Computerised Programming for CNC Profile Cutting

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INTRODUCTION

Computerised Programming Station is now very commonly used for "off-line programming" of CNC profile cutting machines which keeps the cutting machine 100% free for actual cutting. IBM–PC or compatibles, which now serve as the industry's standard, is normally used. User friendly softwares are available which can be operated without any special knowledg of computer programming. The entire programming is done through graphical interface. The investment in a programming station generally can be recovered in a very short time because of the saving in the steel plate due to effective "nesting" and saving in working capital due to faster turnaround. It also adds flexibility to production since the lead-time required for preparing the nesting is drastically reduced and switching over from one job to another is therefore much easier.

In this paper, the main features of a programming station and the major advantages have been described. A typical schematic flow diagram of a computerised programming station is shown in Figure-1.

The programming is done in three basic steps, which are part creation or drafting, nesting and toolpath generation. Thereafter, the nested program is transferred to the CNC machine. The steps involved are described here.

COMPUTER ASSISTED DRAFTING (CAD)

The first step towards part programming is to define the geometry of the shapes to be cut. Part description is done in the same way as is done on the drawing board by using the integrated CAD type software that normally comes with the software package. Pull down menus and prompts make life easier for the programmer. If any standard CAD system (such as AutoCAD) is already in use, the part drawings can be directly imported to the programming station without having to create those parts all over again. Normally this is accomplished by an information exchange utility program, which can pick up the shapes as long the shapes are presented by the CAD system in standard IGES or DXF files. DWG import option is also often available.

Torch entry/exit (lead-in/lead-out) points on the contour, types and dimensions can be defined in a very user friendly way. To give an example, lead–in will be automatically inserted by the software once the type of lead–in i.e., semi–circular or straight line, and the lead–in distance is selected by the user. The "process" will have to be defined if a multiprocess software is being used.

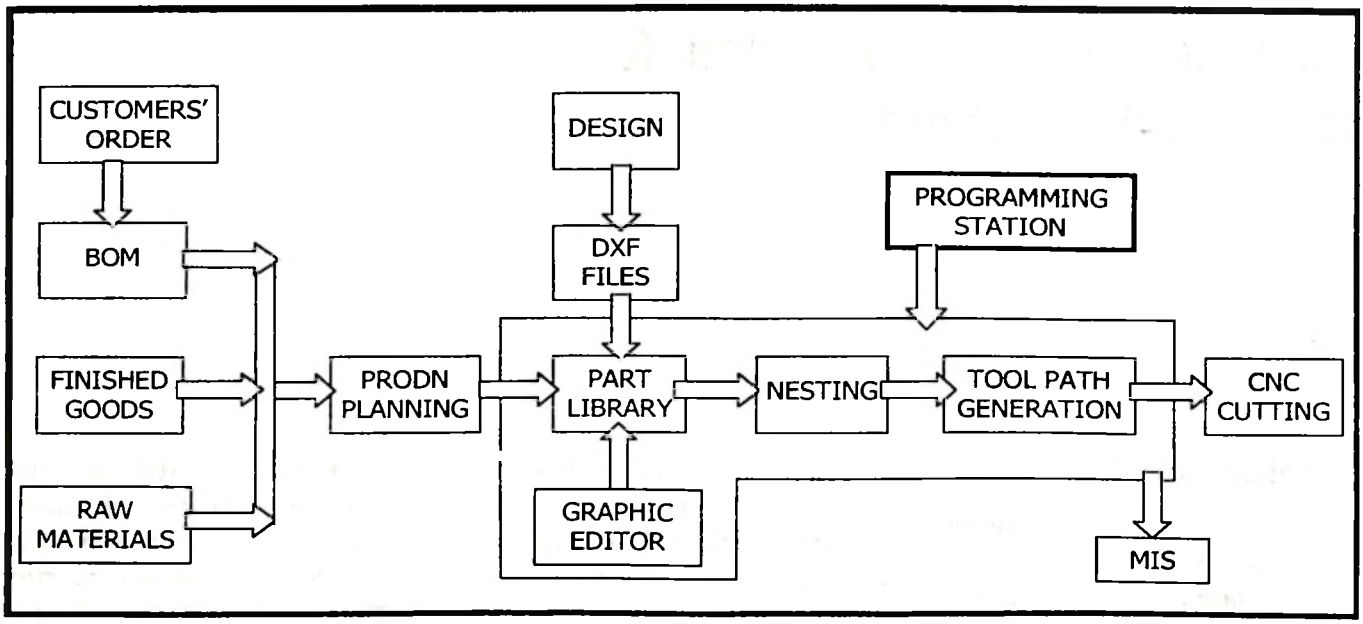
If a programme is being made for cutting a single part, then the toolpath and cutting sequence also need to be defined at this stage.

Figure-2 shows the logical sequences of these basic activities carried out by a part programming module, in the form of a flow diagram.

MARKING

Profile cutting machines are most often equipped with marking device these days. Line marking is frequently used for marking the reference lines for subsequent operations such as bending, welding, etc. Centre points for drilling are also marked on the machine itself. Text marking is used for part identification. The purpose of marking on the cutting machine is to reduce cycle time and improve relative dimensional accuracy of the different operations.

Plasma marking is very popular because of its simplicity. Powder marking, punch marking, ink jet



marking, and many other processes are available. In view of this, marking facility becomes an essential feature in the programming softwares.

Programming for marking is done in a way similar to part definition using the integrated CAD facility. When text marking is used, the software should have the facility to convert the text fonts to machine movements automatically.

NESTING

Nesting is the next step of programming. The purpose of generating nesting is to place and interlace various shapes of same thickness on a given plate in such a way that the utilisation of the plate is maximum and therefore the scrap is minimum.

Efficient plate nesting is therefore of extreme importance. Gone are the days of manual nesting on the drawing board by trial and error method. Nesting can now be done automatically much faster. However, before nesting can be done, a nest requirement file is created with list of parts and quantities against each. Priorities of various degrees, (such as from 1 – 9 and "must nest") are assigned to individual parts. Permission for rotation, flipping, mirroring, etc., can also be assigned to individual parts. Minimum part separation , permission for placing small parts in hole, number of torches to be used, plate size, etc., are also defined. Then the nesting can start.

It may be mentioned here that in automatic nesting, quite contrary to the popular belief, it does not and can not bring out the best solution because that is a mathematical impossibility. The process involves generating different nestings at random and selecting the best out of the lot. This means, in order to get the theoretical best, an infinite number of combinations must be tried; and this will also take infinite time! Therefore, the approach is always heuristic, that is, to find an acceptable solution within a reasonable time frame. Furthermore, there are some process related problems such as distortion, piercing etc., which need the experience of a human mind to solve. Therefore, theoretically obtained "best" nesting may not be good enough from the practical point of view. It is therefore often practical to start with automatic nesting and refine the same by interactive manipulation of the shapes.

Interactive nesting usually offer various features such as jostle, rotate, move, etc., to make manipulation easy. The software will generally allow bridging of parts which are often necessary for controlling distortion and maintaining accuracy of cut-parts.

Output from the nesting gives a cut-list which states how many parts could be placed on the plate against the requirement, so that user can decide if a second plate should be brought in.

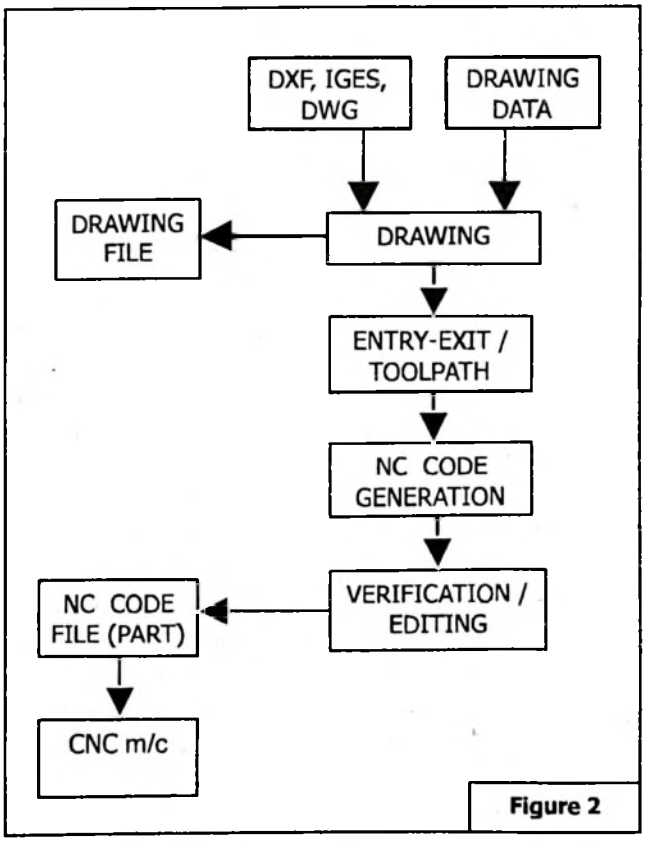


Figure 2

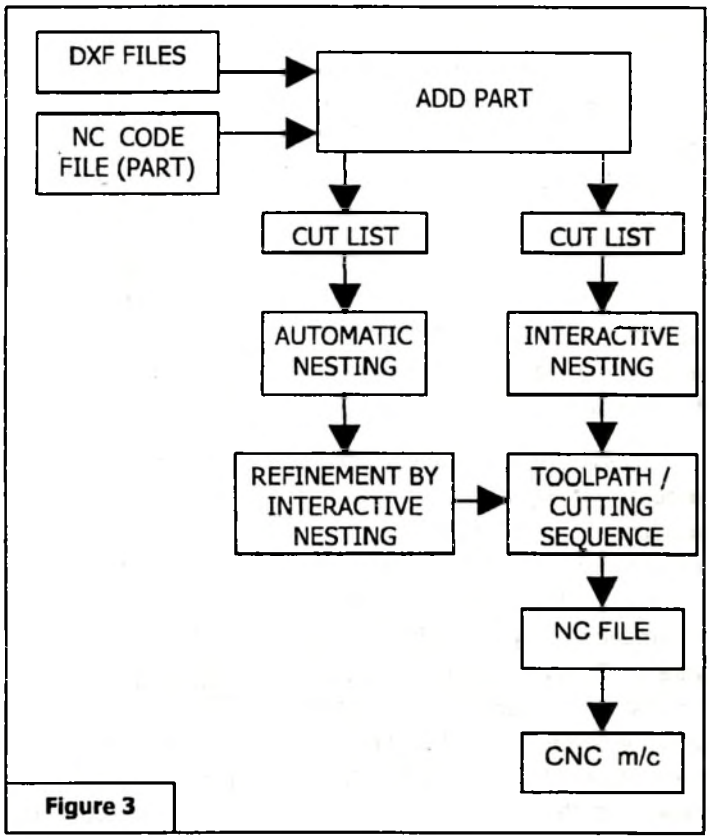


Figure 3

CUTTING SEQUENCE AND TOOLPATH GENERATION

After the nesting is done, the toolpath generation can be done automatically. Preconditions like "minimum rapid traverse" etc., can be defined for generating the toolpath. However, in order to keep distortion to minimum, considerations must be given to the process related inputs, namely the cutting sequence, before finalizing the toolpath. Therefore, refinement by interactive method is usually employed at this stage since these are better done by the intervention of an experienced human mind.

It is desirable to optimize the toolpath in order to minimize the total cutting cycle time. This is classically known as the "traveling salesman" problem. However, it must be appreciated that minimizing the cycle time is not the only goal and due considerations must be given to the process related problems such as distortion control etc, which often affects the toolpath. Therefore, the best toolpath generated by the computer is often not the most desirable toolpath from the practical point of view and an interactive refinement of toolpath is therefore often desirable.

It may be mentioned here that various new cutting methods other than oxy-cutting, such as plasma, laser, water jet, router, etc, are now being used more widely and each of the processes have their own characteristics. Therefore the softwares available often have the facility to generate programmes for any of the processes. This is normally done by selecting the appropriate cutting process during programming. It is often the practice to use marker, plasma and oxy-cutting on the same machine at the same time. The software would generally have the facility for switching and sorting the processes at appropriate stages so that the programme can take care of the multiple processes and the machine operator is not required to intervene during cutting.

Figure-3 shows the logical sequences of these basic activities carried out by a nesting and toolpathing module, in the form of a flow diagram.

PROGRAMME TRANSFER

The software automatically converts the nested toolpath into a series of machine-readable codes in the desired format. The most commonly used format for CNC flame cutting is ESSI, which uses only numerics.

However, word address format (EIA 274), more commonly known as M & G codes, is also often used. Word address is actually a generalised format for all machine tools application. This format uses both alphabets and numerics.

The program thereafter is transferred to the CNC machine for execution and various options for the program transfer are available today.

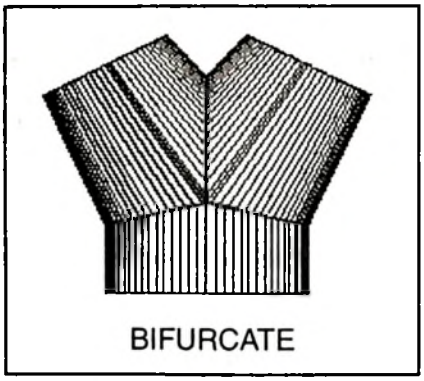
One possibility is to download the program straightaway to the CNC machine from the computer almost instantaneously without any loss of accuracy through the RS232 communication port, using suitable wire or RS422 converter, depending on distance. Punched paper tape, which was the standard of the earlier generation of CNC machines, are now obsolete.

DNC is another concept, catching up in western countries. This allows downloading and distributing jobs from one centralised programming station to more than one CNC cutting machines.

The only limitation of direct communication is the distance and coordination between the programming station and the CNC machine. In such cases floppy or CD can be used provided that the CNC has the facility. A new option which is often available these days is the USB port where the programmes can be loaded on to the CNC using a pen drive.

MIS

After nesting is done, it is possible to get many information using the software which would help us in taking decisions. Information such as cycle time, cutting time, gas consumption, and a print out of the nest can help the operator in planning his work. Costing of parts, weight, etc can be useful for many other purposes such as quotation and design.



OPTIONS

Endless options are now available to make life easy. One such option worth mentioning is a software module meant for pipe joints, space frame joints, lobsters, pipe transformations, bifurcate, etc. Once the user puts in the basic parameters, the programme automatically does the solid modeling, then the development, cut the development into convenient number of pieces, nest the pieces and give out a cutting programme !

Features like estimation, multiple process, DWG import, nesting with DXF, remnant plate nesting and management, digitizing existing drawings, etc., are often available as optional modules. Generally the features are available in the form of independent modules and can be purchased only as required. It may be possible to add modules later and upgrade existing software.

CONCLUSION

Use of computerised programming station for part programming and nesting for CNC cutting is on the increase. This helps in reduction of scrap. Faster nesting preparation ensures shorter lead-time and consequently faster turnaround of capital. It also results in better flexibility of production and better quality of output.

Part creation is done commonly done by an integrated CAD module. It may be possible to integrate the programming station with the CAD system in the design office, which will further eliminate the need of defining the shapes for part programming. Instead the required shapes can be imported from the design office CAD system. Torch entry/exit, marking lines, and text markings are also possible to be defined at this stage.

Automatic nesting can generate a solution, which optimises plate utilisation. However, the solution is always heuristic. Further, in order to take care of the process-related problems, such as distortion, the necessity of modifying the nestings by intervention of an experienced human mind cannot be undermined.

Toolpath of the nesting plan is generated thereafter, again keeping in view the process problems. The computer generates a series of machine-readable code from the nested toolpath automatically, which may be transferred to the machine directly through the RS232 communication ports or by floppy, or by USB port.

The softwares generally come in "modules" so that only the required features can be procured by the user. Various "upgrades" are also available so that features can always be added to the basic modules at a future date depending on requirement. ■