical thickness of the lubricant film, the asperities of bearing and journal touch for the first time. From that moment on, one enters the region of mixed lubrication, in which metal to metal contacts play an increasingly important role. In this particular region, the critical temperature for additive desorption, mentioned above, becomes important. If this critical temperature is high, there is a good chance that the bearing can successfully survive a period of lubricant starvation.
If it is low, a brief period of lubricant starvation may result in severe metal transfer. This, in turn, generally leads to a considerable increase in surface roughness, with the unfavourable result that the minimum thickness of the lubricant film, necessary to keep the surfaces apart, increases. The Stribeck curve then shifts from position I to position II. For this reason, scuffing in bearings usually is an irreversible, self accumulating process.

* Lecture held at the Euratom Tribology Seminar, Ispra, Italy, March 9th, 1971.

Table 1 Tribological aspects of various machines or machine components

machine (component)	lubricated journal bearings	dredging equipment	fuel atomizers	nuclear reactors	rolling element bearings
Type of contact	sliding	sliding	sliding	reciproca-ting sliding	rolling
	solid-solid solid-liquid solid-particle	**solid-particle**	**solid-solid** **solid-particle**	**solid-solid**	**solid-liquid** solid-solid
Main wear processes	**adhesion** **abrasion** cavitation-erosion erosion fatigue (corrosion)	**erosion** abrasion (corrosion)	**fretting** adhesion (corrosion) (abrasion) (fatigue)	**cavitation-erosion** fluid-erosion erosion corrosion	**fatigue** (adhesion) (erosion) (corrosion)

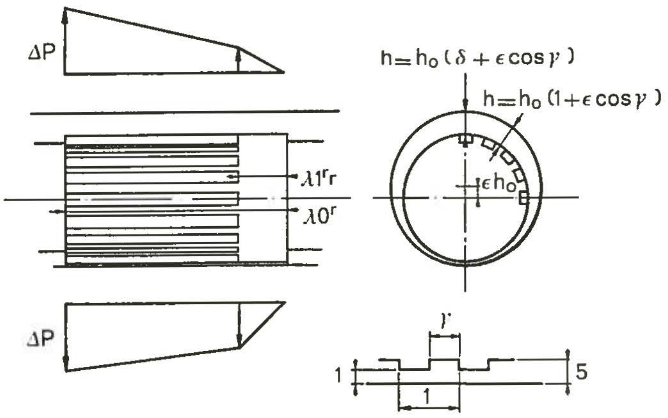


Fig. 1 Bearing for the sodium pump (G. G. Hirs, TNO, Delft)

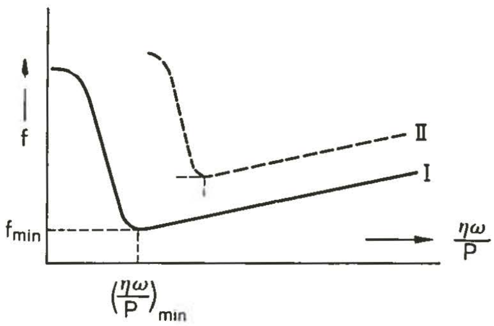


Fig. 2 **Stribeck curve**

f = coefficient of friction

η = dynamic viscosity

ω = rev. per min.

P = load per unit of projected area

h_c = critical film thickness, equal to the sum of the roughness heights of journal and bearing

r = shaft radius

Δr = radial clearance

$$\left(\frac{\eta\omega}{P}\right)_{min} \sim \frac{h_c}{r} \quad \frac{\Delta r}{r} \qquad f_{min} \sim \frac{\pi h_c}{r}$$

At high speeds of rotation, the bearing operates safely in the hydrodynamic region. However, at very high speeds of rotation, cavitation in the lubricant may occur, with the result that the surfaces of high speed bearings sometimes suffer from cavitation erosion. If the shaft is loaded dynamically, another danger which threatens the life of the bearing is surface fatigue due to cyclic stress variations in the lubricant.
It is well known that materials which possess a low fatigue limit, as for instance white metals, often fail as a result of fatigue. Further, the lubricant may contain abrasive particles which can have an erosive action, leading to a gradual increase in clearance, and, finally, corrosive attack may occur, in particular if the lubricant is contaminated with anorganic acids. In corrosive wear, the corrosion process itself can be accelerated by the continuous removal of corrosive surface layers by mechanical action. Also, deformation and the formation of nascent surfaces may accelerate corrosion considerably.

Dredging equipment

In dredging equipment, wear is primarily caused by the sliding of hard solid particles. If the particles are entrained in water, the process is called erosion, if particles become trapped between two relatively moving solid surfaces, the process is called abrasion. Again, corrosion may play a role of some importance, although in most dredging operations, wear due to erosion is so high that the effect of atmospheric corrosion is generally negligible. A consequence of this is that one should try to increase the hardness of the vital surfaces rather than their corrosion resistance.

Fuel atomisers

The life time of fuel atomisers for diesel engines is limited by wear of the small holes in the nozzle through which the fuel is vapourized. Here, wear is due to cavitation-erosion, particle erosion and, in some instances, fluid erosion. Cavitation erosion, which is erosion due to the impact of shock waves, generated during the impact of vacuum cavities, may contribute considerably to the ultimate destruction of the nozzle holes. Fig. 3 shows a cross section through the tip of a used fuel atomiser, showing severe attack as a result of cavitation.
Fluid erosion is due to high speed contact between the pressurized fuel and the inner wall of the nozzle holes. Particle erosion may occur if the fluid contains solid particles. Finally, wear may have an important corrosive component, especially in cases where the fuel has a high water content.

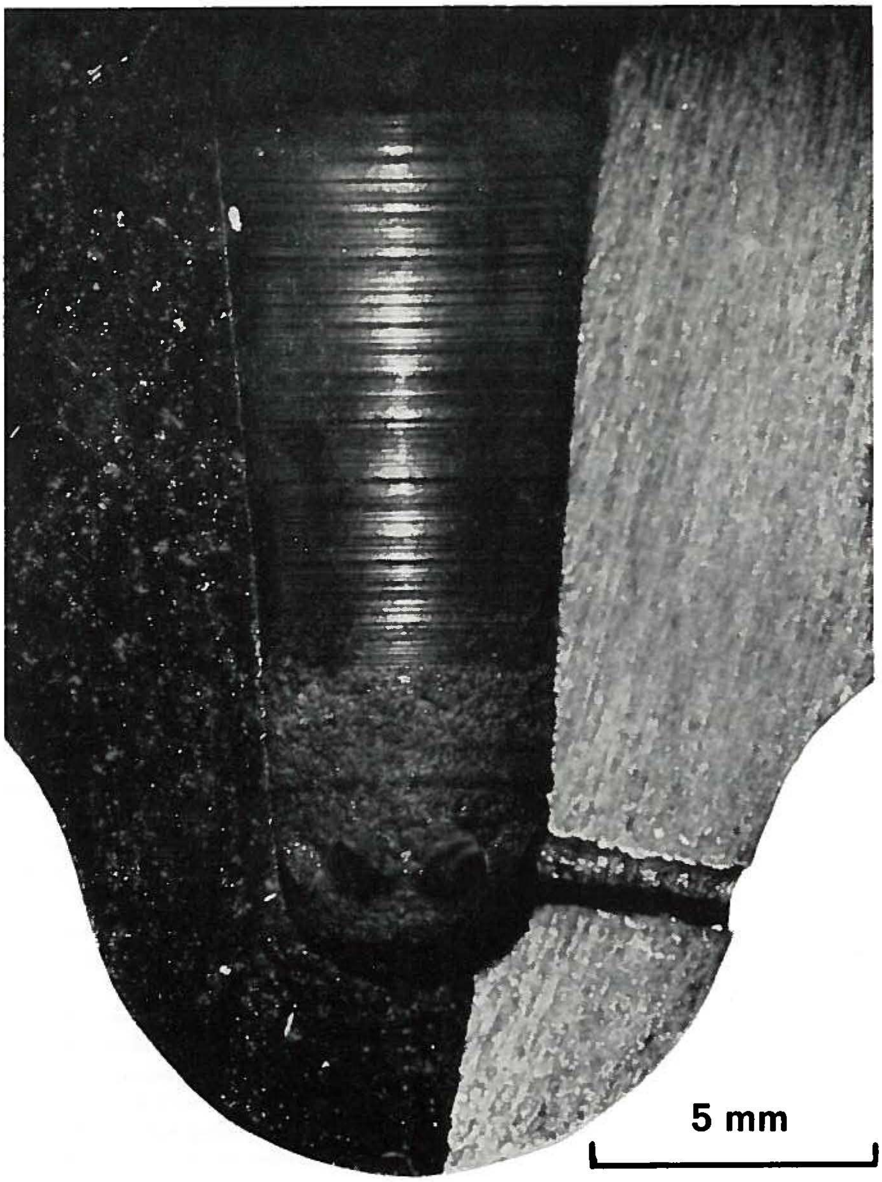


Fig. 3 Tip of a fuel atomiser, showing severe attack as a result of cavitation in the liquid.

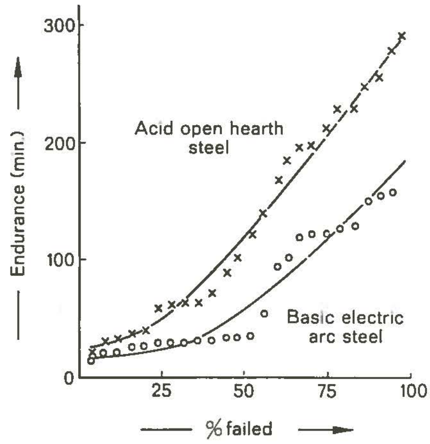


Fig. 5 Life expectancy curves for two types of ball bearing steel 52100, tested with the accelerated four ball tester (D. Scott, National Engineering Laboratory, Glasgow).

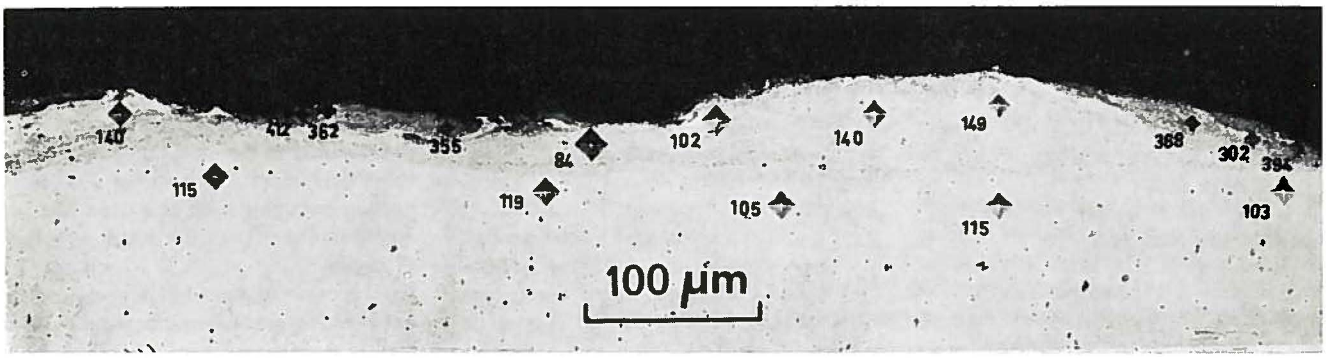


Fig. 4 **Transfer of metal during fretting**
The picture shows a metallographic cross section through a test specimen of SAP (sintered aluminium powder), subjected to vibration against another test specimen of SAP in the organic coolant terphenyl at 400 °C. Metal has been transferred back and forth between upper and lower specimen. Microhardness indentations show that this resulted in considerable work hardening.

This may happen for instance if reserve fuel is kept in ballast tanks, which are normally filled with water.

Nuclear reactors and reactor components

The next problem area is that of nuclear reactors and reactor components. The fact that thermal expansions must be possible makes that several parts cannot be welded together. If vibrations occur, for instance as a result of local turbulence in the coolant, fretting or fretting corrosion may result. Fretting corrosion is not a separate wear mechanism, but the result of the simultaneous or subsequent occurrence of adhesion, fatigue, corrosion and abrasion. If the environment is non-corrosive, which also means non-oxidative, metal to metal contact leads to local weld formation and material transfer. Subsequent contact under conditions of oscillatory movement leads to fatigue of the transferred particles which results in the formation of wear debris. Because this debris is heavily work hardened, it may scratch the vibrating surfaces. This effect may become particularly serious if the contact conditions are such that the debris cannot easily be removed from between the oscillating surfaces. If the environment is oxidative, the debris is generally oxidized, which may increase its hardness and abrasive action considerably. This ultimate, and most destructive stage is reached if iron parts rub together in air. Then, the hard, abrasive form of iron oxide, which is characteristic for fretting corrosion, is formed. An effective measure against fretting damage is to reduce the tendency towards adhesion and weld formation. This principle has been applied successfully in work, performed for the Euratom Centre at Ispra, Italy.
Fig. 4 shows a metallographic cross section through a worn specimen of SAP (sintered aluminium powder), subjected to vibration against another test specimen of SAP. Clearly, severe surface deterioration occurred. The problem could be overcome by application of a sprayed coating of antimony tellurium, to be used in contact with SAP. Recent fretting work in liquid sodium yielded results that were highly welcome from a technical point of view, although, perhaps, of limited scientific interest. It turned out that, between wide limits, composition and structure of stainless steel has no serious influence on the fretting resistance in sodium.

Rolling element bearings

The final problem area to be analysed, is that of rolling element bearings. In these bearings, contact between the rolling elements and the races takes place under nominal rolling friction conditions and fatigue is the predominant destruction mechanism. If the thin, elasto hydrodynamic lubricant film, that is characteristic for the counterformal contact situation, is thick enough to separate the surface asperities of rollers and races, fatigue is of the sub-surface type, caused by cyclic variations in the hertzian stress. Under a high normal load, at high temperature or during running-in of relatively rough surfaces, asperities may penetrate the elasto-hydrodynamic film and adhesive joints may be formed. In a practical bearing, there is always a small percentage of slip between rollers and races which may lead to surface distress, a superficial damage which may considerably accelerate the ultimate damage due to sub-surface fatigue. Further, erosion and corrosion may occur if the lubricant contains hard particles or anorganic acids. A high water content of the lubricant is particularly unfavourable, as water can adsorb in small surface cracks as result of capillary condensation. Another important factor in rolling friction is the purity of the steel from which the rolling elements are made. Recent co-operative work, performed under the auspices of OECD, indicates for instance that the life expectancy of ball-bearing steel 52100 is much influenced by the method of production of the steel. This is illustrated in Fig. 5 which shows results obtained in the National Engineering Laboratory in Glasgow, with respectively acid-open hearth and basic electric arc steel. Obviously, the life expectancy of the acid-open hearth steel is much better than that of the basic electric arc material.

Table 2
Transition temperatures (T) for boundary lubrication for 5 copper-based bearing alloys.
Lubricant: paraffin oil of 35 °C

no	alloy composition	T °C
1	Cu-6Sn	> 170
2	Cu-6Sn-0.01 P	100
3	Cu-6Sn-10Pb	100
4	Cu-6Sn-10Pb-0.01 P	40
5	Cu-6Sn-10Pb-4Zn	45

Objectives for materials research

The above examples show that a successful design of very different machine components, all of which are somehow essential for modern technology, assumes a sound knowledge of friction, wear and lubrication theory, and may, in fact, depend on an optimized choice of materials. This, generally, means one of three things, viz.
— optimization of conventional materials
— development of new materials
— selection of cheaper or non-strategic materials

Optimization of conventional materials

The first of these objectives may well be more important than it seems at a first glance. An example, taken from recent TNO experience, is shown in Table 2. This shows five different copper-based bearing materials, each of which complies with the highest standards of purity and mechanical properties and each of which may easily be chosen as a high-strength bearing material for journal bearings. All materials contain 6 % tin, which forms a substitutional solid solution with copper and, in addition, alloys 3, 4 and 5 contain lead, alloy 4 contains zinc and alloys 2 and 5 contain traces of phosphorus. Lead is present in the form of a separate second phase. Upon application

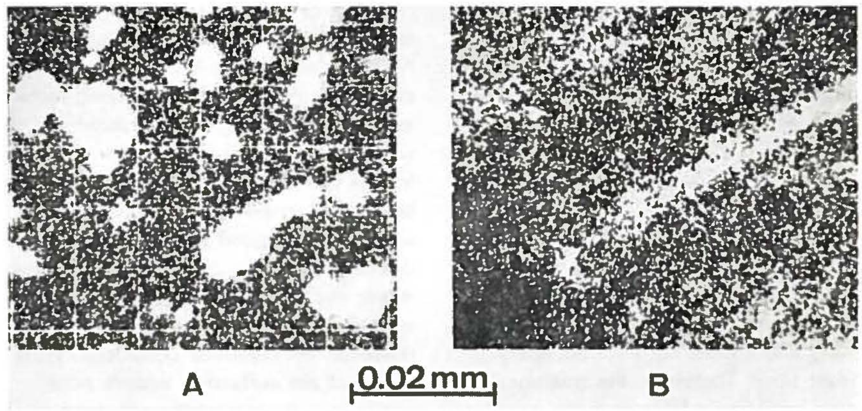


Fig. 6 **Microscan pictures of the surface of a Cu-6SN-10Pb alloy before (A) and after (B) lubricated sliding against plain carbon steel.**
The globules of lead, which appear as white dots in the initial condition, lose their identity during sliding and large parts of the surface become covered with extruded and smeared lead. This smeared lead protects the steel shaft against severe damage if the bearing ever runs virtually dry. On the other hand, the lead film may interfere unfavourably with the adsorption of boundary lubricant films on the Cu-Sn matrix.

of pressure, the copper-tin matrix deforms and some lead is extruded and smeared over the surface. This follows from Fig. 6 which shows microscan pictures of the surfaces of a Cu-6Sn-10Pb alloy, before and after lubricated sliding against plain carbon steel.

A smeared lead film gives some protection against weld formation and metal transfer if the bearing ever runs virtually dry. However, this class of bearing materials is definitely not made for use under dry running conditions. On the contrary, they have earned their well-established position in industrial practice by virtue of the fact that a tin rich surface forms strong bonds with surface active compounds from the lubricant, resulting in effective boundary lubricant films. As stated earlier, it is the desorption temperature of such boundary films which determines the behaviour of the bearing during periods of lubricant starvation. The critical or transition temperatures for lubricant desorption are shown in Table 2. It turns out that materials, which are pretty much interchangeable when judged from an ordinary engineering point of view, have very different critical temperatures for boundary film desorption. In particular, a small quantity of surplus phosphorus, which is used for desoxidation purposes during melting, turns out to be quite harmful.

The scope of this lecture does not permit an explanation of the observed differences. Suffice it to conclude that seemingly insignificant differences in composition may result in critical reductions of the power of a surface to adsorb polar compounds. Although this work is quite new, some companies have already profited by these results and have solved their bearing problems by simply redrafting their requirements for material specification.

Development of new materials

A second and obvious objective for tribological materials research is the development of new materials, frequently in the form of surface coatings or surface conversion layers, to be used under unconventional operation conditions. The development of bearing materials for use in liquid sodium falls in this category. If used in combination with metals, which do not suffer corrosion, sodium has no lubricity, meaning that it does not form boundary lubricant films. Therefore, the traditional solution has always been to cover bearing and journal surface with hard facing coatings as, for instance, stellites, colmonoy, or tungstencarbide cermets. As the resistance against adhesive wear increases proportionally with increasing hardness, this is a reasonably effective measure to overcome periods of metal-to-metal contact. However, it has been shown by several investigators that a very undesirable by-effect of the use of hard surface coatings is their total lack of embeddability and conformability. Embeddability is the power of the surface to embed abrasive particles, thus reducing or even entirely eliminating their undesirable effects and conformability is the power of the surface to conform to shaft deflection and minor misalignments. The latter property is of considerable importance, especially if thermal distortions occur. For this reason it is now tried to develop materials with adequate corrosion and wear characteristics in sodium, which are considerably softer than the usual hard surface coatings. Of course, when trying to comply with requirements regarding embedability and conformability, one is immediately faced with a new problem. This is associated with the fact that a decrease in hardness inevitably means a lower resistance against abrasion. Thus, there may be a dangerous reliability gap. At high values of surface hardness, foreign particles are not embedded, but the resistance against abrasion of the surfaces is high. At low hardness, particles are effectively embedded, thus eliminating the scratching effect before serious damage can occur. At intermediate hardness values, there may be a dangerous area. In testing conventional materials and, in particular, during development of new materials, one is frequently faced with such controversal requirements and, frequently, an optimized solution can only be found after long discussions with engineers and designers.

Selection of cheaper or non-strategic materials

A third objective for tribological materials research can be the ever occurring demand for cheaper or non-strategic materials. A fine example of a fairly successful development of a cheaper bearing material is the development of aluminium-tin alloys, which are frequently used as a replacement for the more expensive copper-based bearing materials. Neither copper, nor aluminium has good sliding properties in dry contact with iron or steel. This situation is not essentially improved by alloying with tin.

However, tin improves considerably the power of the surface to adsorb polar compounds from the lubricant. In this respect, tin functions equally well in aluminium as it does in copper. In AlSn20, tin is present in the form of a second phase, which, in the as-cast condition, completely surrounds the aluminium crystallites. By mechanical deformation and subsequent heat treatment, this structure is modified essentially, the individual aluminium crystals weld together and the tin phase becomes distributed in the form of a continuous thread. The mechanical properties of this material, in particular its resistance against fatigue, are highly superior to those of the alloy in the as-cast condition. Nevertheless, its resistance against surface fatigue of aluminium-tin remains lower than that of copper-tin. It can be increased by the application of a thin, soft layer, for instance consisting of tin-lead. If this layer is really thin enough, the relatively hard aluminium-tin substrate carries the load, while the shear forces are determined by the low shear strength of the tin-lead overlay. As surface fatigue is caused primarily by friction forces in the interface, the endurance can thus be improved considerably. Of course, a requirement for the successful application of an overlay is that it should be there long enough to protect the material during subsequent periods of metal-to-metal contact. If such periods occur frequently, the soft overlay is worn away rapidly. Summarizing, it should be concluded that the replacement of copper-based bearing materials by aluminium-tin alloys requires a careful analysis of the loading characteristics of the bearing. If the loading conditions become severe, copper-based materials may still form the best choice.

Requirements for materials research in tribology

1. Clear definition of research objectives

The first and obvious requirement for successful materials research in tribology is that there should be a balanced choice and clear definition of research objectives. In tribology, the main objective of materials research frequently is comparative testing of potential construction materials. Also, laboratory equipment may be used successfully for determination of the applicability ranges of materials, in particular with regard to the influence of temperature and environment. This can be of crucial importance in cases where the applicability of a material is limited by the occurence of a transition effect, as, for instance, associated with desorption of a boundary lubricant film at a characteristic, critical temperature.

2. Approximation of thermal and environmental conditions

When materials are to be classified with respect to their wear resistance or/friction characteristics, it is essential to bear in mind the specific technical application, and the utmost care should be taken that the test rig is constructed or modified in such a way that the practical conditions, especially the thermal, mechanical and chemical factors that relate to temperature and environment are approximated as closely as possible. Even if the environmental conditions are successfully reproduced in the laboratory, it is advisable to include in the test programme some reference materials on which practical information is available.

3. Realistic choice of movement and attack pattern

A third, and equally important requirement is that the laboratory test should be chosen in such a way that the movement and attack pattern is similar to that in practice, i.e. comparative testing of materials for rolling element bearings should normally be performed under rolling friction conditions. If, however, the useful life of the bearing is limited by sliding friction between the balls and the cage, sliding contact studies should be performed. Although quite obviously true, this rule is frequently broken afterwards in that a specific 'wear resistance' or 'coefficient of friction' is assigned to a material. This, of course, is nonsense: a material which may show excellent friction and wear characteristics under one set of conditions (e.g. lubricated rolling) may fail utterly under other conditions (e.g. dry sliding).

4. Knowledge of the basic mechanisms

Finally, and most importantly, the investigator, responsible for friction and wear research, should possess a sound knowledge of the basic tribological mechanisms, their interdependence and their occurrence in practice. In fact, this requirement is absolutely essential, if one ever hopes to sort out successfully the multitude of phenomena that generally accompany contact between relatively moving surfaces. Lack of knowledge may, in fact, lead to an entirely wrong interpretation of results, even if the objective of testing simply is to classify materials with respect to their wear resistance. This follows, for instance, from the data on boundary film desorption, which are given in Table 2. Say that the objective were to classify the copper-based bearing materials with respect to their wear resistance under conditions of boundary lubrication. If the temperature would not be recognized as the controlling factor, conclusions based on comparative wear testing could be completely worthless. For instance, if the equilibrium interface temperature happened to be 95 °C, materials 1, 2 and 3 would pass the test with flying colours. If, on the other hand, the equilibrium interface temperature would reach a value of 105 °C, alloys 2 and 3 would perform as bad as 4 and 5.
Another example of the danger of comparative testing of materials without knowing the determining factors, can be taken from laboratory testing of materials for application in liquid sodium bearings. Here, the temperature and the oxygen content of the sodium play an equally important role. From work, performed at Battelle in the early sixties, it follows that, at certain combinations of sodium temperature and oxygen content, molybdenum can form sodium molybdates.
As these have a beneficial effect on friction and wear, addition of molybdenum to the bearing material may help to overcome periods of metal to metal contact. At rising temperature or decreasing oxygen percentage, this beneficial effect is lost, and there is no longer a special, tribological reason for adding molybdenum to the bearing material. In other words, at relatively low operational temperatures, or high oxygen contents, molybdenum-rich alloys may rank high in comparative testing. At relatively high temperatures, or low oxygen contents, however, they may well be overclassed by other materials, as for instance tungsten-carbide cobalt cermets.

Summarizing, it is concluded that laboratory testing with the objective to find better materials for use under conditions of relative motion, can be quite useful, provided that the primary aim is to gather reliable information on the comparative performance of potential construction materials. Quantitative transference of data from the laboratory towards practice remains difficult and requires cautious handling.

Publications

1.VII.1970 - 30.VI.1971

H. Boswinkel:
De invloed van enkele verontreinigingen op de warmscheurgevoeligheid van coquille-gietmessing
De Gieterij **4** (1970) nr. 7

H. Boswinkel:
Slinkneiging en warmscheurgevoeligheid van coquillemessing
De Gieterij **4** (1970) nr. 11

F. P. M. A. Julien:
Vloeibaar vormzandprocédé
De Gieterij **4** (1970) nr. 12

H. Boswinkel:
Einfluss eniger Verunreinigungen auf die Warmrissempfindlichkeit von Kokillen-gussmessing
Geisserei-Praxis (1970) nr. 23, S. 365 - 370

B. H. Wijngaard
Kathodische bescherming van staal-constructies in zeewater
Economische keuze van galvanische anoden
TNO-Nieuws **25** (1970) nr. 12

M. J. J. Reidt, Ing. F.I.M.F., H. J. Tiemens:
Analysemethoden voor fosfateerbaden
TNO-Nieuws **25** (1970) nr. 10

Dr. Ir. F. E. v. Wely:
Schokgolven in metalen en de toepassing van schokgolven in de metaalbewerking
De Ingenieur (1970) nr. 40

W. L. Korbee, Drs. H. J. M. v. Rongen, S. Slagter en Dr. Ir. F. E. v. Wely:
The recording of plastic wave propagation in high velocity tensile tests on steel
9th Conference on High Speed Photography, Denver, USA.

Ir. A. W. J. de Gee, A. Begelinger:
Synopsis of the results from an international cooperative head program
Lubrication Engineering, febr. 1970, 56-62

Ir. J.W. Tichler, D. Scott:
A note on the correlation between cavitation erosion and rolling contact fatique ıessistance of ball bearing steels
Wear, 16 (1970) 229-233.

Ir. J. W. Tichler and Ir. A. W. J. de Gee:
Time defendence of cavitation erosion and the effect of some material properties
Proc. Third International Conf. on Rain Erosion and Associated Phenomena, Elvetham Hall, Engeland, August 1970

Ir. A. W. J. de Gee, Ir. G. H. G. Vaessen and A. Begelinger:
Influence of phosphorus on the load carrying capacity under boundary lubrication conditions of copper - 6 tin
ASLE paper 70-LC-7

Ir. A. W. J. de Gee:
Friction and wear of bronzes
Wear, 16 (1970)

Drs. A. Hofstede, J. W. M. van den Brekel:
Some remarks on electro-chemical turning
Annuals of CIRP. Vol. XVIII pag. 93-106

Anoniem
De constructie van gereedschappen voor het smeden en warmpersen
Metaalbewerking **36** (1970) 2.

Ir. J. L. Remmerswaal:
Machinefabriek van Morgen
Metaalbewerking **36** (1970) 4

Centrum voor Metaalbewerking:
Numerieke Besturing - Ontwikkelingsproject FME/TNO
Publ. van het Centrum voor Metaalbewerking, aug. 1970.

M. v. Krimpen:
Technische eisen van machines
Inkoop **96** (1970) 7-8,
Onderhoud **5** (1970) 6

Centrum voor Metaalbewerking:
Handleiding klassificatiesysteem voor werkstukken
Systeem CvM/TNO, januari 1970

Ir. M. J. C. Matthijsen:
Inleiding in het gebruik van beslissingsmatrices
Publ. van Centrum voor Metaalbewerking, maart 1970

Ir. M. J. C. Matthijsen:
Inleiding in het gebruik van opbrengsttabellen voor het bepalen van een keuze in riskante of onzekere omstandigheden
oktober 1970

Ir. A. W. J. de Gee:
Lagermateriaal en grenssmeerfilms,
Thema-editie De Constructeur, nr 1-71

A. Bordes:
Keuze ductiele ferrogietlegeringen
De Constructeur **10** (1971) nr. 6.

Ir. C. A. Boose en M. J. Reidt, Ing. F.I.M.F.:
Een nieuw cyanidevrij zinkbad
TNO-Nieuws **26** (1971) nr. 1

P. Breedveld, Ing.:
Aluminium blootgesteld aan atmosferische invloeden
TNO-Nieuws **26** (1971) nr. 3

C. M. Dicke en M. J. Reidt, Ing. F.I.M.F.:
De bescherming van aluminium bouwconstructies
TNO-Nieuws **26** (1971) nr. 3

P. Breedveld, Ing.:
Bouwen met aluminium
TNO-Nieuws **26** (1971) nr. 5

A. J. G Verbraeken en T. F. van der Lugt:
NuBe-Complement van de automatisering van de informatieverwerking — Basis voor integrated manufacturing
TNO-Nieuws **26** (1971) nr. 6

H. G. Leveling en H. van den Berg:
Warmtegeleidbaarheid van vormzand en gietstukkwaliteit
De Gieterij **5** (1971) nr. 1

Ir. G. H. G. Vaessen en Ir. A. W. J. de Gee:
The influence of water vapour on the wear of lightly loaded contacts
Paper Session 4, Conference of chemical effects at bearing surfaces, January 1971, Swansea, England

Ir. A. W. J. de Gee:
Comments on friction and wear of bronzes
Wear **17** (1971) 83-84

Ir. A. W. J. de Gee en Ir. J. W. Tichler:
Cavitation-erosion of tungsten carbide-cobalt-cermets", ASLE paper 71 Lc-10
Pittsburgh Conference ASME/ASLE (1971)

Ir. M. J. C. Matthijsen:
Inleiding tot het gebruik van beslissingsmatrices
Informatie **13** (1971) nr. 1, 1-9

Ir. J. Koloc en Ir. J. L. Remmerswaal:
Numeriek bestuurde draaimachines in 1970 — Overzicht van drie belangrijke tentoonstellingen: Hannover, Chicago en Osaka.
Metaalbewerking **36** (1971) nr 21, 566-573

M. van Krimpen:
Draadspilbreuk bij een 270 tf schroefslagpers
Metaalbewerking **36** (1971) nr. 23, 637-638

H. Boswinkel:
Shrinkage tendency and hot-tearing of die cast brass
The British Foundryman, nr. 5 (1971)
(Eveneens verschenen in de Giesserei-Forschung - 1971) - nr. 2)

A. H. Th. Balk/Stupré-kommissie:
Materialen voor de bevestiging van gevelplaten
TNO-Nieuws **26** nr. 3 (1971)
(Idem, Bouwwereld **67** (1971) nr. 10

Dipl.-Ing. A. P. von Rosenstiel, H. J. Höhling, W. Kriz en J. Schnermann:
Messungen von Elektrolyten mit der Mikrosonde
TNO-Nieuws **26** (1971) nr. 4

NOTE: The above mentioned publications are available on request.
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Das TNO-Miturn Programmiersystem

Zusammenfassung

Miturn ist ein vom Metaalinstituut TNO entwickeltes, maschinelles Programmiersystem für numerisch-gesteuerte Drehmaschinen. Dieses System ermöglicht eine zuverlässige, schnelle und preisgünstige Herstellung von Steuerungslochstreifen für Drehmaschinen. Über den Mark II Timesharing-Dienst von Honeywell Bull ist Miturn in ganz Europa und den Vereinigten Staaten verfügbar.

Einführung

Das Miturn-Programmiersystem (Metal Institute Turning Programme) ist ein umfassendes Produktionssystem, das aus einer Anzahl von Untersystemen wie z.B. Bearbeitungs-Technologie, Werkzeug-, Maschinen- und Materialdatei aufgebaut ist. Bei Miturn ist die Nutzung der vollen Drehmaschinenkapazität und der vorhandenen Werkzeuge gepaart mit einfacher Programmierung und weitgehend automatisierter Herstellung des Steuerungslochstreifens. Dies bedeutet, dass nach Beschreibung der Geometrie des Ausgangsmaterials und der Endform des gewünschten Werkstücks folgende Operationen automatisch und somit fehlerfrei ausgeführt werden.

— Auswahl des besten Werkzeugs für jede Drehoperation aus dem verfügbaren Werkzeugvorrat.

— Festlegung der optimalen Bearbeitungsfolge

— Bestimmung der optimalen Schnittwerte wie Schnittiefe, Vorschub und Schnittgeschwindigkeit) für jeden Schnitt oder für jeden Teil eines Schnittes.

— Erzielung der programmierten Oberflächenqualität.

— Formulierung der Einstelldaten für die spezielle Drehmaschine.

— Berechnung der zu erwartenden Bearbeitungszeit des programmierten Werkstücks.

— Herstellung des Steurungslochstreifens für Drehmaschine.

Miturn ist, wie die Erfahrungen im industriellen Einsatz zeigen, ein bedeutender Beitrag zur optimalen Nutzung numerisch gesteuerter Drehmaschinen.

Die Verabeitung geometrischer und technologischer Informationen

Im Gegensatz zu allgemeinen Programmierverfahren, die für NC-Operationen verschiedener Art benutzt werden können,

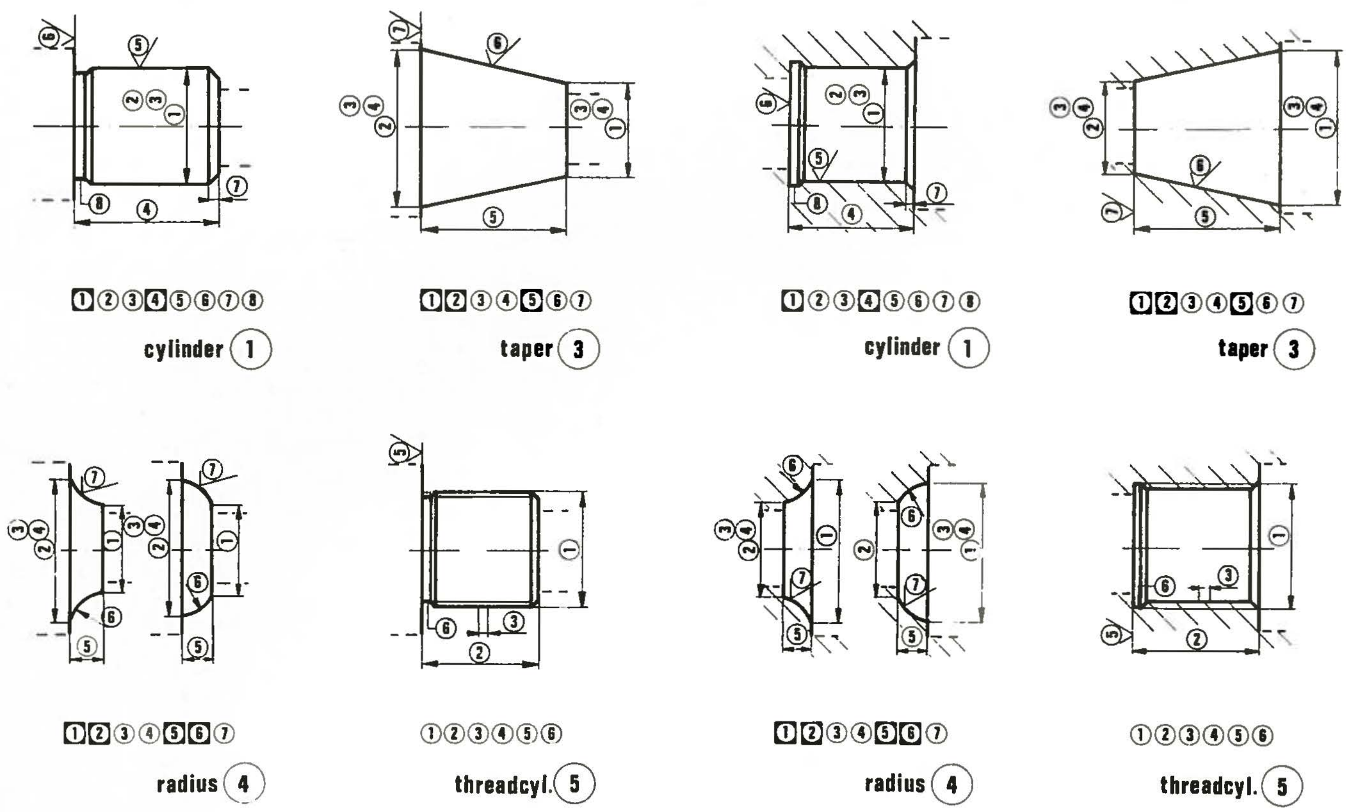
AUTOMATION LEVELS	
1	CHUCKING
2	MACHINING SEQUENCE
3	TOOLSELECTION
4	CUTTING CONDITIONS
5	TOOL PATH
6	PUNCHED TAPE

← MITURN

Fig. 1 Durch den hohen Automatisierungsgrad von Miturn wird der Aufwand für das Teileprogramm entscheidend verringert.

TNO miturn

basic elements

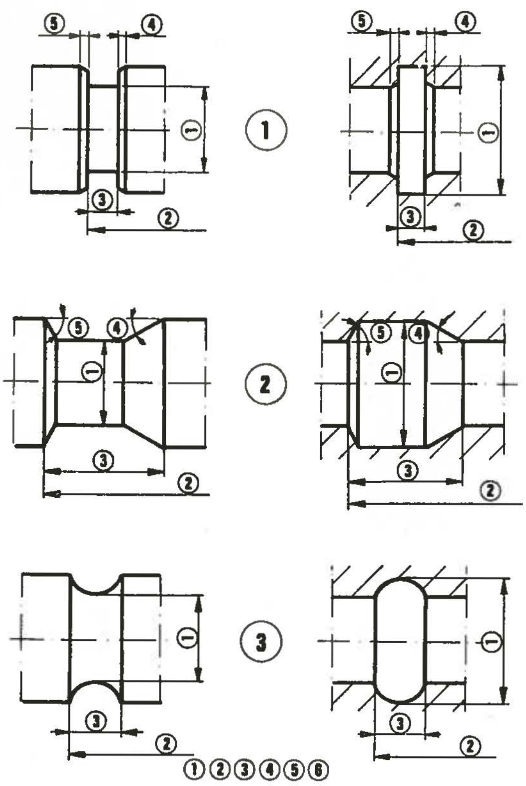


▢ parameters for rough elements
○ parameters for machined elements

▢ parameters for rough elements
○ parameters for machined elements

Fig. 2 Definitionen der Standardelemente zur Beschreibung der Rohteilform und der Endform des fertigen Werkstücks. Die Definitionen der Innen- und Aussenelemente sind dabei dieselben.

superimposed elements



TNO miturn

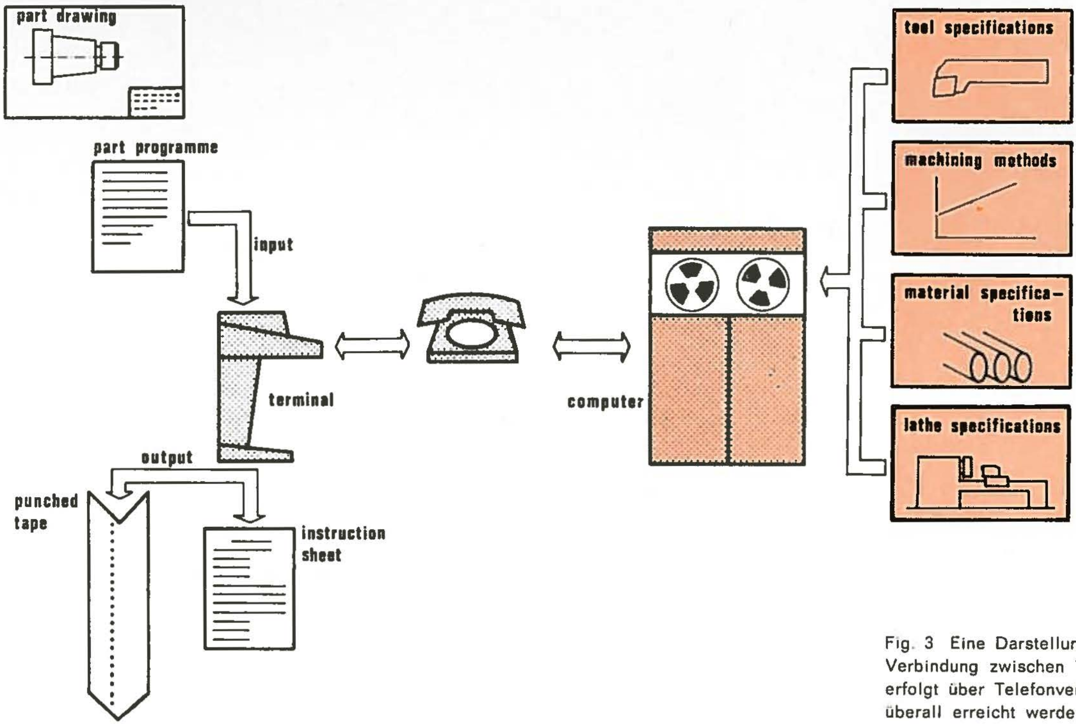


Fig. 3 Eine Darstellung wie Miturn arbeitet. Die Verbindung zwischen Terminal und Rechner erfolgt über Telefonverbindung, so dass Miturn von überall erreicht werden kann.

ist Miturn auf Drehoperationen beschränkt. Dank dieser ,,Spezialisierung ' erlaubt Miturn eine sehr umfassende Steuerung des Drehprozesses und verarbeitet sowohl geometrische als auch technologische Informationen (Fig. 1).
Die Eingabe ist kurz und einfach. Der Programmierer muss lediglich die Ausgangs- und Endform des Werkstücks beschreiben und einige Einzelheiten über die Einspannung und das verwendete Material angeben. Diese Daten werden über ein Terminal dem Rechner eingegeben. Dann bestimmt Miturn welche Operationen wann und wie ausgeführt werden und welche Werkzeuge vorganges mit dem Effekt.

Ein hoher Automatisierungsgrad

Die Operationen, die gegenwärtig mit Miturn ausgeführt werden können sind Plandrehen, Bohren, Zentrierbohren, innen aussen Schruppen und Schlichten, Einstechen und Gewindedrehen.
Der Weg des Werkzeugs wird bei allen diesen Operationen so kurz als möglich gehalten und die Schnittbedingungen für jeden Schnitt oder Teil eines Schnittes neu berechnet. Für jede Operation ist ein Arbeitsmodell vorhanden. Diese Modelle sind standardisiert und liefern die weitgehende Automatisierung des Programmiervorganges mit dem Effekt,

— dass die Programmierzeit und die Fehlerwahrscheinlichkeit beim Programmieren auf ein Minimum reduziert werden,
— sichergestellt ist, dass die Schnittwerte immer optimal sind und
— eine Kollision von Werkzeug und Maschine mit Sicherheit vermieden wird.

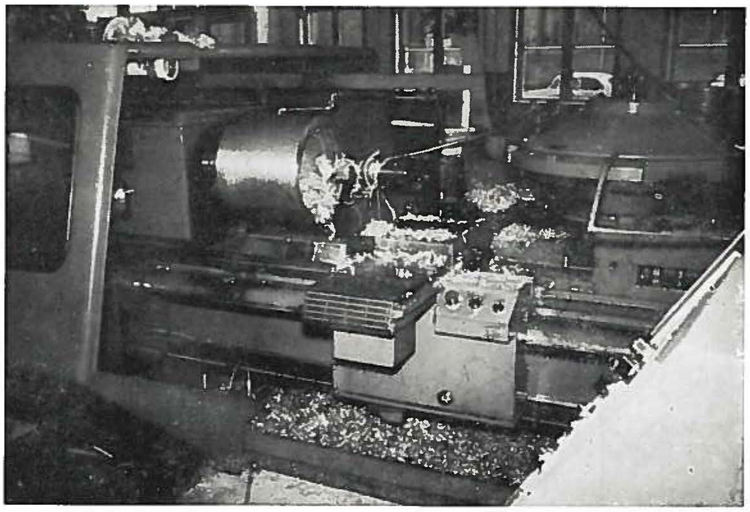
Dieser hohe Automatisierungsgrad führt zu kurzen Vorbereitungszeiten und zu kurzen Werkstück-Fertigungszeiten.

Das Programmieren basiert auf Erkenntnissen der Gruppen-Technologie.

Das Programmieren mit Miturn ist sehr einfach. Alle Daten, die auf einer gewöhnlichen Konstruktionszeichung eingetragen sind wie: Dimensionen, Toleranzen und Rauheit, werden unter Beachtung einiger Folgeregeln als Zahlenangaben niedergeschrieben. Eine Übersetzung dieser Information in eine Rechnersprache ist nicht erforderlich.
Dies ist möglich, weil Miturn auf den Erkenntnissen der gruppentechnologischen Betrachtungsweise des Fertigungsprozesses beruht. Gruppentechnologische Untersuchungen haben gezeigt, dass ungefähr 80 % aller Drehwerkstücke im Prinzip so einfache Formen haben, dass man sie sich aus einer Kombination einiger Standardelementen wie Zylinder, Kegel, Radien, Gewindezylinder und Einstichen aufgebaut vorstellen kann. Der Programmierer beschreibt nun die Ausgangs- und Endform des Werkstücks entsprechend diesen Standardelementen (Fig. 2), fügt einige weitere Information über die Einspannung und den Werkstoff hinzu (Fig. 4) und das Werkstück ist programmiert.

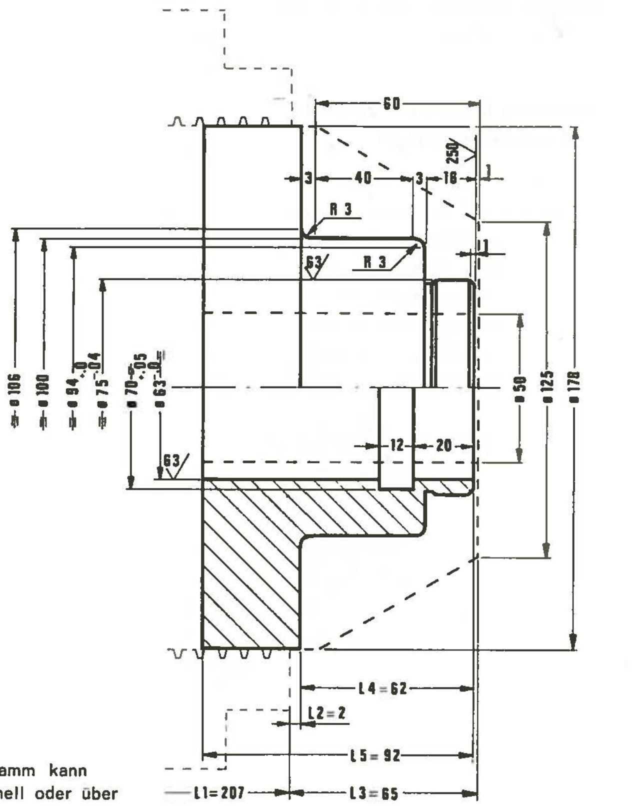
Schnelligkeit, Zuverlässigkeit und Wirtschaftlichkeit

Sobald der Programmierer die Werkstückbeschreibung abgeschlossen hat, werden diese Date über ein Terminal dem Rechner eingegeben. Miturn bestimmt dann alle notwendigen Schritte von der Rohform des Materials bis zum fertigen Werkstück. Dabei benutzt Miturn Informationen, die in Form von Datengruppen im Rechner gespeichert sind (Fig. 3) und erstellt die Daten für das Einstellblatt und den Steuerungslochstreifen. Im Prinzip gibt es daher zwei Arten von Information: Die Werkstückbeschreibung und die Datengruppen im Rechner. Die Angaben in den Datengruppen können dabei den individuellen Bedürfnissen des Miturn-Anwenders angepasst werden, so dass besondere Bearbeitungsbedingungen berücksichtigt werden können.
Da Miturn über einen Timesharing-Rechner verfügbar ist, bestehen die notwendigen Einrichtungen für den Miturn-Benutzer lediglich aus einem Telefon und einem Terminal, ein eigener Rechner wird nicht benötigt. Somit sind auch keine nennenswerten finanziellen Investitionen notwendig. Der Terminal liefert jedoch Zugang zu einem Grossrechner praktisch ohne Wartezeiten und der Benutzer kann sich dieser Vorteile bedienen, ohne dass er allzuviel von Rechnertechnik und Programmiersprachen zu wissen braucht.
Auf diese Weise werden Steuerungslochstreifen für NC-Drehmaschinen schnell, zuverlässig und preisgünstig erstellt.



TNO miturn

example part



first set – up

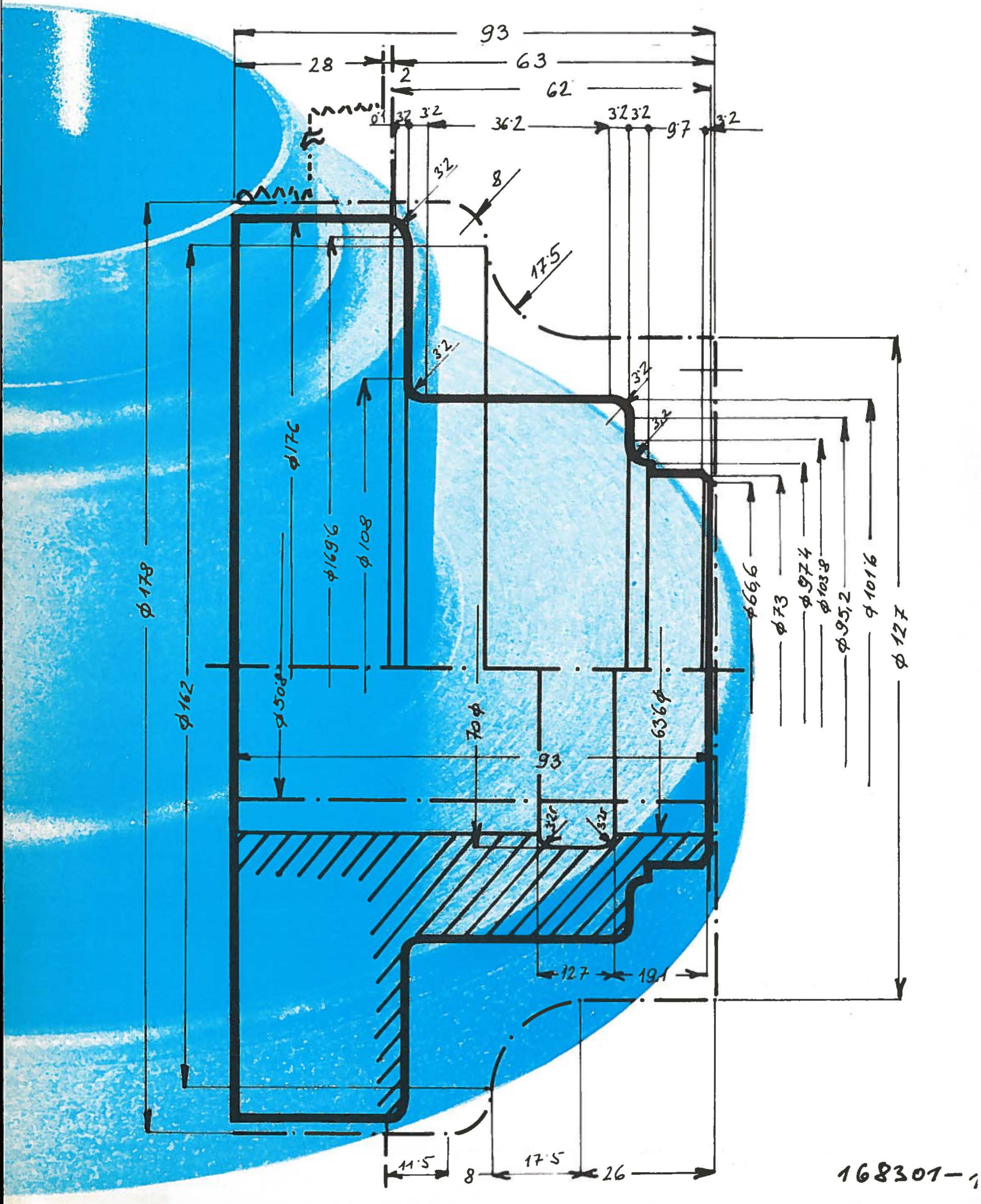
Fig. 4 Das Teileprogramm kann wahlweise konversationell oder über Lochstreifeneingabe (file input) dem Rechner eingegeben werden. Konversationell bedeutet dabei, dass der Rechner Fragen ausdruckt auf die dann der Programmierer antwortet.

part programme

MITURN PROGRAMMING SHEET

* * * * * * * * * * INDENTIFICATION * * * * * * * * *
PROGRAMMER AND DATE? MI TNO
DRAWINGNUMBER? EXAMPLE
DRAWINGSTANDARD? MM
WORKPIECEMATERIAL MEEHANITE G
MACHCAT, CATNO? CAT111 4
* * * * * * * * * * SET-UP SPECIFICATIONS * * * * *
MACH, CYCLE, MAT, MAC, MAS, RIC
4 10 2 1 10 1
L1, L2, L3, L4, L5, L6
207 2 65 62 92 3
* * * * * * * * * * BLANK * * * * * * * * * * * * * * *
NUMBER OF EXTERNAL ELEMENTS? 2
EL. CODES? 3 1
EL1? TPR 125 178 60
EL2? CYL 178 3
NUMBER OF INTERNAL ELEMENTS? 1
EL. CODES? 1
EL1? CYL 50 93
* * * * * * * * * * MACHINED PART * * * * * * * * * *
NUMBER OF EXTERNAL ELEMENTS? 4
EL. CODES? 1 4 1 4
EL1? CYL 75 .0 -.04 16 63 125 1 1
EL2? RAD 94 100 0 0 3 -3 125
EL3? CYL 100 0 0 40 125 0 0 0
EL4? RAD 100 106 0 0 3 3 125
NUMBER OF EXTERNAL GROOVES? 0
NUMBER OF INTERNAL ELEMENTS? 1
EL. CODES? 1
EL1? CYL 63 05 0 92 63 0 0 0
NUMBER OF INTERNAL GROOVES? 1
GR1? GR 70 32 12 0 0 1
FACE ROUGHNESS? 250
* * * * * * * * * * COMMENTS * * * * * * * * * * * * *
EXAMPLE PART PROGRAMME
FIRST SET-UP

Wirtschaftliche Fertigung mit NC-Drehmaschinen durch maschinelles Programmieren



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Die Produktivität und Wirtschaftlichkeit numerisch gesteuerter Drehmaschinen wird entscheidend beeinflußt durch die Leistungsfähigkeit des Steuerungsprogrammes, die Kosten für die Erstellung fehlerfreier Steuerungslochstreifen und die Schnelligkeit, mit der fertigungsreife Lochstreifen im Bedarfsfalle erstellt werden können.
Miturn ist ein maschinelles Programmiersystem, das entwickelt wurde, um die praktischen Probleme der Fertigung mit NC-Drehmaschinen wirtschaftlich zu lösen. Einige der wichtigsten Merkmale von Miturn sind:

Programmieraufwand

Ein Quellenprogramm für ein Werkstück mittleren Schwierigkeitsgrades, für das mit anderen Verfahren stunden- oder tagelang programmiert wird, ist mit Miturn in Minuten fertig. Im wesentlichen müssen nur die Abmessungen des Fertigteils und des Ausgangsmaterials in ein Formblatt eingetragen werden.

Personalproduktivität

Ein Miturnprogrammierer produziert pro Tag bis zu 10 einsatzfertige Steuerungslochstreifen für Neuteile. Denn er schreibt das Programm und erzeugt den Lochstreifen ohne Unterbrechung am Terminal. Warten auf den Rechnerlauf und die damit verbundene mehrmalige geistige Erarbeitung eines einmal durchdachten Problems gibt es nicht mehr. Alle mit dem Transport der Daten zum und vom Rechner verbundenen Fehlerquellen und Kostenfaktoren fallen weg.

Fehlersuche

Ein Miturnprogrammierer erzeugt Lochstreifen, die entsprechend den Ergebnissen mit Hunderten von Werkstücken, mit 99 %iger Sicherheit formfehlerfrei sind. Fehlersuche in der bekannten Weise mit Luftdrehen, Probedrehen, der Vielzahl an Unterbrechungen aller Arbeitsgänge an Rechner und NC-Maschine ist nicht mehr nötig.

Werkzeugwahl

Miturn wählt aus dem vorhandenen Werkzeugvorrat die für das spezielle Werkstück optimalen Werkzeuge unter Berücksichtigung der maschinellen Gegebenheiten. Durch automatische Schnittzeitermittlung für die einzelnen Werkzeuge ist die Voraussetzung für eine geplante Werkzeuginstandhaltung gegeben.

Fertigungsstückzeit

Je besser der Bearbeitungsablauf optimiert wird, umso kürzer sind auch die Stückzeiten. Miturn ermittelt für jeden einzelnen Schnitt die optimalen Zerspanungsbedingungen. Dabei werden sogar Einflüsse des sich durch die Bearbeitung verändernden Werkstückes berücksichtigt.

Werkstückqualität

Durch die rechneroptimierten Zerspanungsvorgänge werden die programmierten Toleranzen und gewünschten Oberflächen entsprechend der Leistungsfähigkeit der NC-Drehmaschine und der verwendeten Werkzeuge erreicht. Dazu trägt u. a. die längs der Kontur konstante und vorbestimmbare Schlichtzugabe bei.

Werkstückfamilien

Manchmal gehören die Produkte eines Unternehmens wenigen Teilefamilien an. In diesem Fall ist es möglich, den Programmieraufwand noch weiter zu reduzieren, denn Miturn beruht auf den Erkenntnissen der Gruppentechnologie.

Flexibilität

Trotz des hohen Automatisierungsgrades kann das Miturn den besonderen Bearbeitungswünschen, Werkstoffen, Werkzeugen und NC-Drehmaschinen eines Unternehmens einfach angepaßt werden. Die Beweglichkeit und Schnelligkeit bei der Programmierung mit Miturn bietet die Möglichkeit, NC-Drehmaschinen auch für schnell wechselnde Kleinstserien und Einzelfertigung wirtschaftlich einzusetzen.

Produktivität der NC-Drehmaschinen

Die schnelle und zuverlässige Lieferung von fertigungsreifen Lochstreifen durch Miturn gestattet eine optimale Maschinenauslastung. Auch der Verlust wertvoller Maschinenstunden durch Prüfdrehen und Fehlersuche auf der Maschine entfällt. Darüber hinaus bietet sich die Möglichkeit, über das von Miturn mit dem Lochstreifen gelieferte Maschineneinstellblatt die Rüst- und Einrichtezeiten der NC-Drehmaschinen entscheidend zu verkürzen. Die zu erwartende Fertigungsstückzeit, als Grundlage einer effektiven Fertigungsplanung, wird ebenfalls errechnet und ausgedruckt.

Rechnerkapazität

Miturn ist in Europa und den USA über den Mark II Time-Sharing-Service verfügbar. Wer ein Telefon besitzt und sich ein Terminal mietet, hat nicht nur Miturn sondern einen Großrechner für technisch-wissenschaftliche Anwendungen am Arbeitsplatz. Selbst in Unternehmen mit großen hauseigenen Rechnerkapazitäten sind Time-Sharing-Terminals heute schon keine Seltenheit mehr.

Finanzierung

Das Finanzierungsrisiko bei Miturn über Time-Sharing ist minimal. Der Investitionsaufwand ist äußerst gering. Über 80 % der Gesamtkosten fallen nur bei Benutzung des Systems an bzw. sind kurzfristig kündbar.

Das Miturn-Programmiersystem bietet die Möglichkeit, den Fertigungsprozeß mit numerisch-gesteuerten Drehmaschinen zu vereinfachen, die Produktivität zu steigern und Kosten einzusparen.
Prüfen Sie die Rationalisierungsmöglichkeiten mit Miturn entsprechend Ihren betrieblichen Gegebenheiten. Wir bieten Ihnen gern jede Gelegenheit, Miturn nach Leistung und Kosten kennenzulernen.

Nennen Sie uns Ihre Wünsche auf anhängendem Fragebogen.

TNO miturn

FRAGEBOGEN

Wir sind daran interessiert Miturn kennenzulernen.
Unsere Programmieraufgaben haben folgende Merkmale:

1. Anzahl von NC-Drehmaschinen (evtl. mit Herstellerangaben):

   ....

   ....

   ....

2. Anzahl und Art sonstiger NC-Werkzeugmaschinen:

   ....

   ....

   ....

3. Bisher eingesetzte Programmierhilfen:

   ....

   ....

4. Geschätzte Anzahl der Neuteile (Werkstückserien) pro Jahr:

   ....

5. Mittlere Seriengröße pro Werkstück:

   ....

6. Anzahl und Art von Teilefamilien (Werkstücke, die sich mit begrenzten Konfigurationsänderungen wiederholen):

   ....

   ....

7. Sonstige besondere Anforderungen an das Programmiersystem:

   ....

   ....

   ....

8. Termin für die Einführung des Programmierverfahrens:

   ....

Senden Sie uns bitte Unterlagen zu über:

☐ Miturn-Kurse: In einem 5-Tagekurs wird eine vollständige Ausbildung in Miturn vermittelt.

☐ Miturn-Vorführungen: An Beispielen wird die Arbeitsweise und Wirtschaftlichkeit von Miturn demonstriert.

Alle Angaben werden vertraulich behandelt.

An
Metallinstitut TNO
"Miturn-Programmiersystem"

4000 Düsseldorf
Teplitzer Str. 12

Tel. (0211) 22 36 29

Absender:

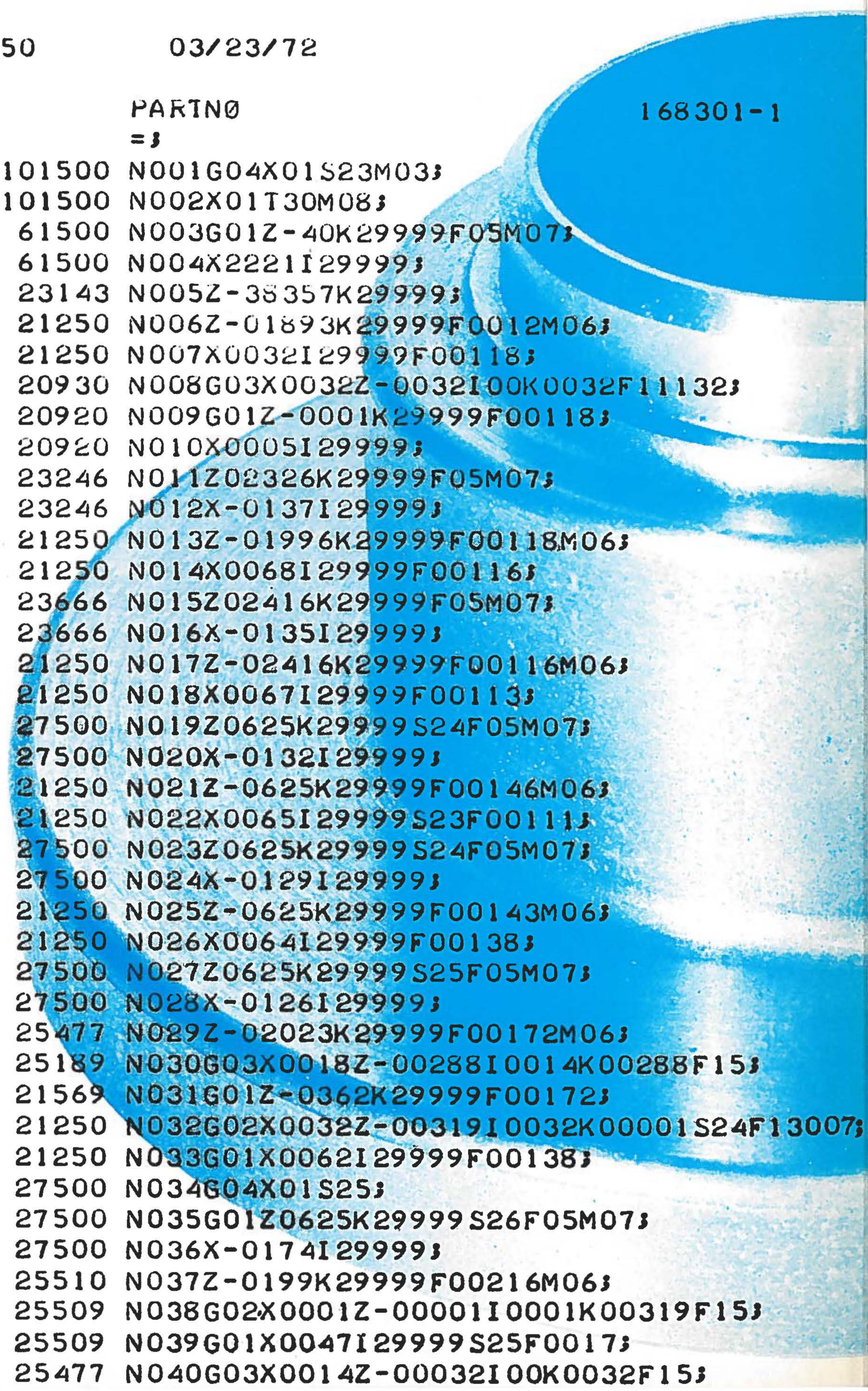
Firma: ....

Ort: ....

Straße: ....

Gesprächspartner: .... Telefon: ....

TNO miturn



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