Getting Started With Setup Reduction Curriculum:

The need for setup reduction

Traditionally, CNC users have not had to run CNC machines at peak potential. The sheer productivity of CNC machines (compared to their manual counterparts) has thrilled many a CNC user. However, things have been changing in the manufacturing environment. Lot sizes are shrinking. Lead times are shorter. Quality expectations are higher. And of course, operating expenses must be reduced.

All of this requires CNC users to provide faster turn-around for the workpieces they produce – and a big part of faster turn-around is related to reducing the amount of time a CNC machine is down during a production run, which of course is the very definition of setup.

All CNC users should have a strong interest in setup reduction. Even people with years of experience should be interested in finding new ways to minimize setup time, meaning you should be able to draw from an entirely new student base, dramatically increasing the number of potential students for your CNC courses.

This course will allow you to relate the setup reduction from the ground up. The objective of this course curriculum is to help instructors relate concepts, techniques, and ideas that will help students go back to their companies and implement a successful setup reduction program.

The presentations of Setup Reduction

We divide the curriculum into four presentations. Each has parallel material in the slide shows (your visuals) and the student manual. Students will be able to easily follow along in their student manual with the presentations you make. And the manual will make an excellent reference when they return to their shops and begin putting this new information to work.

Presentation one: Basic premises (58 slides, about 1-1.5 hour presentation time)

This short, but important, presentation lays the groundwork for what is to come. Included are presentations that acquaint students with important needs of CNC using companies. We discuss application versus utilization and machine utilization versus personnel utilization to help them understand the reasoning behind improving CNC machine utilization. We also introduce the four CNC-using company types and discuss factors making up a company's corporate identity. Finally, we discuss the importance of value added principles in the CNC environment.

Presentation two: Preliminaries (26 slides, about thirty minutes of presentation time)

Here you present principles of setup reduction that can be applied to any form of production equipment. Topics include definition of setup time, the two task types related to setup, the three ways to reduce setup time, and the four steps to setup reduction.

Presentation three: Setup reduction principles (53 slides, about an hour of presentation time)

We include some preliminary information to be sure students understand intentions. Included are presentations on the importance of reducing setup time, justifying expenses, just what is being reduced, and available resources.

Presentation four: Setup reduction techniques (334 slides, about six to eight hours presentation time, depending upon students' level and interests)

In this lengthy presentation, you'll be suggestion countless techniques for setup reduction in the approximate order that setups are made. Main topics include preparation and organization, workholding setup, cutting tools, program zero assignment, program development, program transfer, program verification, and program optimizing. In each main topic, you'll first present typical tasks. Then you'll make recommendations for eliminating tasks, moving tasks off line, and facilitating tasks.

We provide two presentations for some topics (workholding setup, cutting tools, and program zero assignment), one for machining centers and another for turning centers. During the slide show, you can interactively choose whether you want to present one or the other, or both.

Presentation alternatives

We offer some suggestions about how you can best present this course.

In seminar fashion

As you've seen from the approximate presentation times, you'll be able to complete the lecture portion of this course in a relatively short time. When teaching public seminars, I commonly complete this course in one eight-hour day. But keep in mind that the entire course is lecture, with limited time for anything else. While I do encourage participation in the form of questions, comments, and suggestions, students are not working on any projects or exercises. I'm simply assuming students have a high enough interest to make special note of those principles and techniques that apply most to their CNC environments.

You too can, of course, present this material in seminar format, possibly as part of your continuing education programs. You can hold an eight-hour, one-day course, as I do. Or you can break it up into three or four sessions, over the course of a week or month. (Remember that you'll need to review more if there are long periods between sessions, which of course adds to presentation time.)

As part of another course

You may have current CNC-related courses that go beyond the basics. A presentation on setup reduction would work nicely in such a course. While we leave the timing to you, this series of presentations could form one of the modules in any advanced CNC course that strives to improve a student's ability to improve CNC machine tool utilization. Note, for example, that we have other curriculums aimed at cycle time reduction, parametric programming, and advanced CNC techniques. These curriculums blend nicely into a more advanced course we call Maximizing CNC Utilization. Again, the eight hours or so needed to present the setup reduction material should be easy to incorporate into another, longer course.

As a more traditional course – including exercises and activities

It is possible that you're trying to incorporate this material into a more traditional course for setup reduction. In this case, you'll probably want to include lectures, exercises, and lab work in the course. This curriculum material will, of course, work nicely as the lecture portion of the course. And while we provide two exercises to test the student's comprehension of materials presented in Basic Premises and Setup Reduction Principles, you'll be on your own to develop exercises, lab work, and group activities – filling in the rest of the time students will be in class.

We have some suggestions for these additional activities. Admittedly, most technical schools have limited resources when it comes to CNC in general and setup reducing accessories specifically, but this may actually work to your advantage when it comes to develop setup-reducing activities. You'll can easily supply some real-world scenarios that allow great room for improvement.

We recommend stressing at least two different approaches to setup reduction – one aimed at people working for a company with limited resources (like most job-shops) and another for companies that have the resources to engineer most aspects of their CNC environment.

Note that most technical schools tend to stress techniques used by job-shops for several reasons. First, like most job-shops, schools have limited resources. It can be difficult to demonstrate techniques that require greater resources if you don't have the resources. Second, since most students attending basic courses have no experience, you must stress easy-to-understand ways to accomplish tasks. While this may be great for beginners, the easy way to accomplish a task is seldom the most efficient way.

Again, you'll have some pretty good scenarios to improve upon. You'll be able to help students compare entry-level methods to more advanced methods – with the goal being to improve setup time.

Again, we provide two exercises to test comprehension of basic premises and setup reduction principles. But when it comes to providing exercises related to setup reduction techniques, we recommend that you have students take a more hands-on approach. For each major setup category, have students practice setup reduction using the four-step setup reduction approach given during setup reduction principles. Have them use the setup reduction form (a printable handout on the CD-rom disk in the "written documentation" folder).

If your students are coming from industry and they currently work for a CNC using company, we recommend having them use their own company's methods for exercises. If they're not coming from industry (at least not currently working for a CNC using company), have them work on projects in your school's shop.

With each major setup category, have them go through the entire process of reducing setup time, including the videotaping of each task to be able to evaluate current methods. Here are some specific suggestions for each major category.

Preparation and organization (general)
Use your own shop to show organization techniques. Are hand tools conveniently stored? Where and how are cutting tools stored? What about workholding devices? Would your school's storage and organization methods be appropriate for a manufacturing company? What improvement could be made give better resources? Does everything have a place and put back in its place?

As a specific exercise (possibly a group activity) have students design a setup person's work area. Set some criteria (number of setups required per day or week, typical lot sizes, typical cycle times, typical workholding devices and cutting tools, etc.) and see if students can come up with appropriate decisions based upon the criteria you set.

Preparation and organization (for a specific setup)
Confirm that students can tell when a setup person is truly ready to make a setup. The setup person, must of course, have everything needed to make the setup. This involves a lot of gathering, including raw material, workholding device, cutting tool components, and so on. See if students can develop an extensive setup sheet and storage area to allow all components to be labeled and stored.

Again, be sure students understand that companies have different needs. If the related tasks cannot be done off line, all of this gathering must, of course be done while the machine is down. In this case, students must be able to design a very efficient storage and retrieval system – keeping everything very convenient to their CNC machine tools. On the other hand, companies that have ample time to perform these tasks off line may want to centralize their storage and retrieval, possibly doing so with a tool crib.

While the time related to having your students design an efficient tool crib may be excessive, be sure they understand the impact of preparation on setup time. At the very least, assign a project that has them determining the various items that must be gathered.

Workholding setup (machining centers)
Using one of your own workholding devices, have students videotape a someone making a workholding setup and go through the entire four-step process to reduce this time-consuming task. Based upon your school's resources, it's likely that the workholding device being uses will not allow a qualified setup to be made, meaning students should be able to come up with many suggestions to eliminate tasks, move them off line, and facilitate them.

Workholding setup (turning centers)
Using your own workholding device (probably a three jaw chuck), have students videotape a someone performing the tasks related to workholding setup (mounting jaws, boring jaws, setting clamping pressure, etc.). Have them go through the entire four-step process to reduce these time-consuming tasks. Students should be able to come up with many suggestions to eliminate tasks, move them off line, and especially facilitate them.

Cutting tools (machining centers)
Do the same with cutting tools. Again with all components gathered, have students videotape what it takes to assemble, measure, load, and enter offsets for a variety of cutting tools. And again, have them come up with suggestions for improvement. It's likely that your school is teaching students (in basic courses) how to measure offset values for tools right on the machine. Be sure to expose students to how this can be done off line.

Cutting tools (turning centers)
Do the same with turning center cutting tools. Again with all components gathered, have students videotape what it takes to assemble and load them for a variety of cutting tools. And again, have them come up with suggestions for improvement.

Program zero assignment (machining centers)
Stress the difference in program zero assignment tasks between qualified and non-qualified setups. Have students work on facilitating program zero assignment tasks if setups cannot be qualified. If possible (you may not have workholding devices that can be qualified), show students how all program zero assignment tasks can be eliminated if making qualified setups.

Program zero assignment (turning centers)
Stress the difference in program zero assignment tasks between touching off tools and using a tool touch off probe.

Program development
Stress the difference in programming methods for companies that must prepare programs while the machine is down (no off-line time) and companies that can prepare programs while the machine is in production.

Program transfer
Show the impact that loading programs can have on setup time. See what they can come up with to help facilitate the related tasks. It's likely that your school has some kind of manual DNC systems that can be used to demonstrate program transfer tasks. Be sure students understand that most controls allow programs to be transferred while the machine is in production (with background edit). Demonstrate this feature if you have it. Also make sure students understand that there are automatic DNC systems that eliminate the need to walk from the CNC machine to the serving computer during program transfers.

Program verification
Show the impact program verification can have on setup time. Also demonstrate the use of programmed trial machining (as shown in the slide show presentation). Again, see what students can do to eliminate, move off line, or facilitate the related tasks.

Program optimizing
If your controls allow parametric programming, demonstrate the techniques shown in the slide shows related to variable programming of cutting conditions and approach distance.

Admittedly, much of what we've suggested is common sense. And it's likely that you can easily improve upon the suggestions made. Truly, anything that helps students get a better understanding of real-world setup reduction methods should be fair game for what you do.

About the student manual
Again, the student manual includes all four presentations. It should make for excellent homework assignments, and should provide a good reference for students when they actually start applying the techniques they've learned.

Take it on the road!
This material can, of course, be taught on an in-plant basis. There are many portable projection systems available. See the various methods to display the slide shows later in this document. The least expensive way (if you don't have a portable projector) is a laptop computer with TV-out and a television.

Instructor materials

This curriculum truly minimizes the preparation you must do to get ready to teach! Here's what you get.

Microsoft PowerPoint slide presentations

PowerPoint is becoming the presentation software of choice by most presenters. These presentations total over 400 slides to provide your visuals for the course. Note that they're developed in PowerPoint 97 (which is part of Microsoft Office 2000). We actually offer two sets of slide shows, one with audio guidance and the other without. Audio guidance will help you understand how to present material in the course. On selected slides, you'll find an instructor icon (as well as a stop-play icon) that, if clicked, plays an oral description of what you're supposed to be doing at the current point in the slide show. Note that the slideshows with audio guidance are quite long and will take a long time to load (distracting during a class), so we provide another set of slide shows without guidance that will load much faster. The two sets of slideshows are provided on the CD-rom in aptly named folders.

Guidance during slide shows

Again, one set of slideshows includes audio narrations (we call guidance) to help you understand how to make your presentations. Note that these narrations are not intended for your students. Each is directed at an instructor getting ready to teach the course. A special icon on selected slides can be activated to play the related narration.

Microsoft PowerPoint Viewer

Though we highly recommend that you have the actual PowerPoint software, we do include the PowerPoint Viewer. It does allow you to display the slide shows, but you'll have no way to modify them. Additionally, the slide shows are quite long (one over 300 slides). PowerPoint Viewer does not allow you to move around in the slide show nearly as easily as the actual PowerPoint software.

Exercises and answers

We provide two exercises, one for the presentation of basic premises and the other for setup reduction principles which will help you test the students comprehension of these two topics. They're included in a file called "Exercises and answers" in the Written documentation folder of the CD-rom disk.

Ability to print slide show hard copy

PowerPoint allows you to print a hard copy of each slide show (Microsoft calls this printing *handouts*). This may help you prepare if you don't have the computer available. You can include 4, 6, or 8 slides per page.

Free phone assistance

Again, there's a lot of information in this curriculum. If you have questions about any topic, we welcome your phone calls (847-639-8847). Or email us at lynch@cncci.com.

Student materials

While your presentation is an extremely important part of the learning environment, your students must have reference material.

135 page student manual

This extremely comprehensive manual follows along with your presentation step-by-step. Though we don't recommend actually reading from it, students should be able to easily follow along in the manual. It will make for excellent homework reading assignments. And, it's an excellent way for students to review material once the course is finished. Because there is so much information in the book, we recommend that students have some way to remember key pages (a highlighter pen or post-it notes to act as tabs in the book work nicely).

What you still need

In order to show the PowerPoint slide presentations to a group of people, you need the following items.

A computer with Windows 98 (or higher) - Just about any current model computer will work. For best results, Pentium class is recommended (minimum 64 megs internal). If using a desktop computer, you can easily watch the monitor of the computer (facing your audience) to see the slide show as slides are displayed behind you by the projection system. Since the left mouse button advances the slides, you even have a remote slide advance button (as is commonly used with a 35 mm slide projector). If portability is an issue, keep in mind that many of the notebooks and sub-notebooks have ample power to run the presentation software. However, be careful in your selection. Many notebooks do not allow you to send data out through the VGA port *and* see the slide show on the LCD screen of the notebook at the same time. Without this ability, you may have to turn around to see your slides, which can be distracting to your audience. Also, for maximum flexibility, look for a laptop that has the TV-OUT feature. This lets you send composite video to any television that has a TV-IN port with a simple RCA cable.

Microsoft PowerPoint Software (PowerPoint 97 version was used to create the slide show) - Though you can display all presentations with PowerPoint Viewer (included with this curriculum), you will need Microsoft PowerPoint if you intend to modify the slide shows given in this curriculum (and to easily get around and start the slide show from any slide). We highly recommend that you have this ability. This software can be found in any computer store for a price of about $250.00 (it also comes with most editions of *Microsoft Office*). You will find this to be a very powerful presentation-generating program; one you can use to develop your own slide shows for other courses (or of course, modify those in this course curriculum).

A way of displaying the slideshows - You have several alternatives in this regard. Most involve using a device that takes data from the VGA port of your personal computer. First, many schools already have a projection system that can display information from a personal computer. Basically, anything that can be shown on the computer screen can be displayed through the projection system. Second, you can use a device that sits on top of an overhead projector to display your screen shows. In essence, this device makes a transparency of what ever is on the display screen of the computer (I don't like this kind because the light from the overhead is very bright and hurts my eyes). Third, and especially if price is a concern, you can use a simple scan converter (about $200.00 - $300.00) and display your screen show on any television that has a *video in* connector (as most do). Note that many laptops are now coming with a TV-OUT port, having this scan converter built in to the computer. If you must use the RF connector of the television (where an antenna plugs in), an RF converter must be purchased. Since there are so many alternatives for displaying your slide shows, we welcome phone calls (847) 639-8847 if you have questions about your alternatives.

A note about the students you'll attract

In my experience, experienced CNC people have a rather narrow focus. They know a lot about the things they must do every day, but little or nothing about other important CNC-related topics. I'm always amazed by how surprised experienced CNC people are about many relatively basic features they just haven't been exposed to. For example, a person that does general purpose CNC machining will know little about five axis machining – and vise versa. Be sure to take advantage of your students' strong points. As you present the course, be sure to solicit questions and comments each step along the way. We encourage student participation quite often during the slide presentations (at the end of each major topic in setup reduction techniques, for example). The more you can get people to contribute during the class, the better the class will be. And you may be able to collect ideas for future classes!

Remember that your students for this course may have (possibly extensive) CNC experience. I've found that most catch right on to the presentations being made, even for those topics that they've never been exposed to. With the exception of techniques that require parametric programming , you can minimize the tutorial method you're probably using to teach your basic CNC courses. While reviews are still helpful, they can be minimized. Instead of lengthy reviews at the beginning of each session, I simply poll the class for questions. When students have questions, I'll dig back in as deep as necessary to make sure they understand. And I will, of course, bring everyone up to speed on where we left off in the last session, but I do minimize review time.

Putting It All Together

Getting Ready To Teach
As stated earlier, though these course curriculums dramatically reduce the amount of preparation you must do, they do not eliminate it completely. And as any experienced instructor will agree, the key to successful presentations is in becoming comfortable with the material you present. And the only way to get comfortable is through adequate preparation.

Before your first course:
Skim the entire curriculum (at least those modules included in your current course) - Though you do not have to be perfectly comfortable with every detail of the curriculum to begin teaching, you will at least need to understand where the course is going. You can use the course outline, guidance in the slide shows, and student manual to gain an appreciation for the material being presented.

Before beginning each module:
Get comfortable will all discussions in the presentation - While some presentations are relatively short, most are lengthy. Be sure you feel comfortable with all points you need to make before you begin teaching. Again, use the course outline and student manual to increase your comfort level with the entire module.

Before you deliver a session:
Get ready to teach! - Study the lesson plan, guidance, and slide presentation in order to gain an understanding of key points that must be delivered during your presentation. Because modules vary in length, be prepared to review material covered in previous sessions if appropriate.

During your presentation of each session:
Tell them what you're going to tell them - The lesson plan (key points in the slide show at the beginning of each module) will help you prepare your students for what they will be learning. While you don't have to dwell on this slide too long, it will help them know what is coming up.

Tell them - Go though the session, using your slide show as a guide. Be sure to point out the page numbers and sections in the student manual where the information is also included for their own independent study. Be sure everyone is catching on. Encourage participation, questions, and comments. In fact, some of the best suggestions for future additions to your class will come from students. You'll be getting some pretty high level attendees, so take advantage of this opportunity. Have a blackboard or overhead available for making special points.

Tell them what you told them - The lesson summary (included in the slide show for each module) will let you summarize the key points of each lesson.

As you get deeper into the course:
Review often - No student will retain every word of every presentation you make during a course as lengthy as these. On average, you should spend about 10% to 20% of your session time in review, depending upon how well your students are doing. The more problems they are having, the more time you should spend on review.

Let students know where they stand - Be sure everyone knows how they are doing as they progress through the course.

Setup Time Reduction Planning

Part name:	Part #:	Process #:
Step One - Evaluation of current setup	**Tasks currently being done off line:**	
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
	Total time for off-line tasks:	
On-line Tasks	**Related to *preparation* to make setup:**	
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
	Total preparation time:	
Tasks related to tear down of last setup		
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
	Total teardown time:	
Tasks related to making work holding setup		
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
	Total workholding setup time:	

Setup Time Reduction Planning

Tasks related to cutting tools		
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
	Total time for cutting tools:	
Tasks related to CNC program development and transfer		
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
	Total program transfer time:	
Tasks related to CNC program verification (including running first good part)		
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
	Total program verification time:	
Tasks related to first workpiece inspection		
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
	Total first workpiece inspection time:	
	Waste	
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
Task:	Who does?:	Time:
	Total wasted time:	

Off-line time (from page one):		Total on-line setup time:	

Setup Time Reduction Planning

Step Two - Brainstorming for improvements Based on your evaluation, list potential areas of improvement.

Eliminating tasks:

Related task:	Idea:	Cost/Difficulty	Gain:

Moving tasks off line:

Related task:	Idea:	Cost/Difficulty	Gain:

Facilitating tasks:

Related task:	Idea:	Cost/Difficulty	Gain:

Setup Time Reduction Planning

Step Three - Assignment of improvements

Using ease of implementation, cost effectiveness, and the potential for return as your guide, prioritize your ideas for improvements.

Priority:	Improvement:	Assigned to:	Completion date:
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

Step Four: Gaging success	Original on-line time:	Original off-line time:

With each major improvement (or group of improvemnts), you'll want to confirm that the improvement had the expected result. What you'll likely find is that by implementing one improvement, another will occur to you (this is quite common in any continuous improvement program). By repeating step one (the evaluation step) at regular intervals, you'll be able to gage the true effect your improvements have had on setup time.

Date:	Improvements since last evaluation:	New total on-line time	New total off-line time

Student name: Date: 8.33% each Score (of 100%):

1) CNC machine utilization is

- ❑ a) The effectiveness level of CNC machine tools.
- ❑ b) Based solely on how fast CNC machines can cut.
- ❑ c) The effectiveness level of your CNC personnel.
- ❑ d) Based upon the application for the machine

2) The application for a CNC machine is simply what the machine is being used to do.

❑ True ❑ False

3) The wise CNC user should be more willing to have a CNC person waiting for a CNC machine than a CNC machine waiting for a CNC person. Why?

____

____

____

____

4) Name the four CNC using company types.

____

____

____

____

5) Of the following four factors contributing to a company's corporate identity, which is most important?

- ❑ a) Lead time
- ❑ b) Lot size
- ❑ c) % of repeat business
- ❑ d) % of new business

6) For question five, specify why the factor you chose is so important.

____

____

____

____

____

7) Depending upon a company's CNC needs, any factor contributing to company identity could become the most important one.

❑ True ❑ False

8) When a company implements changes to improve personnel utilization, machine utilization usually suffers.

❑ True ❑ False

9) Non-production time is any time when CNC machines are running.

❑ True ❑ False

10) By our basic definitions of setup and cycle time, machines are either in setup or they're in production.

❑ True ❑ False

11) Describe how you can use value added principles to draw people into the CNC environment.

____

____

____

____

____

____

____

____

____

____

12) Conflicts between decisions made and a company's corporate identity do not affect productivity.

❑ True ❑ False

Setup reduction | Exercise two | Principles of setup reduction

Student name: Date: 9.09% each Score (of 100%):

1) If you don't have a lot of repeated setups, you should

❑ a) ignore setup reduction all together.

❑ b) concentrate on cycle time reduction.

❑ c) concentrate on reducing individual tasks repeated in most setups

❑ d) concentrate on minimizing tool maintenance

2) If your lot sizes are very large, you should concentrate more on reducing cycle time than setup time.

❑ True ❑ False

3) Describe the 30% rule-of-thumb for a cost based justification.

____

____

____

____

4) Define setup time.

____

____

____

____

____

____

5) Setup time is directly limited by

❑ a) machining process

❑ b) fixturing

❑ c) cutting tools used

❑ d) all of the above

6) Name the two task types related to setup.

____

____

____

7) In order of importance (priority), name the three ways to reduce setup time.

____

____

____

8) Given unlimited resources, there is no setup task that cannot be eliminated.

❑ True ❑ False

9) Moving tasks off line requires.

❑ a) adequate lead time

❑ b) sufficient production run time

❑ c) enough people

❑ d) all of the above

10) Name the four steps to setup reduction.

____

____

____

____

____

____

____

____

____

____

11) The best way to evaluate current tasks related to setup is to videotape them.

❑ True ❑ False

Student name: Date: 8.33% each Score (of 100%):

1) CNC machine utilization is

- ■ a) The effectiveness level of CNC machine tools.
- ❑ b) Based solely on how fast CNC machines can cut.
- ❑ c) The effectiveness level of your CNC personnel.
- ❑ d) Based upon the application for the machine

2) The application for a CNC machine is simply what the machine is being used to do.

■ True ❑ False

3) The wise CNC user should be more willing to have a CNC person waiting for a CNC machine than a CNC machine waiting for a CNC person. Why?

A CNC machine's shop rate is usually much greater than the hourly wages of any single CNC person.

4) Name the four CNC using company types.

Product-producing companies

Workpiece producing companies

Tooling producing companies

Prototype producing companies

5) Of the following four factors contributing to a company's corporate identity, which is most important?

- ❑ a) Lead time
- ■ b) Lot size
- ❑ c) % of repeat business
- ❑ d) % of new business

6) For question five, specify why the factor you chose is so important.

Every decision in the CNC environment begins with the question "How many parts are we making?"

7) Depending upon a company's CNC needs, any factor contributing to company identity could become the most important one.

■ True ❑ False

8) When a company implements changes to improve personnel utilization, machine utilization usually suffers.

■ True ❑ False

9) Non-production time is any time when CNC machines are running.

❑ True ■ False

10) By our basic definitions of setup and cycle time, machines are either in setup or they're in production.

■ True ❑ False

11) Describe how you can use value added principles to draw people into the CNC environment.

Most people you're trying to draw into the CNC environment are necessary support people (design engineers, manufacturing engineers, inspectors, etc.). One important responsibility of any necessary support person must be to enhance the abilities of value added people (the operators).

12) Conflicts between decisions made and a company's corporate identity do not affect productivity.

❑ True ■ False

Setup reduction   Exercise two   Principles of setup reduction

Student name: Date: 9.09% each Score (of 100%):

1) If you don't have a lot of repeated setups, you should

- ❑ a) ignore setup reduction all together.
- ❑ b) concentrate on cycle time reduction.
- ■ c) concentrate on reducing individual tasks repeated in most setups
- ❑ d) concentrate on minimizing tool maintenance

2) If your lot sizes are very large, you should concentrate more on reducing cycle time than setup time.

■ True   ❑ False

3) Describe the 30% rule-of-thumb for a cost based justification.

A company should be willing to spend 30% of expected savings on an improvement that will have a known payback period.

4) Define setup time.

Setup time is the time it takes to go from making the last workpiece in the most recent production run to making the first good workpiece efficiently in the next production run.

The entire time a machine is down between production runs.

5) Setup time is directly limited by

- ❑ a) machining process
- ❑ b) fixturing
- ❑ c) cutting tools used
- ■ d) all of the above

6) Name the two task types related to setup.

On-line (internal) tasks

Off-line (external) tasks

7) In order of importance (priority), name the three ways to reduce setup time.

Eliminate tasks

Move on-line tasks off line

Facilitate tasks (especially on-line tasks.

8) Given unlimited resources, there is no setup task that cannot be eliminated.

■ True   ❑ False

9) Moving tasks off line requires.

- ❑ a) adequate lead time
- ❑ b) sufficient production run time
- ❑ c) enough people
- ■ d) all of the above

10) Name the four steps to setup reduction.

Evaluate current methods

Brainstorm for improvements

Prioritize and assign responsibilities

Gauge success

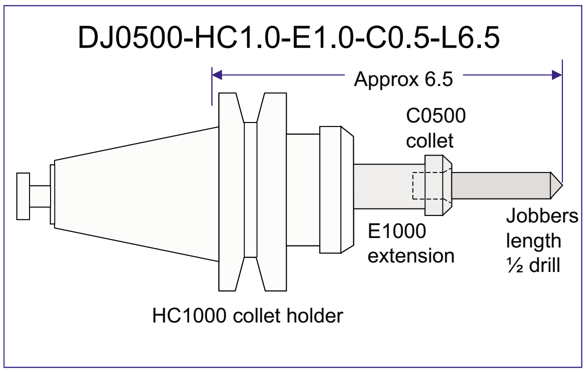
11) The best way to evaluate current tasks related to setup is to videotape them.

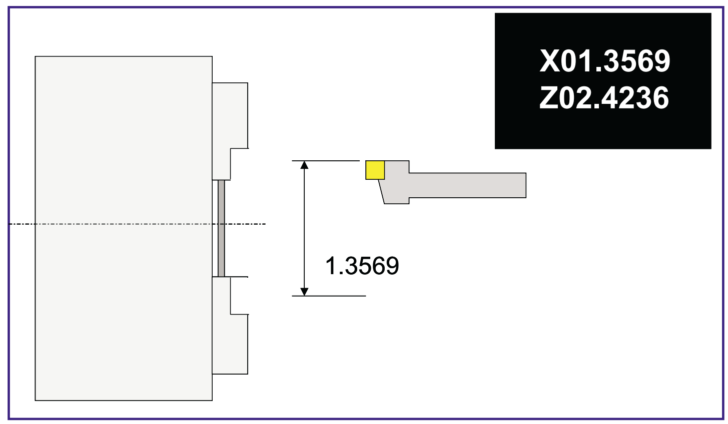
■ True   ❑ False

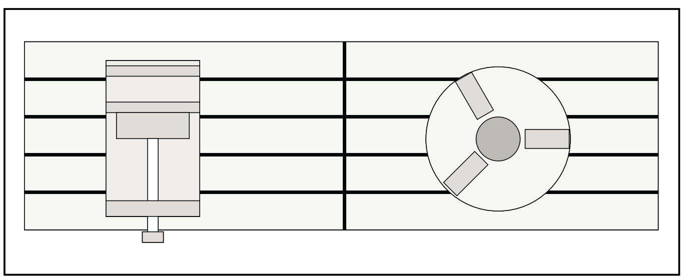
Setup Reduction

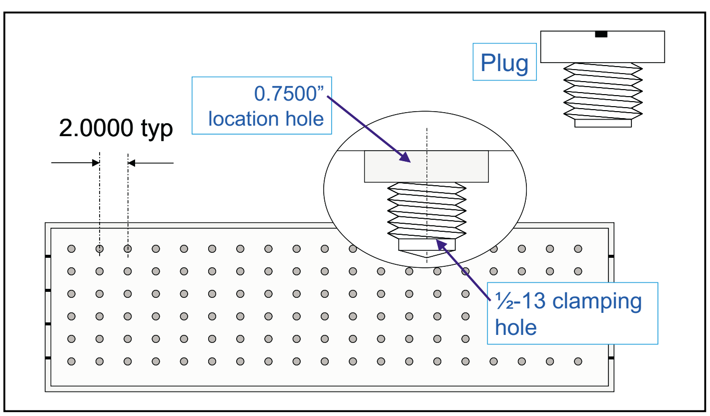
for CNC

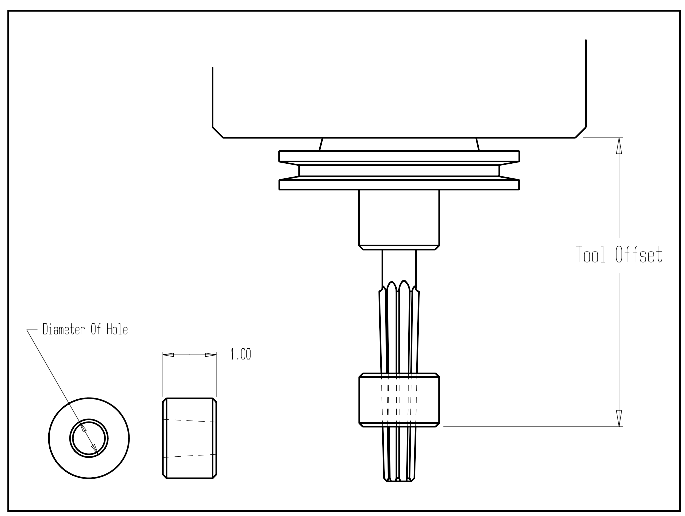
Machining Centers And Turning Centers











Written by Mike Lynch

CNC CONCEPTS, INC.

Machining Center Programming Quick Reference Card

G Codes

Code	Description	Status	Initial-ized	Modal
G00	Rapid motion	Std	Yes	Yes
G01	Straight line cutting motion	Std	No	Yes
G02	CW circular cutting motion	Std	No	Yes
G03	CCW circular cutting motion	Std	No	Yes
G04	Dwell	Std	No	No
G09	Exact stop check, one shot	Std	No	No
G10	Offset input by program	Opt	No	No
G17	XY plane selection	Std	Yes	Yes
G18	XZ plane selection	Std	No	Yes
G19	YZ plane selection	Std	No	Yes
G20	Inch mode	Std	Yes	Yes
G21	Metric mode	Std	No	Yes
G22	Stored stroke limit instating	Opt	No	Yes
G23	Stored stroke limit cancel	Opt	Yes	Yes
G27	Zero return check	Std	No	No
G28	Zero return command	Std	No	No
G29	Return from zero return	Std	No	No
G30	Second reference point return	Opt	No	No
G31	Skip cutting for probe	Opt	No	No
G40	Cancel cutter radius comp.	Std	Yes	Yes
G41	Cutter radius comp. left	No	No	Yes
G42	Cutter radius comp. right	No	No	Yes
G43	Instate tool length comp. (+)	No	No	Yes
G44	Instate tool length comp. (-)	No	No	Yes
G45	Tool offset expansion	No	Yes	Yes
G46	Tool offset reduction	Std	No	Yes
G47	Tool offset double expansion	Std	No	Yes
G48	Tool offset double reduction	Std	No	Yes
G49	Cancel tool length comp.	Std	Yes	Yes
G50	Cancel scaling	Opt	Yes	Yes
G51	Scaling on	Opt	No	Yes
G52	Return to base coord. system	Opt	Yes	Yes
G53	Shift to mach. coord. system	Std	No	No
G54	Instate fixture offset #1	Std	No	Yes
G55	Instate fixture offset #2	Std	No	Yes

Code	Description	Status	Initial-ized	Modal
G56	Instate fixture offset #3	Std	No	Yes
G57	Instate fixture offset #4	Std	No	Yes
G58	Instate fixture offset #5	Std	No	Yes
G59	Instate fixture offset #6	Std	No	Yes
G60	Single direction positioning	Opt	No	Yes
G61	Exact stop check mode	Std	No	Yes
G64	Normal cutting (cancel G60&G64)	Opt	No	Yes
G65	Custom macro call	Opt	No	No
G66	Custom macro modal call	Opt	No	Yes
G67	Cancel custom macro call	Opt	Yes	No
G68	Coordinate system rotation	Opt	No	Yes
G69	Cancel rotation	Opt	Yes	Yes
G73	Chip breaking peck drilling	Std	No	Yes
G74	Left hand tapping cycle	Std	No	Yes
G76	Fine boring with no drag line	Std	No	Yes
G80	Cancel canned cycle	Std	Yes	Yes
G81	Drilling cycle	Std	No	Yes
G82	Counterboring cycle	Std	No	Yes
G83	Deep hole peck drilling cycle	Std	No	Yes
G84	Right hand tapping cycle	Std	No	Yes
G85	Reaming cycle	Std	No	Yes
G86	Boring cycle	Std	No	Yes
G87	Back boring cycle	Std	No	Yes
G88	Boring cycle	Std	No	Yes
G89	Boring cycle with dwell	Std	No	Yes
G90	Absolute mode	Std	No	Yes
G91	Incremental mode	Std	Yes	Yes
G92	Program zero designator	Std	No	Yes
G98	Return to initial plane (G73-G89)	Std	Yes	Yes
G99	Return to rapid plane (G73-G89)	Std	No	Yes

Notes about G codes: 1) Machine tool builders vary dramatically with regard to which G codes they make standard. 2) Parameters control the initialized state of certain G code groups (like G90-G91). 3) Not all control models include all G codes shown in this list.

Common M codes

Code	Description	Status	Initial-ized	Modal
M00	Program stop	Std	No	No
M01	Optional stop	Std	No	No
M02	End of program (no rewind)	Std	No	No
M03	Spindle on forward (CW)	Std	No	Yes
M04	Spindle on reverse (CCW)	Std	No	Yes
M05	Spindle off	Std	No	Yes
M06	Tool change command	Std	No	No
M07	Mist coolant	Opt	No	Yes
M08	Flood coolant	Std	No	Yes
M09	Coolant off	Std	Yes	Yes
M19	Spindle orient	Std	No	Yes
M30	End of program (rewinds)	Std	No	No
M98	Subprogram call	Std	No	No
M99	Subprogram return	Std	No	No

Other M codes you may have

Code	Description	Status	Initial-ized	Modal
____	Pallet change	___	___	___
____	Chip conveyor on	___	___	___
____	Chip conveyor off	___	___	___
____	Hydraulic clamp on	___	___	___
____	Hydraulic clamp off	___	___	___
____	Indexer rotation	___	___	___
____	____________	___	___	___
____	____________	___	___	___
____	____________	___	___	___
____	____________	___	___	___
____	____________	___	___	___
____	____________	___	___	___
____	____________	___	___	___
____	____________	___	___	___

As with G codes, M code numbers vary dramatically from one machine tool builder to another. Be sure to check the M codes list that comes with your machine to see what other M codes you may have.

Table of Contents

Basic Premises

We will begin by presenting the most important themes that are stressed throughout the course. While you may not agree with every detail of what is said in this discussion since your specific experiences may differ from the generalizations we present, these important principles do apply nicely to the vast majority of CNC-using companies. Understanding and accepting these principles will help you get the most from this course.

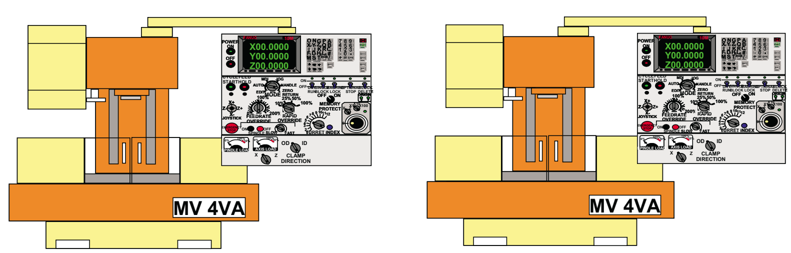
The importance of improving CNC machine utilization

All CNC-using companies want to get the most from their CNC machine tools. And of course, each machine's maximum output potential is directly tied to how well it is being utilized. However, there is much controversy and confusion related to just how a company should best utilize their CNC machine tools. Given the diversity of CNC machine applications, what is right for one company will be inappropriate for another. In this course, not only will we expose many ways to improve CNC utilization, we will also attempt to clarify which methods are most appropriate based upon a company's specific needs.

CNC machine utilization versus application

Do not confuse utilization with application. Utilization is the effectiveness level of the CNC machine tool. The productivity of the CNC machine is, of course, dictated by how well it is being utilized. The application for the CNC machine is simply the kind of work it is performing.

Consider for example, two companies that own identical CNC vertical machining centers. One company makes molds and uses their CNC machining center for machining complex mold cavities. The other company makes manifolds and uses their CNC machining center to drill (many) holes in manifold plates. They may have a limited number of different manifolds



and run them over and over again. The mold application is, of course, much more sophisticated than the manifold application. But it would be incorrect to say that one company is underutilizing their machining center based solely upon its application. The company that uses the CNC machining center as little more than a glorified drill press depends upon their machine every bit as much as the company that makes complex molds.

Actually, either company could be underutilizing their machine. If a CNC machine is not outputting at its maximum potential, it is being underutilized. The company that makes molds, for example, may not know about a helpful program verification simulator that would allow them to verify their program's tool path on a personal computer before it is sent out to the CNC machine. They may be experiencing wasteful downtime while mistakes are found and corrected at the machine during setup. On the other hand, the company making manifolds may not be aware of how an automatic distributive numerical control (DNC) system can reduce program transfer time to under thirty seconds. They may be wasting time as the setup person walks between the CNC machine and the serving computer to command program transfers.

Machine utilization versus personnel utilization

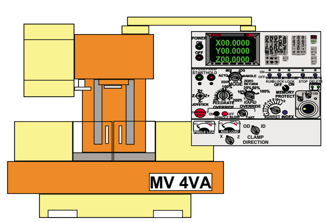
Throughout this course we place the highest emphasis on maximizing CNC machine tool utilization. And this should be of extreme importance to any CNC-using company. However, to many companies it is also of great importance to get the most out of the people that program, setup, and operate their CNC machines. You must understand that when you strive to maximize personnel utilization, machine utilization usually suffers.

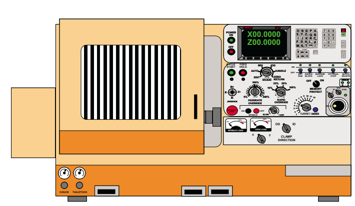
Think about a contract shop that employs one person to take care of each CNC machine the company owns. In this kind of company, each individual must completely program, setup, and run production for every job that comes to their machine. It is quite likely that the CNC machine will sit idle for long periods while this person is programming and setting up the machine. While the company is getting the most from its CNC people, it is not coming close to achieving maximum potential in machine utilization.

Even many product-producing companies commonly attempt to maximize personnel utilization. And unfortunately, they may not be considering the impact this has on CNC machine utilization. Since many management people cannot stand to see anyone sitting idle (even while the CNC machines they are running are producing), they assign their operators other duties to perform during each production run. When it comes to machine utilization, this may be just fine as long as CNC machines don't sit idle while operators perform their other duties. But in reality, this is difficult to achieve. It is not uncommon that CNC machines do often sit idle waiting for the operator to finish some secondary task.

Some companies even have their CNC operators running two or more CNC machines. Again, they're really getting the most out of their CNC operators. However, one machine may be constantly sitting idle while the operator finishes up with tasks on the other machine/s (loading workpieces, changing inserts, inspections, etc.).

In all examples to this point, consider the high price companies are paying to maximize personnel utilization. The shop rate (the amount the company





charges per hour for the CNC machine's use) for a typical CNC machine is usually at least four to ten times the wage of a CNC operator, based upon the complexity of the application and machine size. From a bottom-line standpoint and given the choice, you should be more willing to have a CNC operator sitting idle waiting on a CNC machine than a CNC machine sitting idle waiting for a CNC operator.

Some companies fully accept the impact that maximizing personnel utilization has on CNC machine utilization. In fact, it may be part of the company's general philosophy. For instance, many companies incorporate manufacturing cells. A cell may have several CNC machine tools (possibly along with other conventional equipment) and may be attended by just one person. The primary goal in most manufacturing cells is to complete a workpiece (or possibly even a complete assembly of several workpieces) right in the cell. This can dramatically improve the through-put of products flowing through the company. However, it is not uncommon for one or more machines in the cell to be idle while other operations are being performed, meaning machine utilization may be rather low. Since the priority is improved though-put, the company willingly pays the price in lower machine utilization.

As stated, this course will emphasize improving CNC machine utilization. Since your CNC machines' maximum output is directly tied to how many people are available in your CNC environment, we will often assume you have an adequate support staff - or at least that you are willing to consider changes in the way you currently utilize your personnel.

We want to make one last point about improving CNC machine tool utilization. There are companies that have very predictable production schedules. Many automotive companies, for example, know with great precision just how many workpieces will be required during a day, week, month, and/or year. This kind of company will purchase an adequate number of machines to ensure that their production schedule is met. Once started, as long as there are no changes in required production volumes, there will be no need to ever improve machine utilization. The vast majority of companies, however, do not share this luxury, and will greatly benefit from improvements in machine utilization. We're assuming you work for one of them.

Criteria for wise decisions

Decisions that affect your CNC utilization must of course be based upon your own company's best interests. As stated, there are many expert sales people in this field who can make the features of their CNC-related products sound right for just about everyone. Poor decisions lead to misapplication. Misapplication leads to underutilization. Here we intend to expose in order of importance those factors that contribute to making wise decisions.

Admittedly, every rule has an exception. Exceptions fuel the fires of controversy and confusion regarding your best choices. In this early presentation, we speak in very general terms. As you view this discussion, you may quickly spot some exceptions to what is being presented. Rest assured that we will further clarify a company's specific needs as well as how they are best addressed as we look at some specific examples.

Company type

There are but four types of companies using CNC machine tools. Though there are some overlaps, all CNC users can be placed in one of these four basic categories.

Product-producing companies get their revenue from the sale of a product. In a sense, profit is one step removed from manufacturing since a product will not even come to market if the company cannot make a profit. Product-producing companies tend to have elaborate engineering departments (design engineering, industrial engineering, manufacturing engineering, process engineering, tool engineering, quality control, etc.). All facets of manufacturing tend to be well thought-out - and good reasons can be given for just about everything that is done in the CNC environment. These companies also tend to break up the tasks related to CNC machine usage. One person develops the machining process. Another person designs/orders the related tooling. Another develops the program. Another gathers, assembles, and if necessary, measures the tooling. Another makes the machine setup and runs the first workpiece. Another inspects the workpiece/s. Another completes the production run. Depending upon the product being manufactured, product-producing companies can have rather complicated CNC environments. If the component workpieces to be machined are quite diverse, it is likely that a wide variety of different CNC machine types (along with conventional and special machines) will be required to produce them.

Workpiece-producing companies (also called contract or job shops) get their revenue from the sale of component workpieces to product producing companies. Profit is directly tied to manufacturing since work is quoted based upon an hourly rate for machine usage. While there are exceptions, most workpiece-producing companies cannot afford to engineer their jobs as elaborately as product-producing companies. In fact, they must commonly make component workpieces without the benefit of the product-producing company's help, and for less money than the product-producing company can. This means CNC people working for workpiece producing companies must be extremely resourceful and innovative. Most tend to specialize in but a few machining operations, meaning most will have fewer machine types than product-producing companies. This tends to simplify their CNC environments. CNC people working for workpiece-producing companies must normally perform more than one function. It is not uncommon, for instance, that one person will completely program, setup, and operate their CNC machine/s for the jobs they run.

Tooling-producing companies get their revenue from the sale of tooling (jigs, fixtures, dies, molds, gauges, etc.) to product-producing and workpiece-producing companies. They share many attributes of both product-producing and workpiece-producing companies. Since they actually make a product (the jig, fixture, die, etc.) profit is commonly one step removed from manufacturing, making them similar to product producing companies. However, the quantity of tools (their product) being purchased is usually very small. And most have limited resources, making them similar to workpiece producing companies. Most tooling producing companies do tend to specialize in a tooling type (jigs, fixtures, gauges, molds, etc.), meaning they will typically have fewer machine types than product-producing companies. As with workpiece-producing companies, CNC people working for tooling-producing companies tend to perform several tasks.

With some tooling-producing companies, the product is perishable (wears out and must be replaced on a regular basis). Tooling-producing companies that manufacture cutting tools, like carbide inserts and tool holders really don't fit

Setup Reduction Principles

In value added terms, making a setup is a necessary support task. It does nothing to add value to your product. In addition, making setups is a non-productive task. With most CNC machines, you can't be running production during setup.

While all CNC people will freely agree that anything that can be done to reduce setup time should be done, companies vary with regard to the lengths they will go to reduce setup time. Product-producing companies tend to heavily staff their CNC environments. Their goal is to keep the CNC machine tools running for as high a percentage of time as humanly possible. Any unnecessary downtime is seen as a waste of time and they tend to do whatever it takes to eliminate as much downtime as possible. On the other hand, contract shops tend to minimize the number of people in their CNC environments. A contract shop tends to compromise wasted machine time during setup for the ability to handle all CNC related tasks with as few people as possible.

Regardless of the company type, setup time must be viewed as lost production time, and all companies should be highly interested in minimizing this lost time. In this chapter, we introduce the basic principles of setup time reduction. These principles can be applied to any form of manufacturing equipment, including CNC machine tools. In the next chapter, we will offer many specific techniques that can be applied to reducing setup time on your CNC machining centers and turning centers. Some of these principles will even be helpful during our discussion of cycle time reduction in chapter nine.

The importance of reducing setup time

The reasons why a company would want to reduce setup time may seem obvious. But we wish to state three of them for the sake of completeness.

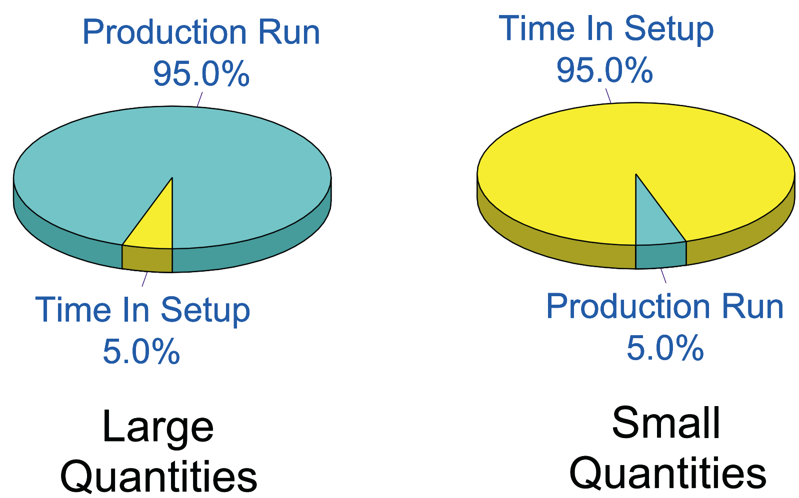
First, many companies are trying to achieve Just In Time (JIT) benefits. They want each required component available at the point it is required, eliminating the need to inventory any of the related components. Since reducing setup time will improve through-put of jobs, setup reduction is a major contributor to any serious JIT program.

Second, reducing setup time improves a company's flexibility. It gives them the ability to run any job at any time without over-taxing setup people or machine tools.

And third, of course companies want to improve profit margins. And there is no CNC machine that can make its company money while it is down between production runs. The machine can only make money while it is in production. And reducing setup time increases the amount of time available to run production.

Should you reduce setup time or cycle time - or both?

As stated during the Basic Premises chapter, there are only two activities occurring with your CNC machine tools. Either machines are in setup or they are running production (in cycle). When it comes to determining the importance of reducing setup time, as opposed to cycle time, the most important factor is your typical lot size.



The larger your lot sizes, the greater the percentage of time that the machine will be in production and the fewer the number of needed setups. With very high production quantities, a very small percentage of the machine's overall time will be spent in setup. There are CNC machines, in fact, that are dedicated to running only one workpiece - day in an day out. Once the job's setup has been made once, the machine will never be in setup again.

For companies that spend less than about ten percent of a given CNC machine's time in setup, any reduction in setup time will have but a small impact on the machine's overall utilization. While setup time reduction may still be considered somewhat important, we would recommend concentrating on reducing cycle time as a way of improving the CNC machine's utilization.

By far, the vast majority of CNC users run relatively low production quantities ranging from one to five hundred workpieces. Indeed, one of the primary reasons for using CNC machine tools in the first place is their ability to efficiently run small lot sizes. In fact, many companies (especially in tool-room and prototype environments) run only one workpiece per production run.

It is likely that your company currently spends a great percentage of a each machine's available time in setup. The greater the percentage of time spent in setup, the more important it will be that you streamline your company's setup procedures to reduce setup time, and the more your company should be willing to invest to achieve this goal. Achieving this goal will result in increasing the machine's overall percentage of time spent machining workpieces, the value added time.

Keep in mind that the extremes in workpiece quantities present special problems for incorporating setup time reduction techniques. For ultra-high production quantities, we already mentioned that so little of the machine's production time will be in setup that it will be wiser to concentrate on reducing cycle time or workpiece loading time. However, very low production quantities also present special problems for setup time reduction. Many of the setup time reduction techniques we show depend on having people perform certain setup related tasks during the production run. If running only one or two workpieces with a short cycle time, it is likely that nothing can be done during the production run to get ready for the next (or some future) setup.

Regardless of how important it is that you reduce setup time, doing so can be quite challenging. Given the wide variety of manufacturing methods used today, each company will have its own special obstacles to overcome. Certain machine tools, for example, lend themselves to quick changeover better than others. Bar feed turning centers are generally quicker and easier to setup than horizontal machining centers.

Diversity of work also presents special setup related problems. Companies that produce families of parts will generally find it easier to minimize setup time than those who produce a wide variety of very different workpieces.

Available personnel is yet another variable in the setup time equation. The more people you have available in your CNC environment, the easier it will be to incorporate setup time reduction techniques.

Even something as basic as the age of your machine tools can affect how difficult it will be to reduce setup time. The state-of-the-art in CNC technology is constantly changing. Newer machines have functions designed to help minimize setup time.

Justification for setup time reduction

Any setup time reduction program will cost something. Even if you or your people are simply applying a technique that does not require a purchase of some new device, the time it takes to incorporate and test the technique must be considered. Depending on how your company operates, you may have to provide justification for the time, personnel, and money your company must invest in the setup time reduction program. Doing so requires an understanding of basic justification principles.

Given the high cost of CNC machine utilization, it should be relatively easy to justify most setup time reduction techniques, especially those that require an investment in only time and effort. Since we are talking about justifying setup time reduction, your justification must be time based, meaning you must know the shop rate of the machine tool/s involved.

When you have a setup time reduction technique that requires justification, first calculate how much your setup/s currently cost. Based on the machine's shop rate and knowing how long it takes to make a given setup, you can easily calculate this cost. Based on knowing how many times the setup is made per week, month, year, etc., you can determine how much your company spends on a given setup. If the improvement you intend to make will be applied to several setups, be sure to repeat this process for each.

Second, approximate the savings in time your improvement will provide per setup. You should be able to easily calculate an expected savings based on the time saved, the machine's shop rate, and the total number of setups involved. Compare the potential savings to the cost for implementation in order to determine if your setup time reduction technique is justifiable.

To determine whether any improvement is justifiable, many companies use a thirty percent rule-of-thumb. With this rule, if the company can save $100.00, they should be willing to spend $30.00 (thirty percent of the expected savings). Most companies will also limit the payback period for justification to say - three months, six months, or one year.

Remember that a savings in setup time provides an equivalent increase in production time, meaning reducing setup time provides a double benefit. Not only are you saving machine time, you are increasing the machine's productive time. Remember to factor this added savings into your setup time justification equation.

We cannot stress enough the importance of knowing your current costs related to making setups as you begin any setup time reduction program. Only by knowing your current costs can you justify any investment in personnel, time, effort, or equipment needed to reduce it.

The relationship between production quantities, process, and setup time

As stated, the number of workpieces to be produced per production run has the greatest impact on how important it is that you reduce setup time. Indeed, production quantities dramatically impact all important decisions made for machining of a given workpiece, including the process by which the workpiece is produced.

Production quantities, process, and setup design are very closely related. The number of workpieces to be produced is the largest single factor that determines how the process should be engineered. Generally speaking, the more workpieces to be machined, the more important it is that workpieces be machined efficiently, resulting in a more elaborate process.

If, for example, only twenty-five workpieces are to be machined, the only real priority may be machining acceptable workpieces. The process engineer will use standard cutting tools, and unless unavoidable, nothing special will be purchased for such a low production quantity. On the other hand, if one thousand workpieces are to be machined in one production run, the process engineer will likely design a completely different process. Instead of simply having to produce acceptable workpieces, acceptable workpieces must be produced efficiently. The higher the production quantities, the higher the emphasis there should be on efficiency. Much more engineering will go into the process to minimize machining time. The purchase of special components related to the setup including special cutting tools, fixtures, and possibly even machinery can be justified if production quantities are high enough.

Just as production quantities determine how elaborate the process must be, so does the process determine how elaborate the setup must be. Because quantities are very high for a given job, for example, the process may call for multiple workpieces to be machined in one machine cycle. This, of course, requires the workholding setup to be capable of holding multiple workpieces.

In similar fashion, just as the quality of the process dictates the resulting cycle time, so is setup time a slave to the process. Generally speaking, the overall quality and sophistication of the setup will be a simple reflection of the process, which is in turn a result of the number of workpieces to be machined.

As a simple analogy, we compare the relationship of production quantities, process engineering, and setup design to matching tires to your automobile. Your tires should be chosen to match the kind of car you drive. If you drive a sports car, the quality of your tires must reflect the high performance capabilities of your car. If you buy tires that were designed for a family car, the tires will be the weak link in your sports car's performance. If, on the other hand, you drive a family car, purchasing high performance tires would be over-kill. The family car now becomes the weak link. Just as tires must be correctly matched to an automobile to ensure that there are no weak links in the car's performance, so must production quantities, process, and setup be matched to ensure that there are no weak links in the manufacturing process.

The engineering effort that goes into the design of the setup plays the biggest role in determining how quickie the setup can be made. Just as every process could be engineered to allow the absolute minimum cycle time, so can every setup be engineered to allow the absolute minimum setup time. However, feasibility, based on production quantities, limits how much engineering goes into the process. In similar fashion, feasibility, based on the process, limits the engineering that goes into the design of the setup.

Though the design of the setup plays a major role in determining setup time, cutting tool and fixture design is beyond the scope of this text. While we freely acknowledge its importance in reducing setup time, we limit our scope to offering specific CNC techniques to reduce setup time.

What are you trying to improve?

During the presentation of Basic Premises, we say that the more a task is repeated, the easier it is to justify improving it. And if your company does a great deal of repeat business, running the same jobs over and over, the more likely it will be that you will be trying to improve entire setups. Truly, it is the entire setup that is repeated.

However, many companies get very little repeat business. In fact, some companies will never see the same job a second time. If you work for one of these companies, you should be looking to improve the most repeated individual tasks - tasks that are done during every (or most) setups. Consider for example, the redundant cutting tool assembly tasks that must be performed during every setup. Improving how tools are assembled will have a positive impact in every setup.

Setup time defined

Our broad definition of setup time goes like this.

> Setup time it the time it takes to go from making the last workpiece in the previous production run to efficiently making the first good workpiece in the next production run.

Truly, anything that happens while the machine is down between production runs is part of setup - and will be fair game for your setup reduction program.

Here are some tasks commonly associated with setting up CNC machine tools.

- Tear-down of workholding setup
- Making of workholding setup
- Tool assembly
- Tool measurement (if required)
- Tool loading
- Program zero measurement
- Offset entry for tooling information
- Offset entry for program zero information
- Program loading

Setup Reduction Techniques

With a firm understanding of setup time reduction principles, you may be anxious to begin your own setup reduction program. But before you start, we ask you to read this chapter to get some specific ideas that should help. While not every technique we show in this chapter will apply to your CNC environment, you'll be able to see how others solved their setup reduction problems. At the very least, you should begin to see the kind of ingenuity it takes to reduce setup time while trying to keeping costs at a minimum.

We're going to be discussing setup related tasks in the approximate order that setups are made.

- Preparation and organization
- Workholding setup
- Cutting tools
- Program zero assignment
- Program development
- Program transfer
- Program verification
- Program optimizing
- First workpiece inspection

In each category, we'll begin by showing the typical tasks that are performed. This is yet another reason why we say you must watch your own setup people. You may find that the tasks your setup people are performing don't match the tasks we show. Our best overall suggestion is that you study your own setup people to come up with potential improvements. While we're going to be showing many techniques, we're probably just scratching the surface of what's possible in your own CNC environment.

After introducing the typical tasks in a category, we'll make suggestions that help reduce setup time. In most cases, we'll be showing techniques related to all three ways to reduce setup time, including eliminating the task, moving it off line, and facilitating the task. This may become a little confusing, because we will have just completed a discussion showing how to eliminate a task when we begin showing how to move the very same task off line. Then we'll be showing how to facilitate it. Remember, we're leaving it up to you to determine which way to reduce setup time is best for you. And of course, you'll be making your decision based upon feasibility.

Preparation and organization for setup

During the discussion of setup reduction principles, we point out that there are certain setup-related tasks that we easily associate with making setups. They may include removing the previous workholding device, mounting the new workholding device, assembling cutting tools, measuring cutting tools, loading cutting tools, assigning program zero, and loading the CNC program into the control (there may be more or less core tasks, based upon how your company works).

We also said, however, that setup time is the total length of time the machine is down between production runs. When you compare the time it should take to perform the obvious setup-related tasks to the total time the machine is down between production runs, it will probably expose the fact that some very non-productive tasks are occurring while the machine is down.

It's not uncommon for example, for a setup person to be able to perform all obvious setup tasks in less than thirty minutes. But two hours later, you're still trying to get a first workpieces to pass inspection! Where does the additional time come from? One of your first goals will be to draw the total time the machine is down between production runs down to the time it should take a setup person to perform the core setup tasks.

In my experience, one common thing that causes the excess time is related to disorganization. Also during our discussions of setup reduction principles, we talk about evaluating your setup people by videotaping the entire setup. We said as you press the record button for the first time, the setup person may look around for a few moments and then disappear for ten minutes. This may happen several times during the setup. Why is he or she disappearing? The answer is probably related to the fact that the setup person wasn't truly ready to make the setup in the first place!

It is not unusual for a company that has never been involved in setup reduction to discover that the biggest single gain they can make with setup reduction is to improve the organization of the CNC environment.

By the way, you can easily determine how organized your setup people are by watching them during setup. It is very easy to spot a disorganized person.

- Do people search the shop for needed items?
- Do all items have a storage location?
- Are storage drawers/bins crammed full?
- Are items put away after each setup?
- Are work areas cluttered?
- Do you see people duplicating tasks?
- Are people making mistakes?
- Do people have to wait for perishable items?
- Are people confused about what they must do?

It should come as no surprise that the time it takes to perform every task related to setup is directly related to the organization of the person performing the task. Remember what we said about repetition. The more you repeat a task, the easier it is to justify improving it. Here we're talking about every setup related task! Any improvement you make that improves general organization, will in turn improve every task during setup. This is why we say that, in many companies, the largest single improvement you can make is related to getting better prepared and organized to make setups.

Actually, preparation and organization can be broken into two categories. We've been talking about the general preparation and organization that occurs in your CNC environment. And we'll continue to make more points about this very important topic. But secondly, there is the preparation and organization that must be done in order to make a specific setup. Tasks related to preparing and getting organized to make a specific setup may include gathering the related documentation, cutting tools, fixtures, gauges, and anything else needed to make the setup, studying the documentation, and keeping a clean work area. More on preparation and organization for a specific setup a little later.

While you should always be looking for ways to eliminate and move off line any preparation and organization steps, many of the things you can do to improve the general organization of your CNC environment will fall into the category of facilitating tasks.

A well-designed work area

Again, it's easy to tell the difference between a poor work area and a good one. Frankly speaking, most attributes of a well designed work area are obvious. But I've seen so many poor work areas that I feel it's necessary to mention them.

Clean, uncluttered bench - I've seen some companies that expect setup people to use the CNC machine table as a makeshift bench. The setup person must, of course, have a place to work. While you may not need a bench next to every CNC machine tool, you should at least have centrally located work areas. Also, use the bench as a workbench, not a storage area. Be sure that the bench doesn't accumulate everything from scrap workpieces to unneeded fixtures and gauges.

Adequate hand tools - Compared to the cost of machine time, hand tools are inexpensive. Don't expect setup people to share them (or supply their own) if you expect to minimize setup time.

Every commonly used tool has a place and is put in its place - While it may be okay to store little used tools in a drawer or tool box, don't make setup people dig around to find tools they use on a regular basis. We've all seen peg-board storage systems that have outlines around where tools are supposed to be placed. While this may seem elementary, you can easily tell when a tool has not been put away.

Keep tools where they're needed - I'm a big fan of Velcro. If your setup people and operators need a special wrench at the far end of a bar feeder whenever a bar is loaded, why not stick the wrench right on the bar feeder within inches of the screw or nut it's needed for? Using Velcro, you can attach a hand tool just about anywhere! The same goes for vise handles. Why keep a vise handle that's needed in every cycle on a workbench that's 10 feet away from the machine? In some cases, this may mean duplicating the tools you use most often, but the additional cost can be easily justified when you consider the time they save. And - don't share often-needed tools among machines. Nothings worse than having a $100,000.00 machine sitting idle while the setup person waits for a $8.00 wrench!

Where is the DNC system? - Remember that current DNC systems are automatic and allow the setup person to load and store programs right from the CNC machine's control panel. If the must load programs from a separate computer, make sure the computer is central to the work area.

Can you keep perishables in the work area? - While this may not be right for everyone, companies that have a finite number of different jobs to run (commonly product-producing companies) know exactly what cutting tools and inserts a setup person (or operator) will need on a regular basis. Why not store a supply of them close by the machine so the setup person doesn't have to go looking for them. The same may apply to soft jaws for turning centers, commonly used vises on machining centers, and other often-needed workholding tools and gauges.

As stated, all of these attributes should be very obvious. But if they're so obvious, I'm wondering why so many companies force their setup people to work in work areas that are less than adequate.

Other factors that contribute to a setup person' ability to be organized

In addition to a well designed work area, there are other things that may be somewhat out of the setup person's hands when it comes to general organization. Be sure these factors don't negatively affect setup time.

Tool crib - A tool crib is commonly used to store cutting tools, perishable tools, fixtures, gauges, and anything else that a company may want to store in a central area. The tool crib can be a setup person's best ally or his worst enemy. Some companies (at least the tool crib attendants in some companies) lose sight of the tool crib's most basic responsibility - to provide the various components being stored in the tool crib to the people that need them in as timely a fashion as possible. The last thing you want when you're trying to reduce setup time is setup people (and machines) sitting idle waiting for items they need from the tool crib.

Material procurement - Do your setup people have the raw workpiece material needed to complete a setup when they're ready to run the first workpiece?

Setup documentation - The documentation you provide your setup people should be aimed at the lowest skill level of people using the documentation. Since most setup people are highly skilled, many companies minimize setup documentation - providing a universal (one or two page) setup sheet. As long as setup people can understand and interpret the documentation quickly, your documentation may be adequate. But if you notice excessive time is required for study, or worse, your setup people must call programmers with questions on a regular basis, it should be taken as a signal that your setup documentation should be improved. The same goes for any other documentation a setup person must use, including production control documentation, quality control documentations, and time reporting documentation.

Personnel utilization - In the discussion of basic premises, we make the point that you should be more willing to have a CNC person waiting on a CNC machine than a CNC machine waiting on a CNC person. The shop rate for a typical CNC machine is commonly at least four times the hourly wage of a CNC person. This being the case, shouldn't you be willing to have four people working to keep the machine from being down? This should be true for any reason, but here we're talking about reducing setup time. More and more companies (especially product producing companies) have discovered that teaming up on setups is a great way to minimize the time a CNC machine is down between setups. Yet most companies can't seem to get away from the thinking: one person per machine. This can be an expensive thought process!

Programming methods - There are many things a programmer does that affects the way setups must be made. You'll want to confirm that programming methods do not adversely affect setup time. Consistency is one major key. If, for example, you have one programmer that programs the centerline path of milling cutters (cutter radius compensation offset is deviation from planned cutter size) and another that programs the work surface path (offset is cutter radius), setup people will be constantly changing offsets, even for tools that are used from one setup to the next. This is not only confusing for setup people, it adds to setup time. Another example: programmers should program the mean value of every tolerance band. If they don't, offsets that were appropriate for a cutting tool in one job will not be correct for that cutting tool in the next job. To find other inconsistencies that lead to additional setup time, simply ask your setup people. They should be quick to point out any problems they're having.

Personal time - While breaks, lunch, and other personal time may not be considered fair game for your setup reduction program, do remember that there are CNC machines that can run during breaks. And if one of these machines is down for setup, production is being lost. If setup people can temporarily postpone personal time until a setup is completed, you'll likely see an increase in productivity.

As you watch your own setup people making setups, you may find other general organization problems. And again, anything you can do to minimize these problems will help reduce setup time in just about every setup being made.

Job order planning

One general organization technique that can really help to minimize setup time has to do with running consecutive jobs that require the same tooling (workholding as well as cutting tools). If of course, you can run two jobs consecutively that both require the same fixture, for example, the time required to make the workholding setup can be eliminated for the second job.

Admittedly, job order planning may conflict with your company's just in time goals. It's quite likely that the order by which you run jobs is dictated by when workpieces are required at the next step in the process. However, totally ignoring the benefits that can be reaped by job order planning may be a mistake. At the very least, provide your company's planner with a list of jobs grouped by minimized setup time. When developing the groups of jobs, be sure to consider cutting tools as well as work holding tools. With this list available, at least the planner can run jobs consecutively when there will be no negative impact on just in time.

Standard tool stations

Yet another general organization technique is related to keeping your most common cutting tool in the machine on a permanent basis. If, of course, a tool needed in the next job is already in the machine, the time related to performing all tasks related to the tool (assembly, measurement, loading, and offset entry) can be eliminated. The number of available tool stations in the machine, of course, has a lot to do with how many standard tool stations you can use. You must keep enough open stations to load cutting tools that are not standard tools.

You should consider the need for standard tool stations when purchasing new equipment. Most machining centers, for instance, can be purchased with different tool changer magazine options. If you run a finite number of