

1979

## The Development and Evaluation of a Self-Instructional Unit on Numerically Controlled Milling

James M. Hoeksema  
*University of Northern Iowa*

*Let us know how access to this document benefits you*

Copyright ©1979 James M. Hoeksema

Follow this and additional works at: <https://scholarworks.uni.edu/grp>

---

### Recommended Citation

Hoeksema, James M., "The Development and Evaluation of a Self-Instructional Unit on Numerically Controlled Milling" (1979). *Graduate Research Papers*. 3864.

<https://scholarworks.uni.edu/grp/3864>

This Open Access Graduate Research Paper is brought to you for free and open access by the Student Work at UNI ScholarWorks. It has been accepted for inclusion in Graduate Research Papers by an authorized administrator of UNI ScholarWorks. For more information, please contact [scholarworks@uni.edu](mailto:scholarworks@uni.edu).

**Offensive Materials Statement:** Materials located in UNI ScholarWorks come from a broad range of sources and time periods. Some of these materials may contain offensive stereotypes, ideas, visuals, or language.

---

## The Development and Evaluation of a Self-Instructional Unit on Numerically Controlled Milling

### Abstract

The objective of this project is to replace the laboratory demonstration with a self-instructional unit (SIU) on numerically controlled milling. The SIU will consist of a cassette tape accompanied by a set of slides. It will be played on a Singer Caramate which will sit directly on top of the machine control unit. The SIU will enable students to satisfactorily complete the NC milling machine activity with no outside assistance.

DEPARTMENT OF  
INDUSTRIAL TECHNOLOGY  
University of Northern Iowa  
Cedar Falls, Iowa 50614-0176

THE DEVELOPMENT AND EVALUATION  
OF A  
SELF-INSTRUCTIONAL UNIT  
ON  
NUMERICALLY CONTROLLED MILLING

James M. Hoeksema

Submitted to the Graduate Committee  
of the Department of Industrial Technology  
University of Northern Iowa  
for the degree of Master of Arts

June 12, 1979

TABLE OF CONTENTS

	Page
INTRODUCTION . . . . .	1
PROJECT RATIONALE . . . . .	1
PROCEDURES . . . . .	2
EVALUATION . . . . .	5
APPENDIX A . . . . .	7
APPENDIX B . . . . .	9

## CHAPTER 1

### Introduction

The Industrial Technology Department at the University of Northern Iowa (UNI) offers a course entitled 33:011 Material Processing Technology. One segment of this course includes an activity on a numerically controlled (NC) milling machine. At present, this activity is an optional exercise that approximately fifty per cent of the students choose to do. All necessary information to complete the activity is given in a laboratory demonstration which lasts approximately fifteen minutes. All students see the demonstration whether they intend to complete the activity or not.

The objective of this project is to replace the laboratory demonstration with a self-instructional unit (SIU) on numerically controlled milling. The SIU will consist of a cassette tape accompanied by a set of slides. It will be played on a Singer Caramate which will sit directly on top of the machine control unit. The SIU will enable students to satisfactorily complete the NC milling machine activity with no outside assistance.

## CHAPTER 2

### Project Rationale

The content of this SIU deals specifically with the operation of the NC mill at UNI. This enables all instructions to be kept simple and specific. This is

desirable since, in most cases, the students using the SIU will have had no previous NC experience.

No programming is covered since this activity utilizes a pre-existing punched control tape. Students who wish to learn numerical control programming are able to enroll in 33:141g Machine Tools.

NC theory is not covered in this SIU. It will be dealt with at a later time in a separate SIU.

Slides and a cassette tape were chosen because of the availability of a Singer Caramate throughout the UNI Industrial Technology Center. Also, slides can be rearranged and thus facilitates additions or deletions to the SIU pending future revisions of the NC activity. If needed, the slides can also be removed from the SIU at random for use in a lecture situation.

### CHAPTER 3

#### Procedures

The instructors of both courses dealing with NC milling, Dr. LaRue and Dr. Revankar, were consulted and it was agreed that if a satisfactory SIU could be developed it would be a useful tool in teaching NC operation and would be used in the 33:011 course.

The Industrial Technology Department provided the materials and supplies needed to produce the SIU.

A meeting was held with Mr. Dick Letsch, the NC instructor at Hawkeye Institute of Technology, Waterloo,

Iowa. He agreed to review the technical content of the SIU and also helped validate the project objectives and content. Originally, content was to include NC theory as well as operation of the NC mill at UNI.

A rough draft of the script was written and a tentative assignment of slides was made to coincide with the analysis of the NC activity presently being used in the 33:011 course. The script was then revised and transferred to a storyboard format. A total of one hundred and twelve slides were needed to cover the content. It was estimated that the SIU would take fifty minutes for each student to experience.

A NC tool board was constructed and mounted on the mill so that students would not have to leave the vicinity while going through the activity (appendix A).

Slides covering the storyboard were taken by the author. A backdrop and flood lights were used at first. The backdrop appeared very unnatural and caused false light readings which gave serious lighting problems.

The prototype of the SIU was presented to the 33:270 Research Projects in Industrial Technology class. They suggested that NC theory and operation of the NC mill be covered in two separate units in that the objectives were independent of one another.

The storyboard was cut to forty-three slides and restricted to operation of the NC mill at UNI. This

made the SIU approximately twenty minutes long. The storyboard was reviewed by Mr. Letsch and Dr. Revankar for evaluation of technical content as well as ease of information flow. Joe Martelli and Marcy Martelli reviewed the storyboard strictly for ease of information flow. The comments, corrections and suggestions of all four were incorporated into a final draft (appendix B).

Slides were taken again without the backdrop and using a flash. The machinery was properly exposed, but the background appeared black. These were also judged as unsatisfactory. Dan Grevas, a photographer employed by UNI, was consulted for advice in taking the slides. He came to the Industrial Technology Center and did some experimental photography himself. Based on his results, a procedure was finally reached that would produce satisfactory slides.

400 ASA Ektachrome slide film was used with available lighting. A three foot square piece of polystyrene was used to reflect the ceiling lights onto shadowed areas. Most of the slides were taken with a one second shutter speed at F 16. This gave maximum depth of field. In a few slides where the plastic reflector was not sufficient, a one half second shutter speed was used at F 16 along with a flash. All copystand slides were taken with a one hundred and twenty-fifth of a second shutter speed and were over exposed one F stop.



In total, four hundred slides were taken to end up with forty-three professional quality ones. Once the correct procedure was worked out approximately eighty per cent were usable.

Another possible contributing factor for the increased percentage of satisfactory slides is that the first two sets of slides were developed by the author and upon the advice of Dan Grevas, all the rest of the slides were professionally developed.

Quakerdale Children's Home, New Providence, Iowa, periodically employs Jim Hemsworth to produce radio spots and promotional slide shows. Quakerdale allowed Mr. Hemsworth to record the script while on their time. The recording was done in the Industrial Technology Center.

The original recording was done on a reel-to-reel tape. This was later edited onto cassette tape. Audible tones were added as the recording was transferred back to reel-to-reel form. A cassette tape was made of this master and inaudible pulses were added.

#### CHAPTER 4

##### Evaluation

Five groups of two students and one group of three students went through the NC milling machine SIU. Of the thirteen students, twelve had no previous NC experience. No special instructions were given to the groups except that they were not to solicit outside help from other students.

At the end of the activity, each group was asked for comments on how the SIU could be improved. Four of the groups indicated no problems and stated that the SIU was explicit and easy to follow.

One group misunderstood frame five where they are told that they will need two pieces of plastic to complete the activity. They took it to mean that each person needed two. Another group suggested that more printed reminders would be helpful as was done in frames thirteen and eighteen. They also would have liked some background music.

Frames twenty-one and twenty-two are designed to prevent damage to the milling machine should it be set-up wrong. One of the groups encountered an improper set-up, and as hoped, got help from the author to remedy the situation before any damage was done.

The average time to complete the activity was twenty-five minutes. All thirteen students satisfactorily completed the activity without the intervention of the instructor. This success rate is evidence of the instructional effectiveness of the numerically controlled milling machine SIU. A copy of the SIU is indexed in the Wagoner Resource Center of the Industrial Technology Center.

APPENDIX A



APPENDIX B

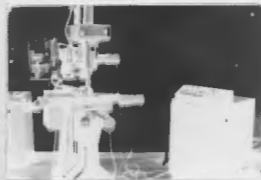
Illustration No. 1



Illustration No. 2



Illustration No. 3



During this program, you will be asked to perform actual milling machine operations. When you hear this tone, (3 sec. pause) stop the audio portion of the program and complete the task that has just been explained. You MUST stop the program within ten seconds after hearing the tone. If you fail to do so, the program will continue without you. When you have completed the task, start the audio portion of the program and continue.

Illustration No. 4



In order to familiarize you with the numerically controlled mill, you will use two different methods to produce two UNI keychains.

It is suggested that you work with a partner, however this is not mandatory.

Illustration No. 5



To complete this activity you will need two pieces of plastic, one eighth inch thick, one inch wide, and two and five eighths inches long. These are pre-cut and can be obtained from the store room. The plastic should have a protective paper on both sides. Do not remove the paper until after the milling is completed and the part has been removed from the jig. The paper will not affect the machining operations and will keep the jig from scratching the plastic.

If you do not have the two pieces of plastic, go get them now.

(tone)

Illustration No. 6



The first step is to secure the workpiece in the jig that is bolted to the table of the mill. The jig must be free from chips before this can be done. If the jig is not clean, get the brush from the tool board and clean it now.

(tone)

Illustration No. 7

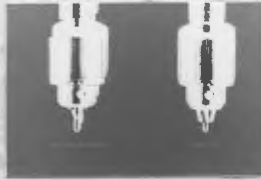


Position the plastic on the jig so that it is snug up against all three of the positioning pins. Then push the handle of the toggle clamp down until it locks and holds the plastic firmly in place.

(tone)



Illustration No. 8



The chuck left in the spindle from the previous cycle will have in it a one quarter inch ball-nosed end mill. You must remove the chuck and replace it with one that holds a three sixteenths inch drill bit.

Illustration No. 9



To remove the chuck, you must first lock the spindle so that it will not rotate. There is a locking pin on the left side of the milling machine head. Push up on the pin and rotate the spindle by hand until the pin engages a hole and the spindle locks.

Illustration No. 10



Get the spanner wrench from the tool board and position it on the spindle nut so that the nut will turn clockwise

as viewed from below the spindle. Apply just enough torque so that the locking pin will not disengage when you let go of it, but don't apply so much torque that it loosens the spindle nut.

Illustration No. 11



Hold on to the Jacobs chuck with your free hand and increase the torque with the spanner wrench until the spindle nut breaks loose. When this happens, remove the spanner wrench and rotate the nut clockwise until you feel it click into a stop position. It should only rotate about one quarter of a revolution before you feel the click. Don't go past the spring loaded stop. The nut must be in this position to remove or install a chuck. In this position, the chuck should fall free from the spindle.

Illustration No. 12



If the chuck doesn't fall free of the spindle, tap

it gently with the heel of your palm while holding on to it with your free hand. Be careful never to let a chuck fall onto the jig or table as this will damage both.

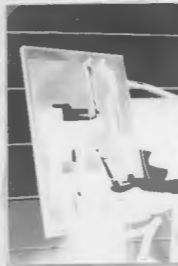
Illustration No. 13



At this time, remove the chuck with the end mill in it.

(tone)

Illustration No. 14



Hang the end mill chuck on the tool board and exchange it for the chuck containing the three sixteenths inch drill bit.

Illustration No. 15



Push the chuck into the spindle and rotate the spindle

nut counter clockwise one quarter turn or until it is hand tight. The chuck cannot fall out of the spindle now so you may let go of it.

Illustration No. 16



Lock the spindle and snug down the spindle nut with the spanner wrench. Be careful not to over-tighten the nut.

Illustration No. 17



Release the locking pin and rotate the spindle by hand to make sure that the locking pin has disengaged.

Illustration No. 18



Stop the audio portion of the program now and install the chuck with the three sixteenths inch drill bit.

(tone)

Illustration No. 19



The next step is to set the switches on the machine control unit.

Illustration No. 20



The feed rate switches in the upper left hand corner should be set at twelve inches per minute for both the X and Z axes, and at eighteen inches per minute for the Y axis. The switch labeled "TAPE/MAN" should be in the "TAPE" position. The "AUTO(DATA)/STEP(JOG)" switch should be in the "STEP(JOG)" position. And the "COMPENSATION" switch should be "OFF". Make sure that the switches are in these positions.

(tone)

Illustration No. 21



Get the aluminum set-up block from the tool board and place it under the drill bit. Make sure the table is clean before you set the block there.

Illustration No. 22



The tip of the drill bit should just skim the top of the block. If this is the case, continue with the program. If not, stop and get help from your instructor.

(tone)

Illustration No. 23



Turn on the power switch on the right side of the machine control unit. A green indicator light should come on and you should hear a whining sound. After a

few seconds you should hear a fan inside the machine control unit.

(tone)

Illustration No. 24



Before you start to do any machining, you should know how to stop the mill in an emergency situation.

If you see that the cutter is going to dig into the jig or some part of the mill, you should push the "ALL STOP" switch. This will immediately stop all movement of the workpiece and a red indicator light will come on. Should you need to do this, do not attempt to restart the mill yourself. Get help from your instructor.

Illustration No. 25



If you push the "START/STOP" switch to the "STOP" position, it will only stop the input of information to the machine control unit. If the mill were in the middle of a cut, it would ignore this stop command and continue until it reached its destination. So, if there

is an emergency, push the "ALL STOP" switch and not the "STOP" switch.

Illustration No. 26



You are now ready to start machining. To start the spindle rotating, push the green button labeled "FOR" on the left side of the milling machine head.

(tone)

Illustration No. 27



Next, press the switch labeled "START/STOP" to the "START" position, release it and press it a second time. The white cycle light will come on and the cutter will move to a position directly above where the right hand hole in the keychain should be. Push the "START" switch again and the cutter will lower to drill the hole. Push it again and the cutter will raise out of the hole. Since you are on the "STEP(JOG)" cycle, you will have to press the "START" switch to initiate each new tool position.



Illustration No. 28



Continue in this manner until both holes are drilled and the tool has positioned itself above and to the left of the workpiece.

(tone)

Illustration No. 29



You are now in the "tool change" position. Push the red button labeled "STOP" on the left side of the milling machine head to shut off the power to the spindle.

Illustration No. 30



The spindle can be brought to a quick stop by pushing the white brake knob on the front of the milling machine head.

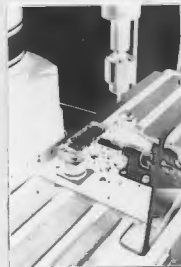
Illustration No. 31



Now exchange the cutters once again so that you have the chuck with the ball-nosed end mill in the spindle. Remember that the spindle nut only needs to be loosened approximately one quarter turn counter clockwise.

(tone)

Illustration No. 32



Once you have the end mill in the spindle and have rotated it by hand to make sure the locking pin has disengaged, you are ready to finish machining the keychain. Start the spindle rotating forward. Now push the "START" switch on the machine control unit to initiate each new tool position until the letters UNI are engraved on the plastic and the cutter is back at its original starting position.

(tone)

Illustration No. 33



Push the "START" switch one more time to rewind the tape in the machine control unit.

(tone)

Illustration No. 34



Stop the spindle and remove the plastic from the jig. Clear away the chips with the brush and place the second piece of plastic in the jig.

(tone)

Illustration No. 35



Change the cutter again so that you are ready to drill the three sixteenths inch holes.

(tone)

Illustration No. 36



Push the switch labeled "AUTO(DATA)/STEP(JOG)" to the "AUTO(DATA)" position.

(tone)

Illustration No. 37



Start the spindle rotating and push the "START" switch on the machine control unit. The white cycle light should come on. The mill should now automatically repeat the same steps you walked it through earlier.

Illustration No. 38



After the tool change, you will have to press the "START" switch once more.

(tone)

Illustration No. 39



When the cutter has returned to its original starting position it will automatically rewind the tape. When you get to this point, stop the spindle and remove the workpiece from the jig. Turn off the power switch located on the right side of the machine control unit.

(tone)

Illustration No. 40



Peel the protective paper off the engraved side of the plastic so you can examine your machining. It will be a good idea to leave the paper on the bottom of the plastic for protection since you will need to smooth the edges on a disc sander.

(tone)

Illustration No. 41



Using the brush, clean the chips off of the jig as well as the rest of the milling machine.

(tone)

Illustration No. 42



Now take your plastic pieces to one of the disc sanders in the wood working end of the lab and smooth the edges. Once you have done this, take the finished keychains to your instructor for evaluation.

(tone)

Illustration No. 43

