AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

AN INVESTIGATION INTO THE OPTIMUM SELECTION OF MACHINE TOOLS BY THE AID OF COMPUTERS

A Thesis submitted in partial fulfillment
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in Mechanical Engineering
(Production Engineering)

BY

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S T A T E M E N T

This dissertation is submitted to Ain Shams University for the degree of master in mechanical engineering.

The work included in this thesis was carried out by the auther in the Department of Design & Production, Ain Shams Univresity, from 1988 to 1992.

No part of of this thesis has been submitted for a degree or a qualification at any other university or institution.

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S U M M A R Y

The investments consumed in the purchasing of new machines and equipment represent a considerable percentage of the national expenditures, of which machine tools and the associated equipment represent a great portion , which makes the study of the most appropriate methods of buying such machines very necessary.

The main objective of the purchasing process of new machine tools should be to obtain the most appropriate machines from both technical and economical sides which satisfy the needs and fulfill the required specifications that should be governed by the components they have to produce.

However, deviations may occur, where machine tools which are unnecessary or unsuitable for the purpose and / or do not satisfy the best economical conditions may be purchased.

In order to improve the output of the purchasing process i.e obtaining the most suitable machine tools with minimum investments the following methodology has been suggested in the present work :

1) Improving the accuracy of the determination of the required machine tool specifications, by formulating the suitable relationships between the machine tool specifications and the workpiece features, using the computer to speed up the specification process.
   The program (**OPTIMACH.S2**) have been prepared for this purpose covering :

   -Center lathe specifications (conventional and CNC)
   -Milling machine specifications (conventional and CNC)

2) Because of the high investments needed to purchase CNC machine tools and in order to utilize their potential economic benefits, only those parts which are appropriate for CNC machine tools must be processed on them. A decision making procedure to determine whether to load the machined parts on a CNC or on a conventional machine tool is introduced. This procedure depends on a scoring system related to the complexity features of the workpiece and other production features of the work place.

The computer program (**OPTIMACH.S1**) has been prepared to speed up this process.

3) In order to assist the machine tool selection process, a point system for weighing the main features of the required machine tools is introduced, and is used as a selection criterion to evaluate the machines offered from different suppliers, where a computer program "**OPTIMACH.S3**", is prepared to speed up the selection process.

The previous suggested procedures have been applied to some practical case studies selected from practice. The results proved the success and time saving of the developed procedures.

C O N T E N T S

N O M E N C L A T U R E

Symbol	Units	Description
A	mm	Cutter approach (milling)
A_d	mm	Allowance in diameter
A_l	mm	Allowance in length
A_w	mm	Allowance in width
a	mm	Depth of cut
Bpy		Batches per year
Bsz		Batch size
C_v		Cutting speed constant
D_o	mm	Workpiece diameter
DOB	mm	Maximum bar diameter
D_{max}	mm	Maximum workpiece diameter
D_{min}	mm	Minimum workpiece diameter
D	mm	Cutter diameter
E		Feed exponent
F_a	N	Axial or feed force component
F_c	N	Main Cutting force
F_r	N	Radial force component
G		Tool life exponent
H	mm	Height of tool cross section
K_c	N/mm^2	Workpiece material factor
K_{s11}	N/mm^2	Specific cutting pressure
K_χ		Plan approach angle factor
K_γ		Rake angle factor
K_t		Tool material factor
K_f		Cutting fluid factor
K_w		Tool wear factor
L	mm	Table length (milling machine)
LCD	mm	Maximum distance between centers
L_i	mm	Maximum bore length
L_o	mm	Workpiece length
L_t	mm	Tool overhang

Lx	mm	Transverse stroke
Lz	mm	Longitudenal stroke
M	mm	Cutter shift from workpiece center
M_t	N.m	Torque
n	rpm	Spindle speed
P_f	kw	Feed power
P_c	kw	Cutting power
R		Spindle speed range ratio
R_a	μm	Surface roughness
R_i	mm	Free distance after clamp
R_{in}	mm	Run in
R_{out}	mm	Run out
RVF_i		Required value of feature (i)
R_z	μm	Average peak to valley roughness
r	mm	Tool nose radius
S	mm/rev	Feed per revolution
SCR_{in}		Score of feature number (i)
SOS	mm	Swing over slide
SOB	mm	Swing over bed
SV_nF_i		Supplier value of feature (i)
S_z	mm/tooth	Feed per tooth
T	minute	Tool life
U	mm/min	Feed rate
v	m/min	Cutting speed
V_r	mm^3/min	Stock removal rate
W	mm	Table Width
W_o	mm	Workpiece width
W_i		Weight of feature number (i)
W_M		Correction factor
X_R	mm	Longitudenal stroke of table
X_{vp}	mm	Milling distance in X direction
Y_R	mm	Transverse stroke of table
Y_{vp}	mm	Milling distance in Y direction
Z		Number of teeth of milling cutter
z		Number of speed steps in gearbox

Z_R	mm	Vertical stroke of table
Z_{vp}	mm	Milling distance in the vertical direction
η	%	Overall mechanical effiency
ϕ		Progression ratio in speed gearbox

CHAPTER I

INTRODUCTORY CHAPTER

Metallic parts are initially manufactured as semi finished products by casting, forging, rolling or extrusion. Due to the nature of such processes the products have relatively large dimensional, geometrical and surface deviations. In order to manufacture finished products with a specified quality, machining processes have to be usually carried out on the semi finished products on proper machine tools.

The part to be machined has several surfaces, which should be machined to attain the specified quality which is given by:

- -Dimensions and dimensional accuracy.
- -Form and form accuracy.
- -Surface quality.

In fact these items are determined by the interaction between the cutting process and the MFTW* system, in which the machine tool usually plays a great role. Moreover the rate of production and hence the manufacturing cost of a product are mainly affected by the machine tool on which it is produced.

The great influence of the machine tool on both technical and economical manufacturing aspects of the machined parts, implies a careful selection of the appropriate machine tool on a techno-economical scientific basis.

In order to manufacture a part with the required shape and size on a machine tool, certain coordinated motions must be

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*.Machine, fixture, tool, workpiece

imparted, which are either primary or auxiliary. Primary motions include the principal or cutting movement and the feed movements, which serve the purpose of removing metal from the workpiece. Auxiliary motions are those required for the proper setting of the tool with respect to the workpiece to ensure the successive machining of several surfaces of one workpiece or similar surfaces of different workpieces. They are performed either manually on conventional machine tools or automatically as appropriate movements in accordance with the machining cycle on automatic machine tools.

1.1-Classification of manufacturing operations

All operations in machining a workpiece on a metal cutting machine tool are classified as either processing or handling operations. Processing operations are those in which the actual cutting process or chip removal takes place. The rest are handling operations and include loading and clamping the work, advancing and withdrawing the cutting tools, releasing and unloading the work, checking the size of the workpiece, etc.

In up-to-date machine tools, the processing operations are performed by the operative mechanisms of the machine tool. Handling operations are performed in various ways in different machine tools. A part or even all of the handling operations are performed in certain cases by corresponding mechanisms. The operator of other types of machine tools performs the handling operations by himself.

The faster the working and handling operations are performed in a machine tool, the less time will be required to produce a workpiece and the more workpieces can be produced in the same period of time by a given machine tool [1].