MEC-E7003 Manufacturing Methods II

INFO 26th of February 2024

Automation

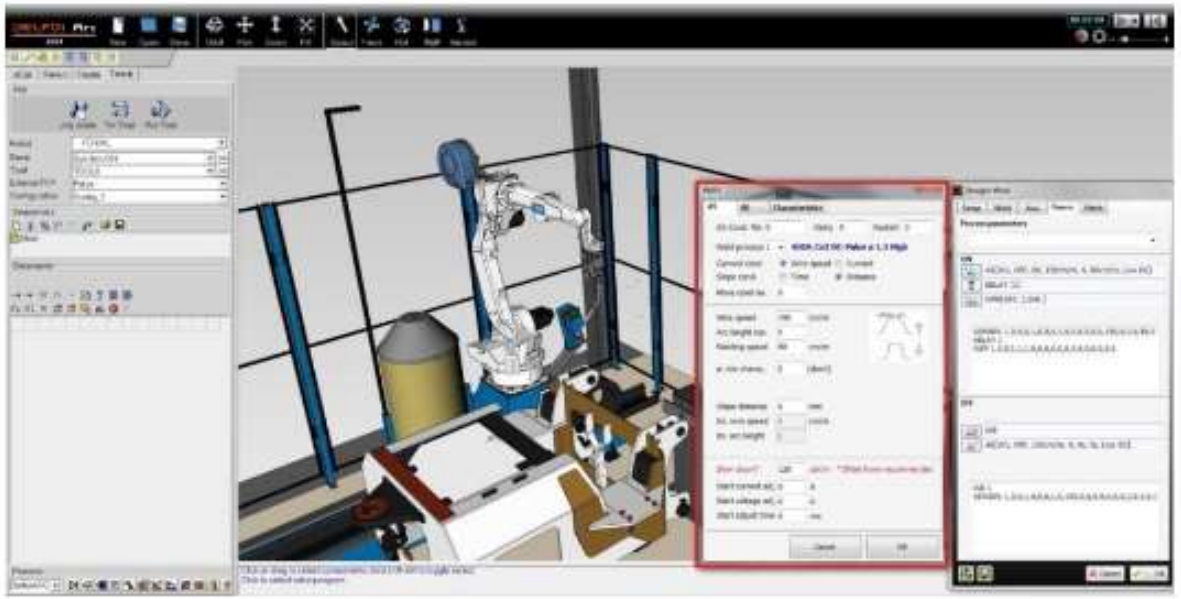
NC technology

- NC machine tools
- NC machine tool use
- NC programming

Numerical control, NC

CAD/CAM simulation

The testing of cutting forces in turning
Machining parameters
Machining optimization



DELFOI ROBOTICS

Today's Agenda

- What is this course about ?
- Course structure, policy, timetable, safety, etc.

Mandatory prerequisite

- **MEC-1080 Production Engineering**
- **MEC-E7002 Manufacturing methods I (ongoing) must be started in period III at the latest**

Teachers

- Juha Huuki
- Pekka Kyrenius
- Eklavya Koshta
- firstname.lastname@aalto.fi

Course overview

- **Credits:** 5 credits
- a master's level course
- to familiarize students with the research lab environment as well as research methods
- All the information: Shared through **https:// Mycourses.aalto.fi**

Learning outcomes

Student:

- knows the basics of NC-and CAD/CAM-programming including industrial robots.
- is able to apply knowledge and skills previously taught in the field of production engineering.
- is able to design and conduct small-scale empirical research.
- is able to produce a written research report based on the results of the research.
- has learned collaborative skills in laboratory exercises and writing reports as a part of a small group.

Assignment guideline

- Fixed size groups of 4 students (grouping in MyCourses)
- Total of 4 assignments:
    1. NC-lathe
    2. Robot
    3. Machining research
    4. CAM
- Assignment (except CAM) have different task i.e teams-meetings for every group and written research report.
- Each assignment must be done by the whole group

Assignment scheduling

(A more detailed information for some assignment is given separately)

- Materials in MyCourses:
  - Instructions for assignments
  - The proposed schedule of laboratory exercises for each group (Adjustment of scheduled times will be agreed separately.)

NC Machining Process

- The basic NC machining process includes the following stages:
- Designing the CAD model
- Converting the CAD file to a NC program
- Preparing the NC machine
- Executing the machining operation

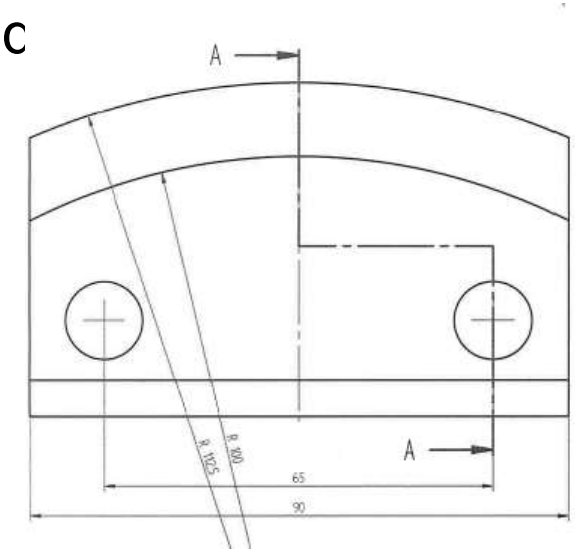
1. CAM simulation

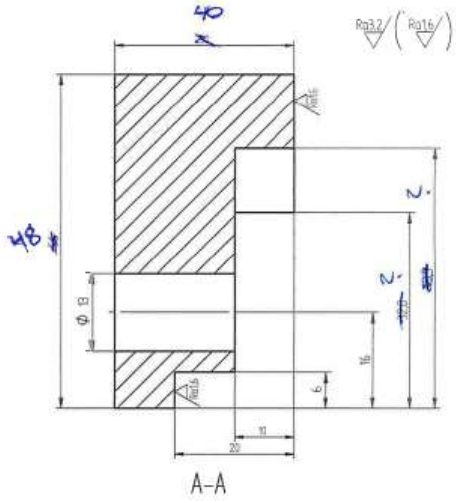
- The deadline of CAM assignment is 2nd of June 2024.

- The group designs the machining simulation model including NC code for workpiece using some CAM-software. Strongly recommended to use i.e Creo.
- The group makes also manufacturing plans for workpiece using manufacturing template.
- The workpiece is: Clamp swivel base part number art.367

http://www.gerardispa.com/media/documents/catalogues/workholding/04.pdf

Update the drawing anc
missing dimensions.





Manufacturing plan

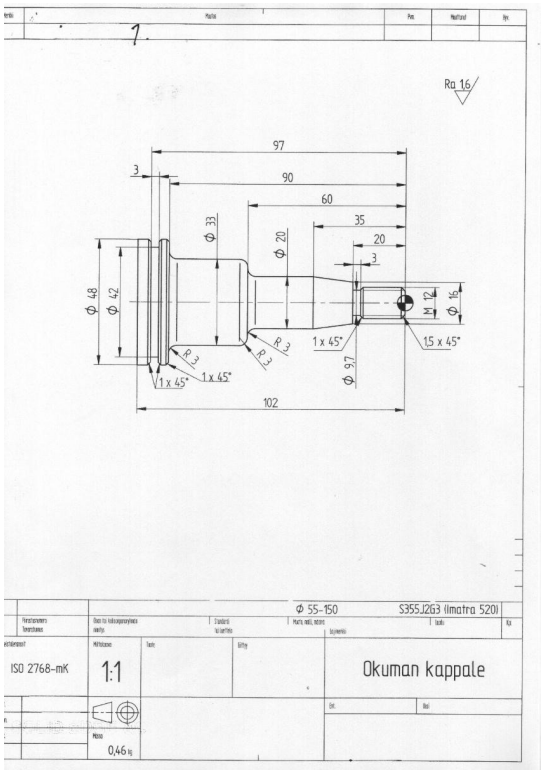
	Manufacturing plan	Part name					Base, dwg # 1002								
	Group x	Material					UNI Fe52 (low-alloy steel)								
		Sandvik CMC:					02.1								
		# of pieces					20								
		Phase of work					machining								
		Machine tool:					Horizontal machining center								
		Fixture:					Machine vise								
		Fixture stop points					side stop								
		preparation base time					5280								
		help time coefficient (prep.)					1,25								
		preparation time					6600								
		cutting time					564								
		aux time					176								
		help time coefficient					1,2								
		cycle time per piece					7488								
		total work time					41,6	hours							

	phase, operation tool insert	D_c [mm]	z_n [pcs]	a_p [mm]	a_e [mm]	no. of cuts	no. of features	f_z [mm/tooth]	v_c [m/min]	n [rpm]	v_f [mm/min]	l_m [mm]	preparation base time [sec]	cutting time [sec]	aux time [sec]
1	familiarization to instructions												1800		
2	fetch tooling												900		
3	transfer NC-program												120		
4	prepare tooling												300		
5	load ATC												1200		
6	prepare fixture												900		
7	fix workpieces												60		
8	start program														
9	**Milling #1, roughing**														
	CoroMill 245 Facemill														
	Cutter (body): **R245-100Q32-12M**	100	7	70	4	3	1	0,35	230	732	1794	2500		250,88	
	Insert type: **R245-12 T3 M-PH**														
	Insert grade: **GC 4020**														
10	Rapid feed														12
11	ATC														5
12	Rapid feed														12
13	**Milling #1, finishing**														
	CoroMill 245 Facemill														
	Cutter (body): **R245-100Q32-12M**	100	7	70	0,2	1	1	0,1	215	684	479	2500		313,12	
	Insert type: **R245-12 T3 M-PM**														
	Insert grade: **GC 1025**														
14	Rapid feed														12
15	APC														120
16	Rapid feed														15
												totals	5280	564	176

NC-lathes

Okuma exercise part I

Okuma exercise introduces the manual programming, setup, and operation of NC lathe.
Aim: to perform step on turning according to the given dimensions.



Setup sheet

Workpiece: S355????, Ø xx mm

Clamped: Okuma LB15 XXXXXXX

a zero-point:

Machine steps:

1. Roughing:
Tool: T080808
Tool-holder:
Insert: Sandvik DNMG 15
f_n =
a_p =
v_c =

2. Finishing:
Tool: T090909
Tool-holder:
Insert:
f_n =
a_p =
v_c =

3. Grooving:
Tool: T121212
Tool-holder
Insert:
a_p =
v_c =

4. Threading:
Tool: T010101
Tool-holder:
Insert:
f_n =
v_c =

The estimated machine time: x min x sec

Writing a program for the OKUMA

- The tools used in this work are at the Okuma tools locations x, x,1x, Tool no. 9 is a zero set tool and a finishing tool
- Find the cutting data from the Sandvik Coromant Turning manual. The material is hardened steel.
- The Okuma machine is controlled by a subroutine NLAP function. This means that the groups writing the program define the basic form of the machined piece and give the starting point of the machining. The machine's controller calculates the necessary toolpaths according to the given cutting data. An NLAP An NLAP function/subroutine is also used for the finishing. The program template is shown below (Note: All of the points are not shown in the example; the missing items are marked by a question mark (?)). Search for the missing information from Okuma Programming Manual folder, or complete the code yourself.

```
%
O1234 (Ei nolla vaan O niin kuin ohjelma. Pakollinen alussa)
N10 G50 S3000
N20 M90
N30 G90 M42
NLAP1 G81 (Muodon määritys alkaa NLAP k.s. Prg.Man. s.235-244)
N33 G21 G42 X? Z0 F0.? (Työkalun kompensaatio oikealla G42)
N40 G01 X? Z-?
N50 G01 Z-?
N52 G01 X? Z-?
N60 G02 X? Z-? I? K? (Kaaret G02 ja G03 k.s Prg.Man. sivut 82-86)
N70 G01 Z-?
N100 G01 X? Z-?
N102 ???
N104 ???
N106 ine. (Muoto riippuu tietty kappaleestanne)
N110 G40 (Kompensaatiot pois G40. Käsky pitää olla omalla rivillä)
N112 G80 (NLAP muodonmäärityksen loppu)
N120 G00 X500 Z250 (Työkalunvaihtopisteeseen pikaliikkeellä)
N125 T080808 (Roughintatyökalun vaihto paikasta 8)
N130 G96 S?? M42 M03 (Vakiolast.nopeus G96. Sandvik sorvaustyökalut)
N140 G01 X? Z? M08 F2 (Siirrytään lastuamisen aloitus pisteeseen)
N150 G86 NLAP1 D2 F0.2 E0.2 W0.2 (NLAP rouhinta kutsu)
N170 G00 X500 Z250 (Taas työkalunvaihtopisteeseen)
N180 T090909 (Viimeistelytyökalu)
N190 G96 S? M42 M03 (Uusi työkalu uudet lastuamisarvot)
N200 G01 X? Z? M08 F2 (Aloituspisteeseen)
N210 G87 NLAP1 (Viimeist.kierto. Syöttö määritetty rivillä N33 F0.?)
N230 G00 X500 Z250
N240 T121212 (Pistotyökalu)
```

```
N250 G96 S? M42 M03 (Pistotyökalun lastuamisarvot)
N270 G01 X? Z-? M08 F2 (Lähestytään)
N280 G01 X? F0.? (Pistetään)
N290 G01 X? F? M09 (Poistutaan ylös)
N300 G00 X500 Z250 M05
N310 T020202 (Kierteitystyökalu)
N320 G96 S?? M42 M03
N340 G01 X? Z-? M08 F2 (Lähestytään)
N370 G33 X? Z-? F? (Kierteitys k.s Prog. Man s. 87-89)
N380 X? (Kierretkä ei lastuta kerralla)
N390 X? (vaan käytettään useita)
N392 X? (kiertoja)
N393 X?
N395 X? (joissa lastuamissyvyys)
N396 X? (pienenee loppua)
N398 X?
N398 X? (kohden)
N400 G00 X500 Z250 M05 M09
N500 M91
N600 M02 (Ohjelman lopetuskäsky)
%
```

- The programmable zero-point of the piece is located on the front face of the piece. This frontal surface does not need to be adjusted in the program, because it is typically already adjusted in the time setting (Does not always apply to serial production).
- The program is written in WordPad or Notepad.
- The thread is made on the front end of the piece due to the structure. The thread is selected from a range of 1.5 – 3 mm.
- Programming is done using an NLAP. As the machine program memory is very small, so very long programs cannot be loaded.
- Make notes during the work. The piece is set up, the tools are measured, and the program is run under the supervision of the staff.
- In case of problems just ask for help from the staff

Part II NC-lathe / Okuma exercise

- Every group has given draft 2d-drawing for NC-Okuma exercise.
- Scheduling for groups, see timetable from MyCourses.
- The workpiece features must include: chamfer, external turning, grooving and thread.

NC-lathe / Okuma part II continue

- Write a program for the OKUMA with notepad using the template.
- Calculate total time for lathe operations
- **Task: a drawing, setup sheet, calculated machine time and NC-program.**
- Use time and effort to make NC-program
- Upload task to Mycourses:
  drawing, setup sheet, machining time and NC program.
- Workgroup take part Okuma demo in laboratory. See time from Mycourses

Programming the Okuma device:

Writing a program for the OKUMA

- The tools used in this work are at the Okuma tools locations x, x,1x,. Tool no. 9 is a zero set tool and a finishing tool
- Find the cutting data from the Sandvik Coromant Turning manual. The material is hardened steel.
- The Okuma machine is controlled by a subroutine NLAP function. This means that the groups writing the program define the basic form of the machined piece and give the starting point of the machining. The machine's controller calculates the necessary toolpaths according to the given cutting data. An NLAP An NLAP function/subroutine is also used for the finishing. The program template is shown below (Note: All of the points are not shown in the example; the missing items are marked by a question mark (?)). Search for the missing information from Okuma Programming Manual folder, or complete the code yourself.

```
%
O1234 (Ei nolla vaan O niin kuin ohjelma. Pakollinen alussa)
N10 G50 S3000
N20 M90
N30 G90 M42
NLAP1 G81 (Muodon määritys alkaa NLAP k.s. Prg.Man. s.235-244)
N33 G01 G42 X? Z0 F0.? (Työkalun kompensaatio oikealle G42)
N40 G01 X? Z-?
N50 G01 Z-?
N52 G01 X? Z-?
N60 G02 X? Z-? I? K? (Kaaret G02 ja G03 k.s Prg.Man. sivut 82-86)
N70 G01 Z-?
N100 G01 X? Z-?
N102 ???
N104 ???
N106 jne. (Muoto riippuu tietty kappaleestanne)
N110 G40 (Kompensaatiot pois G40. Käsky pitää olla omalla rivillä)
N112 G80 (NLAP muodonmäärityksen loppu)
N120 G00 X500 Z250 (Työkalunvaihtopisteeseen pikaliikkeellä)
N125 T080808 (Rouhintatyökalun vaihto paikasta 8)
N130 G96 S?? M42 M03(Vakiolast.nopeus G96. Sandvik sorvaustyökalut)
N140 G01 X? Z? M08 F2 (Siirrytään lastuamisen aloitus pisteeseen)
N150 G85 NLAP1 D2 F0.? U0.? W0.? (NLAP rouhinta kutsu)
N170 G00 X500 Z250 (Taas työkalunvaihtopisteeseen)
N180 T090909 (Viimeistelytyökalu)
N190 G96 S? M42 M03 (Uusi työkalu uudet lastuamisarvot)
N200 G01 X? Z? M08 F2 (Aloituspisteeseen)
N210 G87 NLAP1 (Viimeist.kierto. Syöttö määritetty rivillä N33 F0.?)
N230 G00 X500 Z250
N240 T121212 (Pistotyökalu)
N250 G96 S? M42 M03 (Pistotyökalun lastuamisarvot)
N270 G01 X? Z-? M08 F2 (Lähestytään)
N280 G01 X? F0.? (Pistetään)
N290 G01 X? F? M09 (Poistutaan ylös)
N300 G00 X500 Z250 M05
N310 T020202 (Kierteitystyökalu)
N320 G96 S?? M42 M03
N340 G01 X? Z-? M08 F2 (Lähestytään)
N370 G33 X? Z-? F? (Kierteitys k.s Prog. Man s. 87-89)
N380 X? (Kierrettä ei lastuta kerralla)
N390 X? (vaan käytettään useita)
N392 X? (kiertoja)
N393 X?
N395 X? (joissa lastuamissyvyys)
N396 X? (pienenee loppua)
N398 X?
N398 X? (kohden)
N400 G00 X500 Z250 M05 M09
N500 M91
N600 M02 (Ohjelman lopetuskäsky)
%
```

- The programmable zero-point of the piece is located on the front face of the piece. This frontal surface does not need to be adjusted in the program, because it is typically already adjusted in the time setting (Does not always apply to serial production).
- The program is written in WordPad or Notepad.
- The thread is made on the front end of the piece due to the structure. The thread is selected from a range of 1.5 – 3 mm.
- Programming is done using an NLAP. As the machine program memory is very small, so very long programs cannot be loaded.
- Make notes during the work. The piece is set up, the tools are measured, and the program is run under the supervision of the staff.
- In case of problems just ask for help from the staff

Okuma’s work report

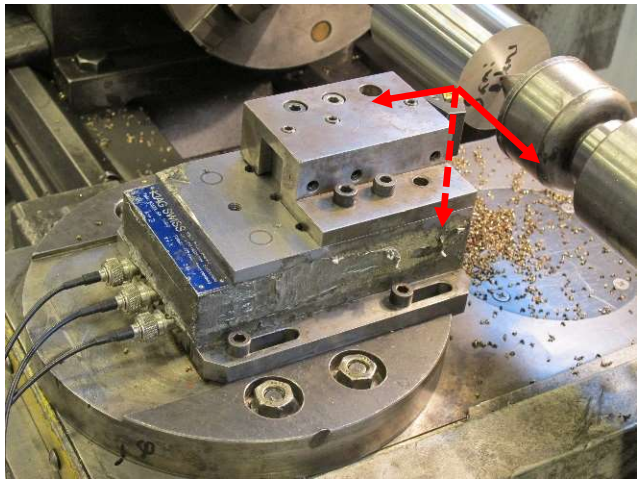
- Should included the following elements:
- 1 INTRODUCTION Work background,goals,etc.
- 2 Theory
- Theory of lathes and turning, especially in NC -lathes. Theory of NC–programming and tools etc.
- 3 APPLIED PART Used Equipment
- Used tools,cutting data,toolpaths Okuma’s NC program description
- 4 SUMMARY
- 5 REFERENCES
- ATTACHMENTS
- The length of the report(max 12 pages)

3. Industrial robot (Fanuc)

- No pre-tasks, hands-on exercise + report only
- Mandatory to attend, location K2-building machine shop 107
- Instructor Pekka Kyrenius
- FEC system (Fanuc Education Cell)
- Intro to industrial robot operating, programming & testing
- Pick & place demo environment
- Modification of demo program
- Topics: frames (coordinate systems), tool (gripper) setup, robot registers
- Starts 10:15 am (do not be late, please)
- A written group exercise report, 1-2 pages, of “lessons learned” during the exercise must be emailed to the instructor within 5 working days (1 week). Pdf preferred.

4. Machining Research

- Instructor: Eklavya Koshta
- Designing and performing cutting experiments in turning on a manual lathe.
- Title: Examining the effects of cutting parameters on cutting forces.
- Pre-requisite questions and tasks:
  - Both student and group-specific (see Instructions in MyCourses).
  - **Answers must be uploaded to MyCourses at the latest the day before the actual exercise session.**
  - The answers and related theory are discussed in the beginning of the exercise.
- Monday, Wednesday, & Friday (exceptional) are reserved for MR.
- Writing final report and submitting to MyCourses two weeks from the exercise.



NC-exam

- Pre-requisite exam includes the basic theory needed in this course.
- **Examination will be held on Tuesday 12nd of March at 09.00 - 11.00. Hall K1/ K326**
- Book: Radhakrishnan, P., Subramanyan, S., & Raju, V. (2008). Cad/cam/cim. New Age International.

  Chapter 12: CNC Machine Tools (pp. 341-471)
- Link to e-book:https://ebookcentral.proquest.com/lib/aalto-ebooks/detail.action?docID=437710
- Questions are selected from the list in the end of Chapter 12. In addition, NC code identification task is included.
- Grading: failed/passed/passed with distinction
- With distinction can be obtained only on the first attempt and will raise the personal course grade by one (1)!

Written reports

- Research reports are written based on the laboratory exercises.
- Assignment-specific instructions of the reports are given separately.
- Groups should explain contribution of each member in the reports (i.e. who has done what).
- The grading of reports is primarily based on the first versions of the reports.
- The reports must be uploaded to MyCourses within two (2) weeks from the date of the actual exercise. Late submission will decrease the grade. Extra time for writing reports can be given on request.

Grading

- Grading of assignments is based on written reports (mostly, grades, 0 - 5), pre-requisite tasks and activity in exercises.
- The (group-specific) course grade is the average of grades of all the assignments.

Rules in the laboratory

- Manuals, folders etc. must not be taken out of the lab.
- Computers in lab are for practical working only and shall not be reserved and used for writing reports.
- Staff has a priority to use devices.
- Eating and drinking is not allowed in lab.
- Only 3D images, CAD/CAM files and NC programs are allowed to be stored to computer hard disks.
- Remember to have a **memory stick** and to take a backup of a file.

K2 machine shop safety 1

- working alone in machine shop is forbidden
- machine tools may only be used by authorized personnel
- one K2 *staff member* must always be present on location to supervise
- student access is only during designated group work times
- never leave machine running unattended

K2 machine shop safety 2

- machine tool guards must be used, use chip/coolant shield
- use secure work-holding fixtures, remove spanner or chuck key
- protective gear (eyes & hearing) plus suitable clothing must be used, long hair must be tied back

K2 machine shop safety 3

- Attachment (fixture) of work pieces and tools must be secure in order to prevent unfastening due to cutting forces
- Be extra careful when employing rapid feeds or tool changes operations
- Keep hands off moving parts when machine tool is in operation

K2 machine shop safety 4

- get to know nearest first aid point and eye wash station as well as nearest exit routes in case of fire
- machine and surroundings (floor) must be cleaned afterwards
- remove chips only with hook and brush, do *not* use pressurized air

K2 machine shop safety 5

- all tooling & equipment must be returned to right / proper places
- report tool damage, maintenance needs and safety concerns immediately to staff
- no eating or drinking at machine shop (room 105d is for coffee breaks).