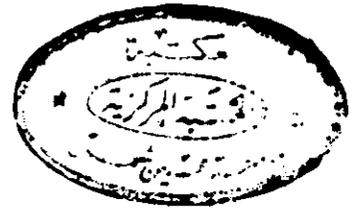


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# OPTIMIZATION OF SOME MACHINING VARIABLES IN TURNING

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## S U M M A R Y

The economics of machining processes depend mainly on the assigned values of the machining variables; cutting speed, feed and depth of cut, which are usually determined from engineering tables or by mere experience.

A preliminary statistical study carried out in one of the military factories, among engineers and skilled lathe operators, revealed that the machining variables determined either from the engineering tables or by experience vary widely in a random manner from one person to another. On the other hand, the operators were found to have a general tendency towards the selection of small values of the machining variables. The selected values were found to lie far from the optimum values, which leads to relatively higher manufacturing expenses and lower production rates.

This emphasized the need for a scientific method for the determination of the optimum machining variables, which takes into account the different factors affecting the machining process.

The aim of the present investigation was to develop an optimization technique for the determination of the optimum machining variables in turning.

The machining problem was dealt with as an operations

research problem. A mathematical model of the machining process in turning was established which involves the objectives and the restrictions encountered in machining.

The possible constraints were investigated both in rough-and in finish machining. In order to express the different constraints mathematically, empirical relationships relating the different machining quantities e.g. cutting forces, cutting temperature, tool life, machine tool overall efficiency and surface roughness to the machining variables were obtained experimentally.

The machining tests were carried out using carbide tools in rough-and finish machining of some tool steels (C125W2, X210Cr12 and 142WV13) which are widely used in the manufacturing of forming tools (pressing, deep drawing, extrusion, .... etc).

The obtained functions were properly arranged to construct the mathematical models of the machining process. The problem was handled by two different optimization techniques; the Big-M simplex method dealing with the linearised model, and the technological logic algorithm developed in the present work, dealing with the general nonlinear model.

According to the proposed optimization strategy, the

corresponding optimization algorithms were developed. Computer programs were prepared to determine the optimum values of the machining variables for each of the two methods. The application of both techniques to the manufacturing of a metal forming punch as a practical example has resulted in the optimum values for each machining step.

While the same values of the output data were obtained by using either technique, the computational time and hence the computational expenses in the cases of the developed technological logic algorithm were found to be half those of the linear programming method. Moreover the computer core store used in the case of the technological logic algorithm was less than that in the case of linear programming by 35%. Accordingly, the technological logic algorithm developed in the present work is more efficient than the linear programming technique.

An economical comparison between the machining test results obtained for C125W2 (high carbon tool steel) using the optimum values of the machining variables (minimum manufacturing cost criterion) and those using the practical values indicated that the machining time can be reduced by 65% and the manufacturing cost can be reduced by 82% by using the optimum machining variables.

Materials having poor machinabilities result in

relatively lower optimum machining variables and hence higher manufacturing costs.

The values obtained according to the maximum production rate criterion, on the other hand, were found to be too high to be attained with usual machine tool capacities, so that the minimum manufacturing cost criterion is more convenient to be used as an objective function in the optimization process.

The optimum values obtained by the aid of the computer were tested by actual machining tests. The measured quantities (cutting temperature, tool life,  $b_{lim}$  ....etc) were found to lie within  $\pm 7\%$  of the calculated values. The optimization technique developed in the present work is therefore recommended to be used as a standard program for the determination of the optimum machining variables in industry.

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SYMBOLS LIST

Symbol	Computer Code	Units	Definition
$a$	A	(mm)	Depth of cut
$a_{lim}$	ALM	(mm)	Limiting depth of cut
$a_o$	AO	-	
$a_1$	A1	-	Parameters of the (u-v) relationship
$a_2$	A2	-	
$a_{max}$	AMAX	(mm)	Maximum depth of cut
$b_{lim}$	BLM	(mm)	Limiting width of cut
B	B	(mm)	Flank wear land
C	KOL	-	Coolant code
$C_b$	CBU	-	Constant of the BUE relationship
$C_\eta$	CN	-	Constant of the efficiency relationship
$C_s$	CS	mm/N	Compliance of the MFTW system
$C_o$	CO	-	Constant of the cutting temperature relationship.
$C_{fe}$	CFE	-	Code of the feed gearbox
$C_{sp}$	CSP	-	Code of the speed gearbox
$C_v$	CV	-	Constant of the (T-v) relationship
$d_c$	DS	(mm)	Workpiece diameter at the clamping section
$d_w$	DW	(mm)	Workpiece diameter at the working section
$D_i$	DI	(mm)	Spindle inner diameter (bore)
$D_o$	DO	(mm)	Spindle outer diameter