Machining Processes Laboratory

Introduction

The laboratory for research in metal machining is located in building D2. The lab was donated by ISCAR Ltd. - a world leader in producer of unique and innovative cutting tools for metalworking, including turning, grooving, milling, hole-making, boring and threading tools. It is a multinational company with representation in 50 countries.

The laboratory provides the students the essential hands-on training with modern machines and equipment, complementing their theoretical studies, and serves for research by the academic staff.

Machining is a key technology for industries in aerospace, die and mold, automotive, defense etc.

Iscar Lab Ceremony July 2007

Machining Processes Laboratory

Staff

Dr. Michael regev supervises the lab on behalf of the mechanical engineering department. Email: michaelr@braude.ac.il

Mr. Hayyim salev is the Operator of conventional Basic machines Laboratory.

Mr. Yitzchak yifrach is head of design and production specialization and instructor of the course: "Machining processes cutting". Email: Yifrach@braude.ac.il

For more information, please contact Mr. Yitzchak Yifrach.

Objectives

1. Training engineering students in the progressive machining process
2. Establishing exclusiveness of the college in the subject of progressive machining process
3. Fostering relevant research by academic staff
4. Fostering cooperative students' projects together with Iscar engineers , toward final projects
5. The lab supports teaching and research activities in machine design, machining processes and machine tools and other technical areas.
6. A receipt of garnets in the academic exploratory part of the laboratory
7. Providing services(commercial projects) to industries in the region

Machining Processes Laboratory

Policies: General, Safety

General

- No food or beverages are allowed in the laboratory area.
- Laboratory hours 8:00am-4:00pm.

Safety

- Most of the equipment in the lab is pre-configured in fixed stations. Under no circumstances you should try to move, troubleshoot, or open any equipment for any reason unless there is strong evidence that lack of your action may cause harm to a person or equipment.
- Eye protection is required for operation of all hand tools and powered, automated equipment, including CNC mills and lathe, and similar operations in the Lab.
- Long hair or loose clothing must be constrained to prevent getting caught in moving equipment.
- Watches, rings and other jewelry should be removed while operating all powered, automated equipment.
- **Never attempt to operate any equipment without authorization and proper instruction. If you are uncertain about how a machine operates, ask the lab Coordinator for help.**

Machining Processes Laboratory

Basic Machining Laboratory

The Basic Machining Laboratory consists of: manual lathe, vertical milling machine, drill press, grinding machine, and various cutting tools.

Mr. Hayyim salev is the Operator of conventional basic machines laboratory. He manufactures partial machinery for lecturers that deal in research of different subjects in the mechanical engineering department.

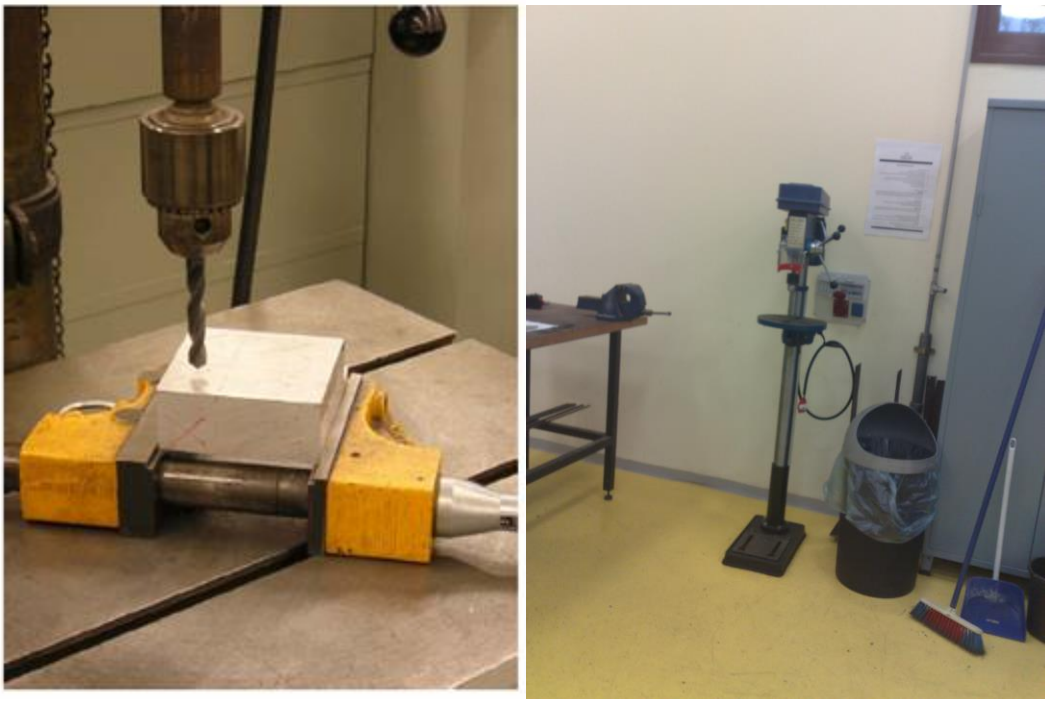
Turning machine

Turning machine

Machining Processes Laboratory

Basic Machining Laboratory

Vertical milling machine



Drill press

Machining Processes Laboratory

Basic Machining Laboratory

Horizontal spindle surface grinder

Machining Processes Laboratory

Computer Numerical Control (CNC) Machining

Introduction

CNC Machining, or Computer Numerically Controlled Machining, is a fast, high-tech method of creating complex parts with very low tolerances in a short period of time.

General Information

The Computer Numerical Control, CNC, Machining process produces 3D objects by removing material. Automated milling machines are pre-programmed to cut away material according to a specific path.

Several cuts are usually necessary; first a rough cut using a large-radius bit (no tight inside corners) and then final cuts to exact dimensions. The processes of tool selection and changing, and cooling of the work piece are all automated and handled by the milling machine.

The advantages of using a CNC mill include

- Variety of materials
- Recyclables
- Capacity to produce high-quality metal molds
- Accuracy the CMM (Coordinate Measuring Machine) raises the accuracy of the tool movement (to within ± 0.01mm).

CNC mill uses G and M codes to describe the cutting and spinning motions of the tools as well as their speed.

- G codes specify motions while M codes specify machine commands.
- G code can be written by hand or generated by ProEngineer or Catia.

Machining Processes Laboratory

Computer Numerical Control (CNC) Machining

High precision CNC lathe turning

Takisawa TC-4 CNC 2 Axis Turning Center

Hitachi Seiki VA 65 CNC Vertical Machining Center 3 axis

Machining Processes Laboratory

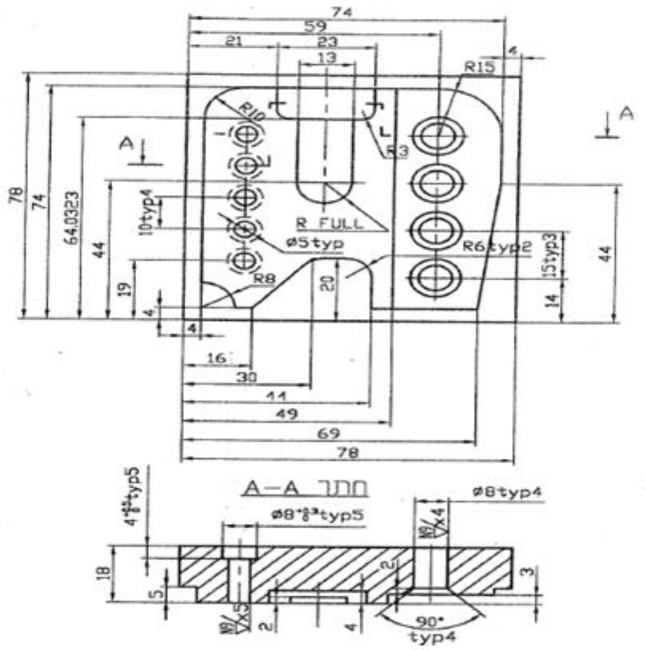
Computer Numerical Control (CNC) Machining

The Computer Aided Design (CAD) covers theoretical and practical concepts including:

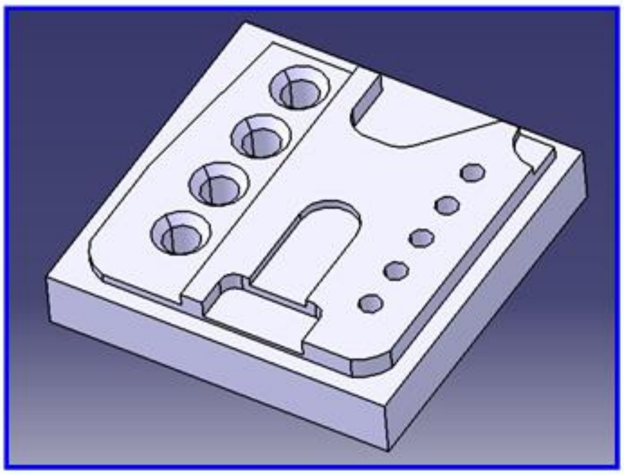
- Part modeling
- Assembly modeling
- Simulation model and FEM

To use the CNC Mill, a user must first create a Computer Aided Design (CAD) file using any of several CAD software packages available on campus. These include Catia, SolidWorks, and ProEngineer.

Example: Sketching Exercise



The geometric model that get accepted from the sketch with Catia software



Machining Processes Laboratory

Computer Numerical Control (CNC) Machining

After a model is created, tool selection and pathing must be programmed; the user decides where the cutting tool will go and when, and which tool will be mounted as it does so. This process can be programmed in Catia & ProEngineer here on campus or with other software packages. Having a part CNC milled at the CMU Mechanical Engineering machine shop is considerably simpler.

What materials can be used?

Materials that can be used include all of the following: Aluminum, Carbon Steel, Stainless Steel, Titanium, Magnesium, Brass, Copper, Special Alloys, Plastic, woods.

How much does it cost?

1. Cost depends on material, tolerance, and size.
2. Cost depends on the choice of material because certain stock materials are more expensive than others. Often higher grades of stock take more time to cut and are therefore more expensive. Harder materials cause more wear on the mill.
3. Cost depends on tolerance. Tolerances using a CNC milling machine can be as tight as 1 thousandth of an inch. Production tolerances are sometimes acceptable because human error and machine deviances are inevitable. The tighter the tolerances needed, the higher the cost.
4. Cost depends on size.
    - 4.1. Larger pieces lead to higher fixed cost (larger machine)
    - 4.2. Depending on complexity, parts take longer to machine and therefore cost more in terms of variable costs, including labor, excess material, and wear down.

What are some limitations?

CNC Milling is a very useful procedure. There are, however, a few limitations on what can be produced by the mill, and a few factors which must be considered to make an economical design.

1. The CNC mill uses rotary bits, so when milling inside corners a finite radius is unavoidable. Outside corners can be made quite sharp if necessary, but some inside corners can have as a minimum the radius of the cutting tool.
2. The workpiece must be solidly mounted to the milling table by a bracket piece, bolt holes, or a clamp. This should be taken into consideration when designing a part to be CNC milled. Of course the part can be mounted by a flange which is manually removed after machining.
3. Tool wear
   - 3.1. Tool bits wear down and deteriorate with more use.
   - 3.2. Especially true if material being cut is as hard as the drill bit used (metal cutting metal)
4. Machine code
   - 4.1. Must have NC file in the end to use the CNC milling machine.
   - 4.2. CAD must be exported to IGS format (ProE) or NC code must be written (can become very tedious) for the process to work.
5. Size limitation
   - 5.1. The product being made must “fit” into the CNC machining station.

G and M Codes

G-Code serves for describing the tool path by means of coordinates, while M-codes are used for describing machine commands, such as tool types, speeds and starting the ending the program. Both are necessary to run the program.

Machining Processes Laboratory

Computer Numerical Control (CNC) Machining

Short introduction to G codes to know

G00 positioning (rapid traverse)
G01 linear interpolation (feed)
G02 circular interpolation CW
G03 circular interpolation CCW
G04 dwell
G07 imaginary axis designation
G09 exact stop check
G10 offset value setting
G17 XY plane selection
G18 ZX plane selection
G19 YZ plane selection
G20 input in inch
G21 input in mm
G22 stored stroke limit ON
G23 stored stroke limit OFF
G27 reference point return check
G28 return to reference point
G29 return from reference point
G30 return to 2nd, 3rd & 4th ref. point
G31 skip cutting
G33 thread cutting
G40 cutter compensation cancel
G41 cutter compensation left
G42 cutter compensation right
G43 tool length compensation + direction
G44 tool length compensation - direction
G49 tool length compensation cancel
G45 tool offset increase
G46 tool offset decrease
G47 tool offset double increase
G48 tool offset double decrease
G50 scaling OFF
G51 scaling ON
G52 local coordinate system setting
G54 work coordinate system 1 select
G55 work coordinate system 2 select
G56 work coordinate system 3 select
G57 work coordinate system 4 select
G58 work coordinate system 5 select
G59 work coordinate system 6 select
G60 single direction positioning
G61 exact stop check mode
G64 cutting mode
G65 custom macro simple call
G66 custom macro modal call
G67 custom macro modal call cancel
G68 coordinate system rotation ON
G69 coordinate system rotation OFF
G73 peck drilling cycle
G74 counter tapping cycle
G76 fine boring
G80 canned cycle cancel
G81 drilling cycle, spot boring
G82 drilling cycle, counter boring
G83 peck drilling cycle
G84 tapping cycle
G85,G86 boring cycle
G87 back boring cycle
G88,G89 boring cycle
G90 absolute programming
G91 incremental programming
G92 programming of absolute zero point
G94 per minute feed
G95 per revolution feed
G96 constant surface speed control
G97 constant surface speed control cancel
G98 return to initial point in canned cycle
G99 return to R point in canned cycle

Machining Processes Laboratory

Computer Numerical Control (CNC) Machining

Short introduction to M codes to know

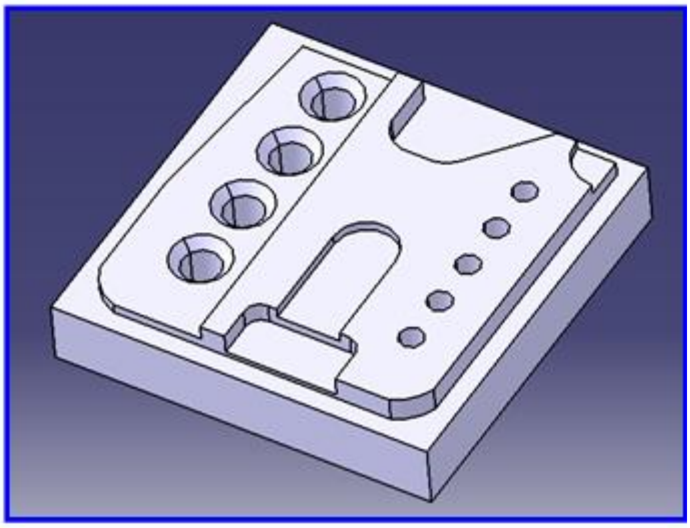
M00 program stop
M01 optional stop
M02 end of program (no rewind)
M03 spindle CW
M04 spindle CCW
M05 spindle stop
M06 tool change
M07 mist coolant ON
M08 flood coolant ON
M09 flood coolant OFF
M19 spindle orientation ON
M21 tool magazine right
M22 tool magazine left
M23 tool magazine up
M24 tool magazine down
M25 tool clamp
M26 tool unclamp
M27 clutch neutral ON
M28 clutch neutral OFF
M30 end program (rewind stop)
M98 call sub-program
M99 end sub-program

Machining Processes Laboratory

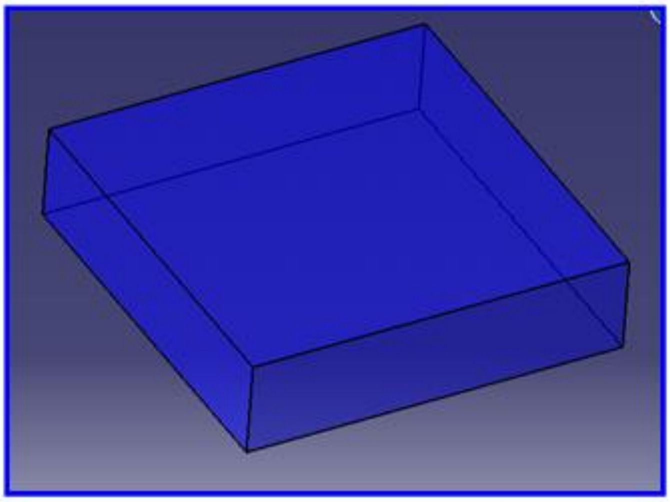
Computer Numerical Control (CNC) Machining

Example to the process of computerized production with Catia software

Example to part that required to manufacture



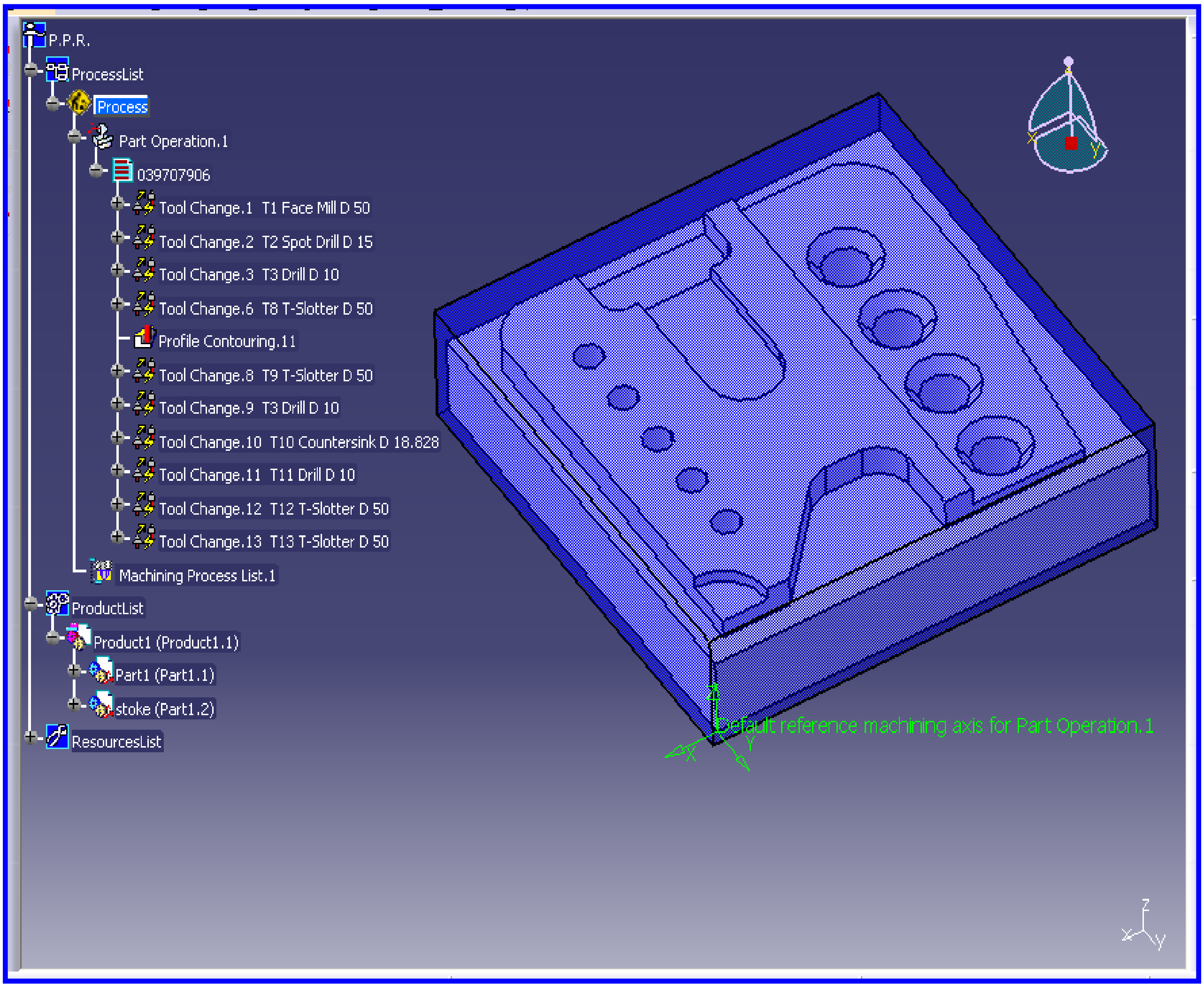
Stage of number 1- Building of suitable raw material to the problem



Machining Processes Laboratory

Computer Numerical Control (CNC) Machining

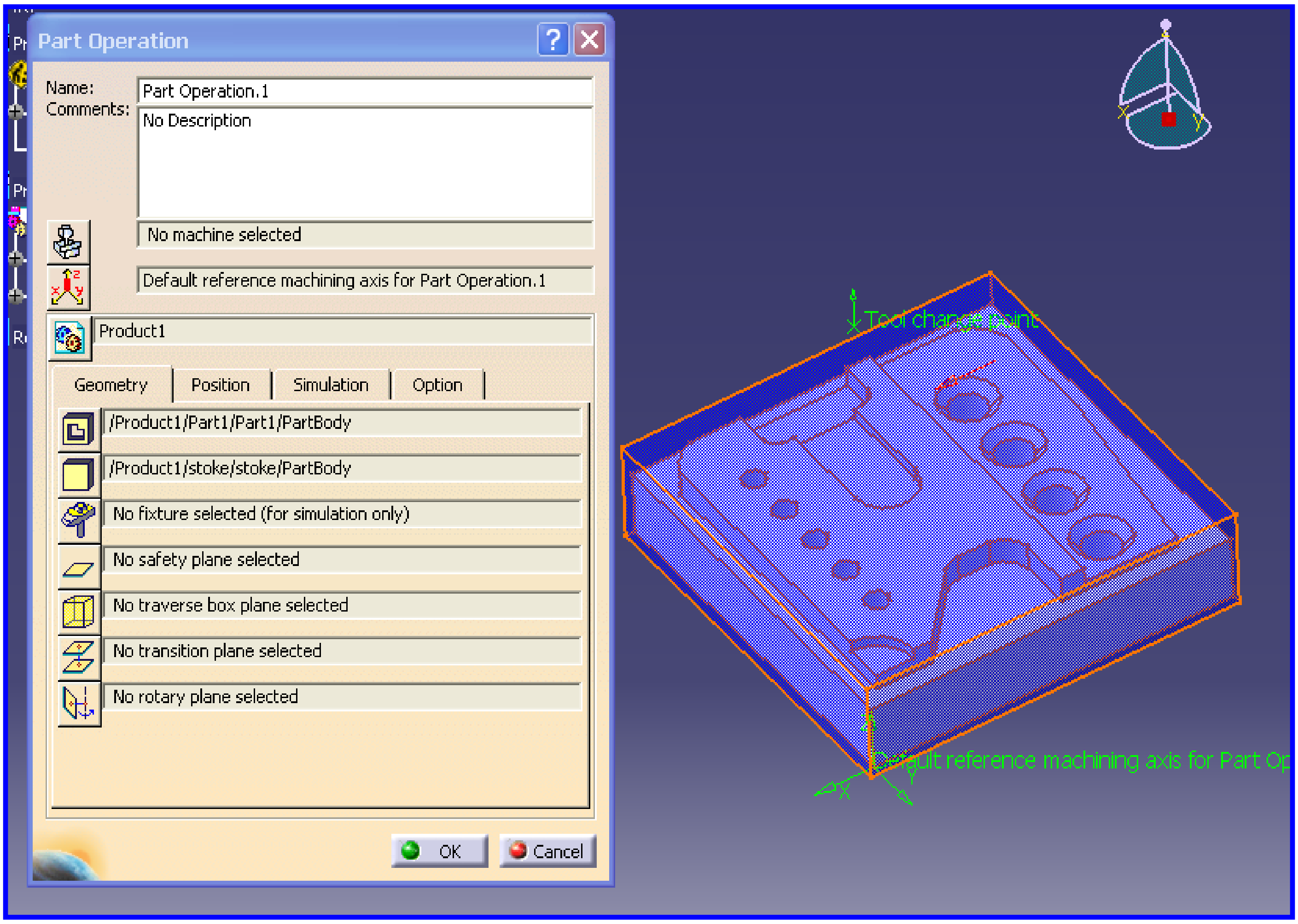
Stage of number 2 - Use the NC Catia software (CAM)



Computer Numerical Control (CNC) Machining

Stage of number 3 - preliminary definitions like:

1. Type of raw materials
2. System of axes
3. Type of machine & so on



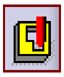
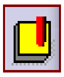
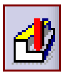
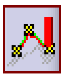
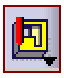
Machining Processes Laboratory

Computer Numerical Control (CNC) Machining

Stage of number 4- Building the process production

4.1 - We start with choice a function from within menu

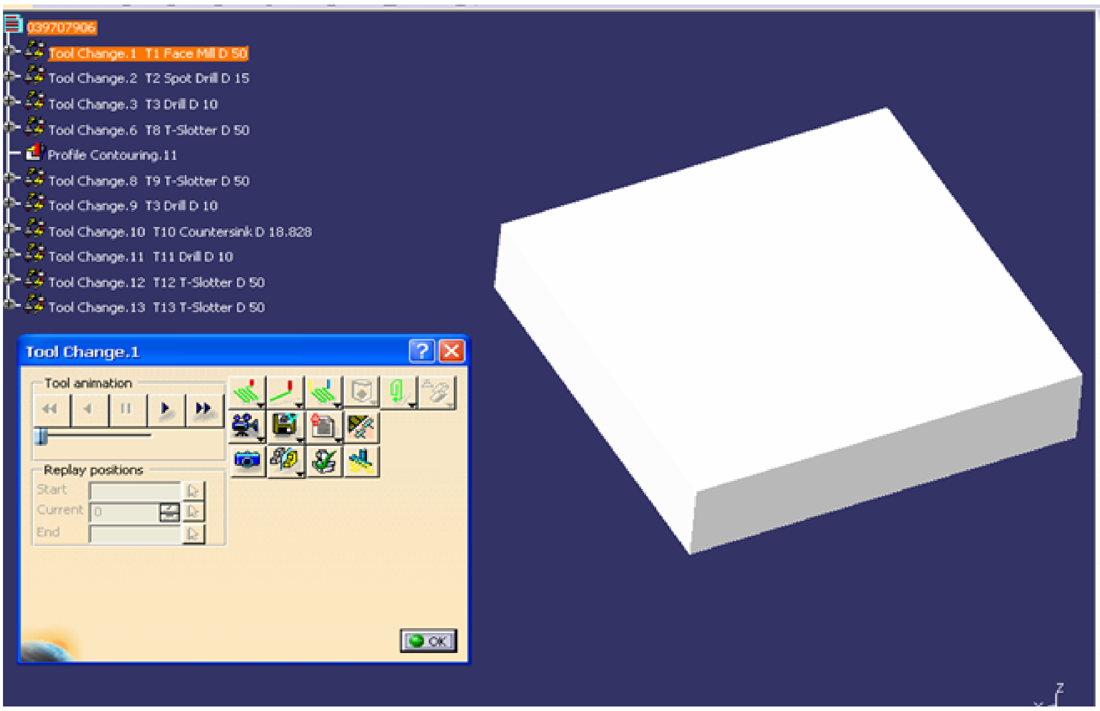
Examples of some optional functions

Icon	Name	Definition
	Pocketing Operation	It machines open or closed pocket with or without inner domains.
	Facing Operation	It is a plane milling operation used for cutting constant offset of material on a planer area.
	Profile Contouring Operation	It consists in cutting material along a hard boundary in same or zig-zag direction.
	Curve Following Operation	It machines a part by following a curve with the tool tip.
	Groove milling Operation	It allows you to machine groove area with a T-slot tool.
	Point To Point Operation	It consists in moving the tool from a selected point to another selected point at a given machining feedrate.
	Prismatic Roughing Operation	It is a operation used to rough machine the drafted or multiple bottom pockets.
	Prismatic Machining Area	It allows you to define an area from your geometry and record it. Further this area is used for pocketing or profile contouring.
	Prismatic Rework Area	It is the area which is remained unmachined after performing the previous operation.

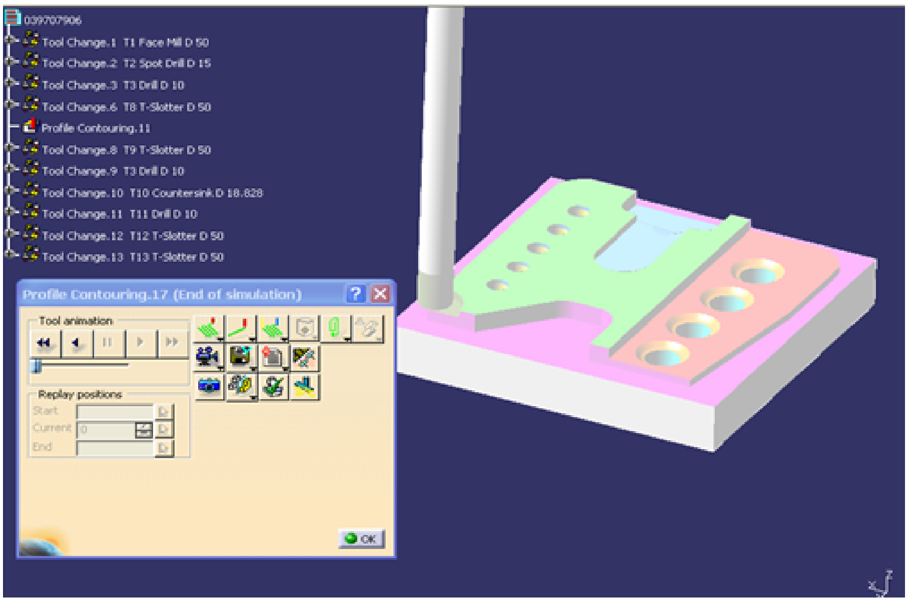
Machining Processes Laboratory

Computer Numerical Control (CNC) Machining

- After all the relevant definitions for all function, get accepted the full program
- You have to run a simulation to the testing of the results



The part that get accepted in the end of the simulation


039707906
Tool Change.1 T1 Face Mill D 50
Tool Change.2 T2 Spot Drill D 15
Tool Change.3 T3 Drill D 10
Tool Change.6 T8 T-Slotter D 50
Profile Contouring.11
Tool Change.8 T9 T-Slotter D 50
Tool Change.9 T3 Drill D 10
Tool Change.10 T10 Countersink D 18.828
Tool Change.11 T11 Drill D 10
Tool Change.12 T12 T-Slotter D 50
Tool Change.13 T13 T-Slotter D 50
Profile Contouring.17 (End of simulation)
Tool animation
Replay positions
Start
Current
End
OK