SOME ASPECTS OF AN INTERACTIVE PROGRAMMING SYSTEM FOR NC MILLING

by

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Dedicated

to

my Parents

CERTIFICATE

The thesis entitled **SOME ASPECTS OF AN INTERACTIVE PROGRAMMING SYSTEM FOR NC MILLING** being submitted by **Mr. B. Satyanarayana** to the Indian Institute of Technology, Delhi, for the award of the Degree of Doctor of Philosophy, is a record of bona fide research work carried out by him. He has worked under our guidance and supervision and has fulfilled the requirements for submission of this thesis, which has attained the standard required for a Ph.D. degree of this Institute. This work has not been submitted elsewhere for the award of any degree or diploma.

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ABSTRACT

The concept of NC (Numerical Control) and CNC (Computerized Numerical Control) in machine tools has contributed a great deal to automation and flexibility in manufacturing. In small/medium batch manufacturing, machining of complex contours with conventional machining is neither economical nor accurate. These can be achieved on a NC milling machine or a machining centre more economically.

The input to NC machine is an ordered set of instructions called part program, that specifies the cutter location data and related machining functions in a machine acceptable format. Manual part programming is easy for simple contours, however, it becomes tedious, time consuming and error prone when the complexity of part configuration increases. A number of computer aided part programming systems such as APT, 2CL, ADAPT are available. These systems need experienced part programmers with knowledge of programming, mathematics and machinability data, since the input data is required in a specific format designed in the system.

The emphasis in the present work is on the design of an interactive programming system which facilitates the operator on the shop floor, having no knowledge in programming, to be able to generate the necessary machine code for machining the components within a short time. The present programming system consists of modules for machining contours, pockets, cams and dies.

The contour milling module can generate the CLDATA for machining profiles bounded by lines and circular arcs. The

machining can be done either in side or out side with conventional or climb milling process. There are mainly three point definitions, ten line definitions and ten circle definitions. A new concept based on triangle construction has been proposed for obtaining the geometry of a circle tangent to two known circles. An algorithm has been developed for eliminating the redundant drive surfaces and providing minimum tool travel for milling the pockets. The system can also provide the required draft to the contour surface.

The cam machining module is designed to provide the necessary NC program blocks for machining the cam profiles. The cam profiles can be defined by geometric curves, by follower motion or through a set of points. A promising new concept for approximating the tool path close to the defined cam profile, within the specified tolerance, has been proposed. The CLIP algorithm, presented in this module, automatically chooses the best of the available interpolations (e.g. linear and circular interpolations) for selecting the intermediate points on the profile to guide the cutter for machining the profile. It provides the minimum number of intermediate points. This module can be used for machining the elliptical profiles and pockets. The cam module, with little modification, is also used for machining the scroll threads of any pitch.

The die module is designed for machining dies, moulds and patterns. The die cavity can be described as a combination of the regular solid surfaces such as spherical segment, frustum of cone, frustum of pyramid, torus segment and frustum of wedge.

Simple algorithms have been developed for generating the CLDATA for any of these primitive surfaces. These algorithms incorporate the type of the cutter (flat end mill, ball end mill and bull end mill) and prepare machining instructions, either for a male die cavity (convex surface) or for a female die cavity (concave surface), as desired. In case of the moulds or patterns, the system provides the necessary shrinkage allowance to the die cavity. Another feature of this module is the machining of the forming dies. In case of these dies, if the dimensions of one of the die halves have been supplied, the system computes the dimensions of the other die half based on the gap to be maintained between them. The programming system is also supported with character machining module. Alphanumeric characters of both normal type and inverted type can be engraved at any location on the workpiece. The inscriptions can be arranged along straight lines in required orientation or along circular arcs.

The influence of the cutting conditions on the economics of the machining operations, becomes increasingly important. NC programming system is more successful only when the proper cutting conditions have been adopted in the part program. A new approach has been proposed for the selection of cutting parameters in this programming system. Non-linear Multiple objective optimization has been recommended instead of single objective optimization methods which are presently in use for metal cutting problems. New NLGP (Non-Linear Goal Programming) algorithms have been developed to provide a satisfactory solution for the multiple objectives with the desired goals.

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