



5-Axis Machining

CNC systems for
high-performance machine tools



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Flexible 5-axis machining

FANUC series 30i and 31i-A5 are high performance CNCs for 5-axis machining, providing a innovative features and functions to produce high quality parts simply, efficiently and reliably.

Functions for simultaneous 5-axis machining

- Tool Center Point Control (TCP)
- 3D Cutter Compensation
- Tool Posture Control
- Tool Cutting Point Command
- Smooth TCP and High Speed Smooth TCP

Auxiliary functions

- Nano Smoothing 2
- Machining Condition Selection Function
- Machining Quality Level Adjustment Function
- 3D Manual Feed
- Workpiece Setting Error Compensation
- 3D Interference Check
- 3D Error Compensation
- Volumetric Compensation

TWP – Tilted Working Plane



World-class CNC systems for high-performance applications

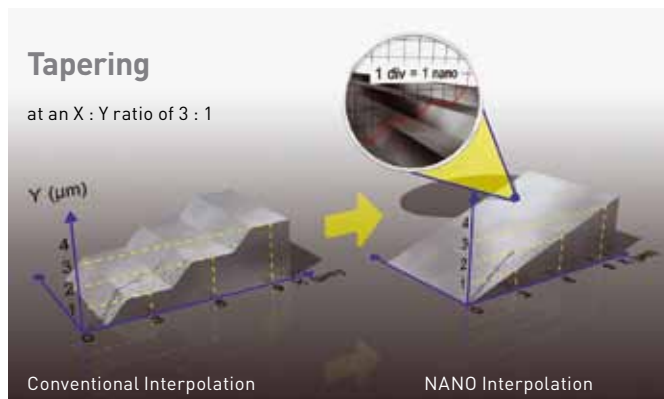
Speed, precision and flexibility

The requirements of 5-axis machining for mold and aerospace manufacturing are very challenging, demanding the highest performance and precision. The application of 5-axis machining is rapidly expanding into general manufacturing to reduce setup and cycle times, and to eliminate multi-machine setup errors. This is driving a demand for more flexibility, with machine independent part programs, features that allow tool geometry decisions to be made by the operator during setup, and run-time tool wear offsets.

CNC technology from the world's leader

CNC technology is at the heart of the machining process and, with over 2,400,000 CNCs and 12,700,000 servo motors installed worldwide, FANUC is the undeniable market leader. This success is built on high performance systems with the highest precision and reliability.

The series 30*i* and 31*i*-5 CNCs are capable of performing extremely complex tasks with speed, precision and flexibility, characteristics ideal for 5-axis milling and turning in the mold and aerospace industries, and general manufacturing.



Series	31i-5	30i
Max. controllable axes	26	40
Max. interpolated axes	5	24
Spindle	6	8
Max. I/Os	3072 / 3072	4096 / 4096
Embedded Ethernet	√	√
Dual Check Safety	√	√

Superior surface finish with nano-precision

FANUC's unique nano interpolation calculates all motion commands with nanometre (10^{-9} m) precision and executes them with a highly reliable, digital servo system. Even though part programs may be written only at a micron (10^{-6} m) resolution or less, nano interpolation together with 16-million count feedback devices control the axes paths at a higher precision to achieve a superior surface finish quality when cutting tapers or contours.

Intelligent look-ahead

The look-ahead function plays an important role in the high-speed machining of sculptured surfaces, where tool paths are typically generated as numerous small linear segments. Effective look-ahead ensures that the machine will never have to "wait" for the next piece of data, which could negatively effect part quality and machining time. FANUC's advanced 30*i* and 31*i*-5 CNCs look-ahead in the part program by up to 1000 blocks, making intelligent decisions to improve part quality and optimize cutting speeds.

The CNC handles the large part programs with ease, providing up to 8MB of internal memory, up to 4GB of external ATA flash memory, and high-speed Ethernet transfers.

Modern machine tools, including the increasingly popular 5-axis machining center, place exacting demands on the CNC for exceptional speed, precision, and reliability.



User-friendliness has many facets

Intuitive operation

The CNC holds a large amount of data about the machining process and it all must be readily available to the operator. Using crystal-clear LCD monitors with display sizes up to 15", intelligent softkey support, and intuitive menu structures, the 30i series controls make it easy to access multiple sets of data quickly and in a familiar, user-friendly format.

Operational and part program compatibility

When developing faster and more reliable hardware, and increasingly innovative software, the CNC manufacturer should also ensure part program and operational compatibility. Part program compatibility is important so that the multitude of existing part programs run on the new controls. Operational continuity is important to the CNC operator to allow them to move confidently between machines. Unnecessary reprogramming and training costs are avoided. FANUC is committed to product compatibility, so that once you have learned how to use one FANUC CNC, you will quickly become familiar with the latest generation.


Machine and tooling independent programming

Traditional simultaneous 5-axis machining required that all tooling and setup decisions be made for a specific machine before the post generated a part program. Simplifying the part programming process is essential in order to expand the use of 5-axis technology to a wider market. FANUC has been proactive in developing features to simplify the application of 5-axis machines, providing features to allow machine and tool independent part programs to be generated.

CAD/CAM connection

Software available from many CAD/CAM providers will support the requirements of 5-axis programming for FANUC CNCs. In addition, designers can create free-form surfaces using non-uniform rational B-spline geometry (NURBS) that is executable by the CNC. These mathematically defined surfaces are interpolated smoothly and accurately to provide a part geometry that is completely faithful to the designer's original concept. Smoother machining also typically allows faster cutting rates.





More flexibility for 5-axis machining

5-axis and 3+2 machining

"3+2" axis machining has existed for some time – also known as milling in a tilted workplane. It is sufficient for applications where the workpiece can be tilted and then machined with three conventional axes. For more complex applications, such as the machining of free forms, 5-axis machines where all axes are controlled simultaneously must be used.

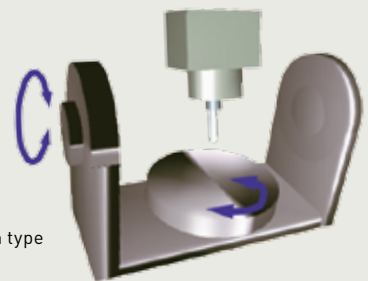
Supported machine configurations

FANUC CNCs are flexible in their application to either 5-axis simultaneous or "3+2" machine tool designs. Rotary axes can either position the tool, the part or a combination of both. FANUC CNCs are easily configured by the machine tool builder to support special heads and tables that rely on a defined plane of rotation to enhance the productivity of the machine tool.

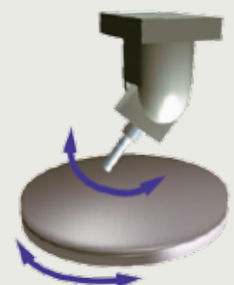
Head rotation type



Table rotation type



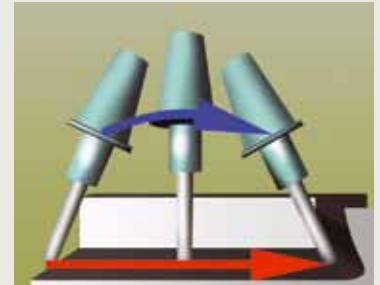
Mixed type
(both head and table rotate)



Functions for simultaneous 5-axis machining

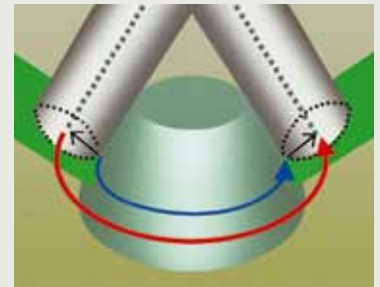
Tool Center Point Control (TCP)

Tool Center Point Control allows the operator to specify the tooling geometry length at machining time and to adjust tool length offsets in the tool axis direction, taking into consideration the path of the tool center point. It controls the movement at the tool center point so that it follows the programmed path, even if the tool axis direction changes. The function supports both linear and circular interpolation.



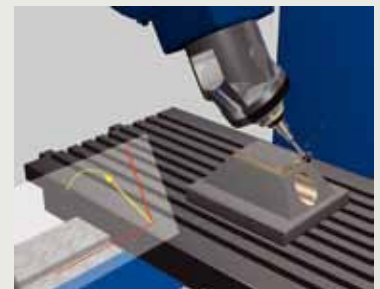
3D Cutter Compensation

3D Radius Compensation allows tooling radius or diameter to be specified and adjusted at machining time, eliminating the need to re-post the part program when tooling changes, and to ensure part accuracy as tools wear. 3D Radius Compensation also checks for interference, particularly where internal corners require a change in direction of the tool, and will stop the process to avoid instances of over milling.



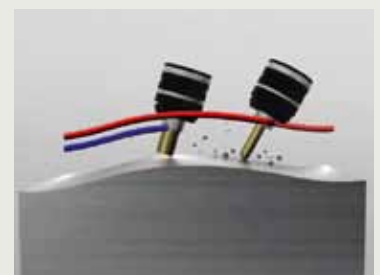
Tool Posture Control

The function of Tool Posture Control is an extension of TCP that controls the dynamic path of the tool center point on a straight line. The motion of the tool is linked to the vector between the starting and ending points to avoid any unintentional stock removal by the side of the cutting tool. Tool Posture Control is mainly used in side cutting, where pockets or forms with varying angles are being milled.



Tool Cutting Point Command

Tool Cutting Point Command enables the definition of the orientation of the tool relative to the programmed path for end, ball or bull-nose milling tools – information that traditionally would have had to be specified in the CAM system. Now an operator may determine the optimum cutting conditions at the machine and the CNC will automatically adjust the cutting tool path.



Smooth TCP and High Speed Smooth TCP

Smooth TCP is an enhanced Tool Center Point function, detecting any sharp discontinuities in the tool orientation generated by the CAM system, and smoothing the motion to reduce machine shock. It smooths the motion of rotary axes and thereby contributes to a uniform tool traversing movement. High-Speed Smooth TCP also optimizes the Tool Posture Control function which is of great benefit for side cutting. High-Speed Smooth TCP can be commanded within existing tool posture control programs to improve the uniformity of the tool side movement. The benefits gained from these new features are smoother surfaces and shorter cycle times.

Auxiliary functions

Nano Smoothing 2

Nano Smoothing 2 automatically converts linear-segmented part programs into continuous free-forms that can be executed by the CNC's built-in NURBS interpolator technology. The result is a faster, "more fluid" motion and an exceptional surface finish for both 3-axis and 5-axis machines.

Machining Condition Selection Function

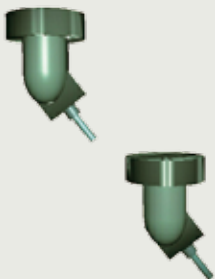
Machining Condition Selection Function is a way for the operator to set the priority between cutting speed and precision. With 10 defined steps, cutting speed can be prioritized during roughing operations for maximum productivity, and then precision prioritized for the final finishing cuts to maximize part quality.

Machining Quality Level Adjustment Function

Machining Quality Level Adjustment Function extends the features of Machining Condition Selection to include surface finish as an additional factor to be considered. This works in conjunction with Nano Smoothing 2, providing a surface finish grading from 1 to 10 for the 'smoothness' of the finished part. The selection of the three parameters – speed, accuracy and smoothness – is simplified by providing a graphical tool on the CNC display. The operator simply moves a cursor on a three-dimensional grid to make the selection, and the CNC does the rest, automatically assigning the necessary parameters.

3D Manual Feed

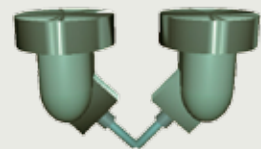
Whether machining with 3-axis on tilted working plane or 5-axis simultaneously, operators need to be able to manually intervene in the case of an emergency, for example, after a tool breaks. For 3-axis machining, simply retracting the Z-axis typically frees the tool. Simultaneous 5-axis machines require a more intelligent solution, as multiple axis may need to be coordinated to retract the tool. FANUC has solved this problem by providing the "3D Manual Feed" function for 5-axis machining. The machine operator can retract the tool along its machining axis at the press of a button, or move parallel to the working plane.



Tool axis direction feed



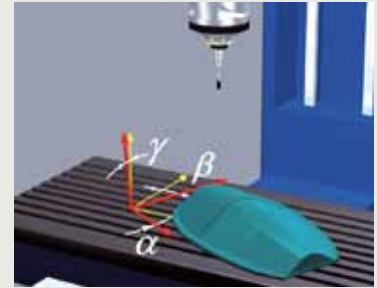
Tool axis right-angle direction feed



Tip center rotation feed

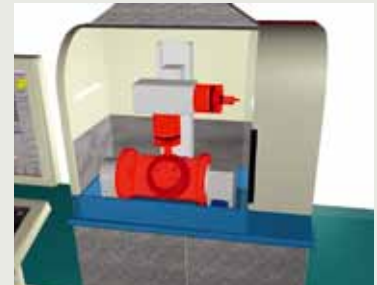
Workpiece Setting Error Compensation

With large workpieces, a part is often clamped in the machine for a number of operations and then removed for an inspection or a measurement. When the workpiece is re-clamped, positioning and orientation errors are often unavoidable. The Workpiece Setting Error Compensation feature detects any change in position and orientation using standard measurement cycles and automatically adjusts the axis paths before continuing with the part program.



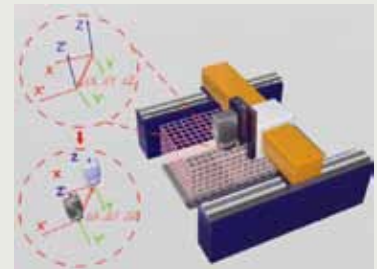
3D Interference Check

3D Interference Check is a monitoring system that works whenever the machine axes move, whether in automatic or manual mode. The critical working area of a machine are modelled in the CNC using standard geometric elements (planes, rectangular parallelepipeds and cylinders) that are defined using absolute dimensional data (to the micron-level) and work in conjunction with the tool geometry data that is also stored in the CNC. The control uses all this spatial data to determine whether any moving part of the machine may collide with any of the fixed elements such as the table, fixtures and other machine structures. Since all the checks are made in real-time, the feature is capable of preventing practically all potential collisions. This function is available for both milling and turning machines.



3D Error Compensation

This feature in the 30i and 31i-5 series FANUC CNCs can correct geometric machine errors by processing three-dimensional performance data of the total machine volume. The result of this error compensation is a much higher level of processing precision.



TWP – Tilted Working Plane

Tilted Working Plane or “3+2” machining requires simple and concise guidance to be implemented successfully. As there are a number of ways to define the Tilted Working Plane, FANUC provides an on screen visualisation to use either Euler angles, ‘Roll – Pitch – Yaw’, three points, two vectors, angular projection or the programmed tool direction. The operator can easily input component data depending on the information that is available.



FANUC Series 30i-MODEL A

MANUAL GUIDE i
ACTUAL POS. (ABS.)

X	-50.000	DIST TO GO	600	SPINDLE	S1	01 13:58:04
Y	0.000	XYZ	0.000	FEED	0%	0 SAMPLE_07
Z	245.772	XYZ	0.000	MM/MIN	0%	N 00000005
A	45.000	ZAC	0.000			T 0
			405.000			D 5 H 0
						S 0 H1
						F 0.0000000
						600 17 40
						600 49 90
						600,2 13.1

SIMULATE-ANIMATE



61001: DRILLING

REWIND START PROCES SINGLE STOP

SAMPLE_07

```
26 G1850 A1. Q1. X-50. Y50. Z-20.  
I225. J45. K0. T1. ;  
77 G1001 W1. I1. J0. L-100. K10.  
CS. F30. Z2. ;  
78 G1210 B0. H0. U-50. ;  
79 ;  
80 ;  
81 ;  
M5 (KEYSYAHEN) ;  
82 D1 ;  
83 G1850 A1. Q1. X-50. Y-50. Z-20.  
I315. J45. K0. T1. ;
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INIT CUTDSP INTERF TLPTH GRPOFF

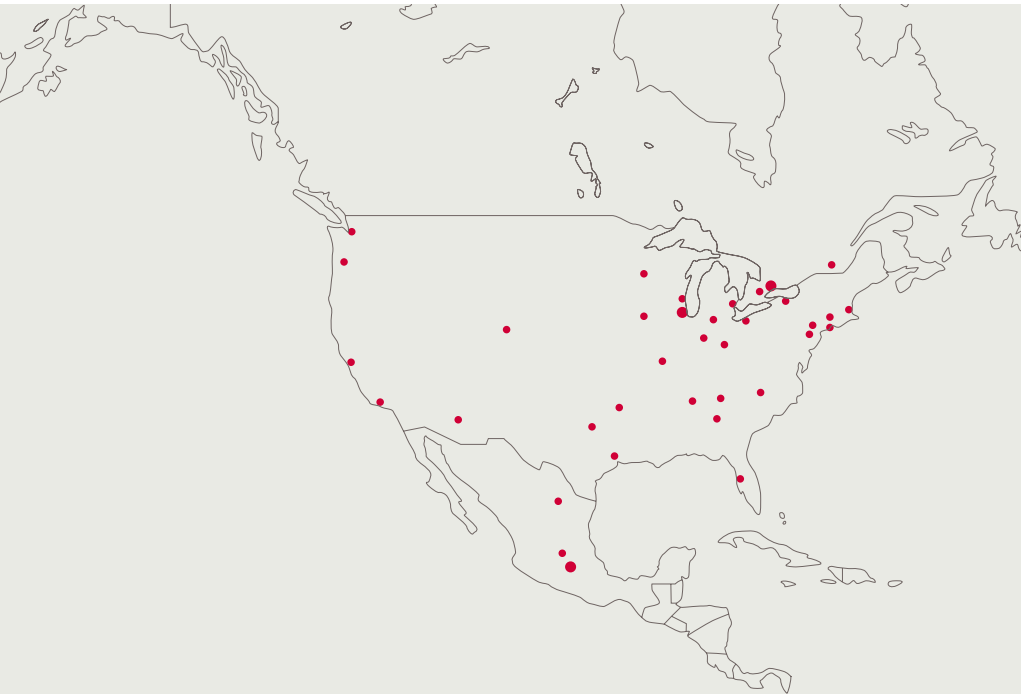
Simple and user-friendly operation

10 unbeatable arguments for controls from FANUC:

1. Maximize machine uptime and minimize TCO with FANUC's world class reliability, delivering MTBF rates in excess of 17 years.
2. Secure investment with a 25-year replacement part availability and support commitment.*
3. Increase competitive edge with state-of-the-art technologies to increase quality, efficiency, reliability and to reduce cycle times.
4. Minimize training and support costs with continuity of operation and upward compatibility to run existing programs on new CNCs.
5. Reduce delivery times with quick and easy at-the-machine programming.
6. World-class factory-trained service, training as well as free lifetime technical support provide decades of trouble-free operation and the lowest MTTR.
7. Boost efficiency with Ethernet enabled data and remote diagnostics.
8. Minimize downtime by separating CNC and PC technologies.
9. Rely on a world class partner for simple through complex machine tools.
10. Simplify integration with FANUC robots by using the standard interface.

*When a FANUC CNC system is out of production, we strive to have replacement parts for 25 years. Replacement parts are available for purchase or through extended service contracts. If and when parts are no longer available due to discontinued component manufacturing, we offer repair and reuse. We strive to engineer replacement parts with the same functionality, form and fit. We offer on-site FANUC factory-trained service and support on FANUC CNCs for the lifetime of your machine.





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