sharnoa

CNC CONTROLS

PYTHAGORAS

Pythagoras CNC control

3-axis Contouring

5-axis Indexing

The *PHYTHAGORAS* CNC Control is a successor of **SHARNOA** Tiger family of CNC Controls operating worldwide already 25 years. *PHYTHAGORAS* uses state of the art electronics, advanced mathematical algorithms and **LOTS of FIELD EXPERIENCE.**

5 AXES INDEXING TECHNOLOGY

PHYTHAGORAS supports 5 axes applications in Index mode (rotary axes can be indexed to any angle, milling in X, Y, Z), which are more than 90% of all 5 axes applications.
Special 5 axes functions reduce dramatically the set up time and help enormously to prevent collisions.

5 AXES SPECIAL FUNCTIONS

- **Free Part Positioning**
  - The work piece can be placed in any coordinate and orientation inside the working volume of the machine and then "Home" point is marked.
  - The control dynamically calculates the desired contour and automatically takes into consideration the real machine geometry (including precise kinematics calibration data) and ensures accurate motion in all 5 axes.
  - The control compensates for real tool length, radius and tool holder dimensions.
- **Axes Motion Related to the Actual "Home" Position.**
  - CAD/CAM has to create the G-code program only once (in "part coordinates") !
    This is regardless of the placement of the part.
  - Once the part is repositioned on the table the operator has just to indicate the new home position and there is no need for another CAD/CAM run.
- **Collision Avoidance and Tool Path Verification.**
  The control detects possible future collision of tool, tool holder and machine parts against each other and prevents it from happening. The control performs collision protection in:
  Simulation mode - to prevent wrong part placement;
  "On-the-fly" mode – prevents crash during milling.
- **Hand-wheel Motion of Tool in Indexing Plane and Retract Direction.**
  - The "standard" directions of the linear axes rotate into the indexing plane. The MPG moves in 2 or 3 axes simultaneously following the initial X-Y-Z directions but in the already rotated plane.
- **Position Correction.**
  Easy way to correct position of any fragment in G-code program in regards with measurement results, changing:
  - "Homes" position in machine coordinates;
  - "Homes" position in "rotated" index-plane coordinates;
  - Index-plane coordinates in original axes directions.
- **Advanced Graphic Presentation**
  - Scale, mouse-driven rotating, surface points and home coordinates; Forbidden and Restricted zones
  - Machine, Tool, Material stock and Removal presentation
    - **Photo realistic "SOLID" simulation** of the machine tool motion, machine components, cutting tool, material stock, work-piece and holding fixtures allows graphical presentation of the process.

PHYTHAGORAS combines real-time **DSP** electronics and powerful industrial PC platform. This configuration is easily upgradeable and therefore insures the machine owners ever improving performance.

MAIN FEATURES.

- Dual language system, standard ISO and traditional SHARNOA languages
- Block processing time less than 0.1 millisecond.
- Dual encoder implementation on 5 axes.
- Linear, Circular, Helical, Spline and NURBS Interpolation.
- Controlled Acceleration and Deceleration Look Ahead, Feed Forward and S-Curve speed control with Sub-micron accuracy
- Backlash compensation, Cross-axis compensation, Temperature Compensation
- Advanced and friendly Graphic presentation

Pythagoras CNC control

5-axis Contouring

The **PHYTHAGORAS** CNC Control is a successor of **SHARNOA** Tiger family of CNC Controls operating worldwide already 25 years.

PHYTHAGORAS uses state of the art electronics, advanced mathematical algorithms and **LOTS of FIELD EXPERIENCE.**

PHYTHAGORAS supports all 5 axes machine kinematics .
1. Table / Table (Part rotates around the tool);
2. Head / Table (Pivoting Head and Rotary Table).
3. Head / Head (Rotary and Pivoting mo tions by Head).

5 AXES TECHNOLOGY
Special 5 axes functions reduce dramatically the set up time and help enormously to prevent collisions.
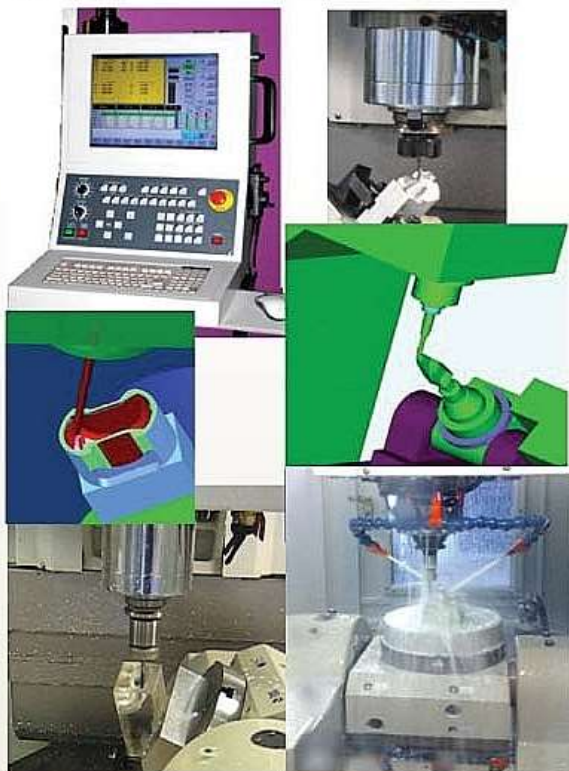
PHYTHAGORAS combines real-time **DSP** electronics and powerful industrial PC platform.

This configuration is easily upgradeable and therefore insures the machine owners ever improving performance.

MAIN FEATURES.
• Dual languages (ISO and traditional SHARNOA).
• Block processing time less than 0.1 millisecond.
• Multi "Home" programming.
• Canned cycles: Drilling, Tapping, Peck Drilling, Boring.
• Parametric programming.
• Linear, Circular, Helical, Spline, NURBS Interpolation.
• Controlled Acceleration and Deceleration
• Look Ahead, Feed Forward and S-Curve speed control with Sub-micron accuracy
• Backlash, Cross-axis, Temperature compensation
• Advanced and friendly Graphic presentation
• Dual encoder implementation on 5 axes.

5 AXES SPECIAL FUNCTIONS
• **Axes Contouring Control**
5-axis **Simultaneous Motion** with Tool normal to the surface, Dynamic axes rotary/linear synchronization.

• **Free Part Positioning**
▪ The work piece can be placed in any coordinate and orientation inside the working volume of the machine and then "Home" point is marked.
▪ The control dynamically calculates the desired contour and automatically takes into consideration the real machine geometry (including precise kinematics calibration data) and ensures accurate path motion in all 5 simultaneous axes.
▪ The control compensates for real tool length, radius and tool holder dimensions.

• **Axes Motion Related to Actual "Home" Position.**
▪ The G-code program can be created only once (in "part coordinates") ! This is regardless of the part placement.
▪ Once the part is repositioned on the table the operator has just to indicate the new home position. No need for another CAD/CAM run.

• **Collision Avoidance and Tool Path Verification**
The control detects possible future collision of tool, tool holder and machine parts against each other and prevents it from happening. The control performs collision protection in:
Simulation mode - to prevent wrong part placement;
"On-the-fly" mode – prevents crash during milling.

• **Indexing Control Mode**
▪ The mode, when rotary/pivoting axes are used for positioning and the cutting takes place with only the three linear axes moving. Index cutting planes designation allows milling 3 axes program in a plane rotated in any 5-axis position direction.
▪ **Hand-wheel Motion** of Tool in Indexing plane and Retract Direction. The "standard" directions of the linear axes rotate into the indexing plane. The MPG moves in 2 or 3 axes simultaneously following the initial X-Y-Z directions but in the already rotated plane.

• **Position Correction.**
Easy correction of position of any fragment in program in regards with measurement results, changing:
▪ "Homes" position in machine coordinates;
▪ "Homes" position in "rotated" index-plane coordinates;
▪ Index-plane coordinates in original axes directions.

• **Feedrate Adaptive Control Proportional to Spindle Load.**
The actual spindle load during cutting used as feedback for close loop control of cutting feed rate. This:
▪ Increases tool life;
▪ Shorter machining time while cutting island shapes.
▪ Reducing tool changes due to improved tool life;

• **"Rough-to-Finish" Surface Quality Control over 3-D Contouring in High Speed Machining Mode.**
▪ "Rough" allows short time roughing trajectory.
▪ "Finish" makes precise and high quality surface.

• **Photo realistic "SOLID" simulation** of the machine tool motion, machine components, cutting tool, material stock, work-piece and holding fixtures.

PYTHAGORAS

List of ISO supported G-Codes and M-functions

G-Codes

G-code	Function		G-code	Function
G00	Travers motion and positioning			
G01	Linear interpolation			
G02	Circular interpolation CW		G60	Single Direction Positioning
G03	Circular interpolation CCW		G61	Exact stop mode
G04	Dwell		G62	Automatic corner override *
G06.2	Non-uniform B-Spline interpolation – NURBS *		G64	Exact stop mode cancel *
			G65	Non-modal call of user macro
G06.05	Spline Interpolation *		G66	Modal call of user macro
G7	Plane rotation		G67	Modal Macro call cancel
G7.1	Plane rotation cancel		G68	Coordinate system rotation
G8	3D tool path conversion to 5-axis processing *		G69	Coordinate system rotation cancel
			G73	Drilling Canned cycle
G09	Exact stop		G74	Left Hand Rigid Tapping cycle
G10	Tool offset value and work coordinates shift		G74.1	Left Hand Tapping cycle
			G76	Fine Boring cycle
G12.1	Polar coordinate interpolation mode		G80	Canned cycle cancel
G13.1	Polar coordinate interpolation cancel mode		G81	Drilling cycle
			G82	Drilling/Counter Boring cycle
G15	Polar coordinates command cancel		G83	Peck drilling cycle
G16	Polar coordinates command		G84	Rigid Tapping cycle
G17	XY plane designation		G84.1	Tapping cycle
G18	ZX plane designation		G85	Boring cycle
G19	YZ plane designation		G86	Boring cycle
G20	Inch input designation		G87	Back Boring cycle
G21	Metric input designation		G88	Boring cycle
G28	Return to Reference Position		G89	Boring cycle
G29	Return from Reference Position		G90	Absolute command designation.
G30	2nd, 3rd and 4th Reference Position Return		G91	Incremental command designation
			G92	Programming of absolute zero point
G31	Skip function		G93	Inverse Time Feedrate *
G34	Display a String		G98	Return to initial point for canned cycles
G37	Input a Number or Numbers		G99	Return to point R for canned cycles
G40	Tool radius compensation cancel		G110	Enable Forbidden Zone Entry Check
G41	Tool radius compensation, left		G111	Disable Forbidden Zone Entry Check
G42	Tool radius compensation, right		G125	Tool motion in MDI backward to the last move active (5-axis) *
G43	Tool length offset, +			
G44	Tool length offset, -		G140	5-axis tool path rotation (RTCP) cancel
G49	Tool length offset cancel		G141	5-axis tool path rotation (RTCP)
G50	Scaling off		G147	5-axis indexing plane rotation position correction
G50.1	Mirror off			
G51	Scaling on		G149	Start Round and/or Chamfer.
G51.1	Mirror on		G-149	Cancel Round and/or Chamfer.
G54	Shift to work coordinate system 1		G199	On-line update between CNC and PLC variables
G55	Shift to work coordinate system 2			
G56	Shift to work coordinate system 3		G998	Smoothing On (High Speed Machining)
G57	Shift to work coordinate system 4		G999	Smoothing Off
G58	Shift to work coordinate system 5		G1000	Special Spline in 5-ax machining *
G59	Shift to work coordinate system 6		G5001	Run SHARNOA G-code

* Optional functions (can be implemented by request).

M-functions.

The machine builder may specify **its own M-codes**, from M200 to M999, via the integrated PLC system.
The standard CNC M-functions are listed in the table below.

M-code	*Function*
M00	Program stop
M01	Optional stop
M02	End of program
M03	Spindle forward rotation
M04	Spindle reverse rotation
M05	Spindle stop
M06	Tool change
M07	Coolant On
M08	Spray On
M09	Coolant and Spray OFF
M11	Spindle orientation On
M111	Spindle orientation (maintenance) On
M13	Tool search
M14	Pocket search
M18	Rigid Tapping On (ISO approach)
M20	Magazine home position search
M22	End of Program and Power OFF
M24	Chip Conveyor CW On
M25	Conveyor CW and Wash Down On
M26	Conveyor CW and Wash Down Off
M27	Conveyor CCW and Wash Down On
M29	Rigid Tapping On
M30	End of Program
M33	Spindle CW On and Coolant On
M34	Spindle CCW On and Coolant On
M35	Rotary Axis A or C Clamp
M36	Rotary Axis A or C Unclamp
M38	Program, Spindle, Coolant Conv. Stop

M40	Spindle Load Adaptive Control On
M41	Spindle Load Adaptive Control Off.
M48	Tool Clamp (maintenance)
M49	Tool Unclamp (maintenance)
M50	Tool length measurement devise (Renishaw or equivalent) ON
M51	Tool length measurement devise (Renishaw or equivalent) OFF
M53	Spindle measurement probe ON
M56	Manual Tool Change
M70	Graph View (versus time) On
M71	Graph View Off
M75	Pot Up (maintenance)
M76	Pot Down (maintenance)
M81	Arm 0 (maintenance)
M82	Arm 60 (maintenance)
M83	Arm 180 (maintenance)
M98	Subprogram call (ISO approach)
M99	Subprogram end.
M104	Coolant Through Spindle On
M105	Coolant Through Spindle OFF
M129	Spindle Orientation (maintenance)
M135	Tilting Axis B Clamp
M136	Tilting Axis B Unclamp
M170	Inch units (SHARNOA approach)
M171	Metric units (SHARNOA approach)
M195	Rotational axis modulo 0 – 360 degr.
M199	Automatic change of servo parameters.

The machine builder, to implement his machine design requirements, may specify other M-codes, not listed above.
The machine builder and end –user can address any custom made macro program and/or subroutine to run as additional M-code. This mechanism allows easy running of any program within existing program in memory (widely used by implementation of Measurement Subroutines Library).

IV) Calculation functions.

Standard arithmetic calculations
: _ + _ - _ * _ / () # [for parameters]
Logic operations:
< / <= / <> / > / >= / = = / JMP / SKP

Trigonometric functions:
SIN / COS / TAN / CTAN / ATAN / ACOS / ASIN
Mathematical functions:
EXP / SQRT / LOG / ABS / ROUND / FIX / FUP / FRC

High Speed Machining CNC control

HIGH SPEED MACHINING

Fast Servo Loop

Position, Speed, Torque and Current Control in sinusoidal Commutation mode.
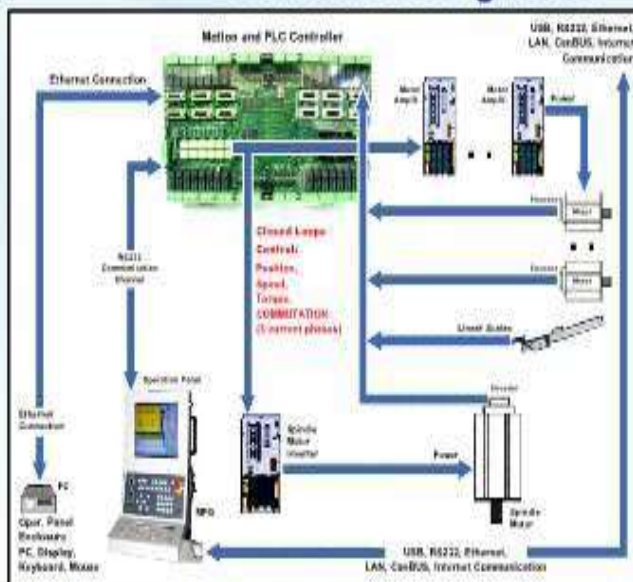
Block processing time less than 0.1 millisecond.

Agility

Advanced Look Ahead.

Dynamic S-Curve algorithm with Jerk control.

Smooth-on-line trajectory calculations.

Hardware Configuration

Accuracy

PID Servo Loops with advanced Feed Forward, Low Pass and Notch filters.

High Speed Feedback Reading.

Dual Feedback [motor Encoder and Scale in parallel].

Minimizes Backlash and Mechanical Coupling.

Dynamic resolution change of control commands and feedback readings.

Ballscrew pitch, Cross axes and Temperature compensations.

Speed adapted to specified accuracy

Machining speed decided automatically according to the accuracy demand.

"Rough to Finish" Surface quality control in 3D Contouring.

Fast Data Transfer

RS-232 (max 115 Kbps), CAN Bus, 2 x USB and 2 x 100BaseT Fast Ethernet channels.

Data storage volume 40 GByte min, unlimited number of programs.

HARDWARE

Multi processor architecture of DSP and FPGL for Real-Time operation.

Number of axes:

Basic configuration - 3 axes plus Spindle.

Extended version - 4th NC axis plus 3 auxiliary axes.

Optional: up to 8 additional NC axes or 7 NC axes plus 2nd Spindle (total 12 axes).

All axes digital current control and Spindle - speed control.

Number of I/Os:

Digital: Basic configuration - 64, Extended 128.

Analog:
  Inputs: Basic - 4, Extended - 8.
  Outputs: 16.

Touch Inputs: 1 per axis for exact position capture.

Industrial PC platform

User friendly interface.

Windows based advanced graphics and communication.

PLC

Independent, fully synchronized Motion and Logic tasks capable of "on-the-fly" actions.

Multiple "handshake" communication methods with external devices.

Multi-tasking, Object oriented Function Block Diagram (FBD) graphical language (IEC 1131-3).

Extended library of "Ready-to-run" standard motion and logic blocks with open architecture for "custom" blocks.

Graphical programming and Real-time Debugging tools for quick modifications and diagnostics.

High Speed Machining CNC control

Continued

SOFTWARE

Multi-language International HMI support.

Multi G-code including ISO.

Manu-driven machine builder (OEM) support for machine-depended parameters setup.

Maintenance, diagnostic tests and parameters change can be performed during machine operation.

Tool tip path simulation (with plane, 3-D, scale, magnification, rotation and tool diameter).

Easy start program run from any block in the middle of program, continued machining after interrupt, tool compensation change and home position shift.

Programming Features:

Parametric programming, Trigonometry and Arithmetic functions.

Cartesian, Polar and 3D G-codes.

Conditional and Unconditional Jumps, Cycles, Macros and Subroutines.

Automatic calculation of Fillets, Intersections and Contact between Straight Lines and Circles.

Canned Cycles: Drilling, Boring, Tapping, Rectangular, Circular and User-Defined subroutines.

Multi-"Home" programming and on-line shifting.

Jogging, Vector positioning, Contouring, Point-to-Point positioning.

Multi-axis Linear, Circular and Helical Interpolation.

Electronic Gearing and Electronic Cams.

Coordinate transformations with shift, rotation, mirror and scaling factors allowing index plane change for machining.

Cubic, Spine, Polynomial interpolations, NURBS, 1/T control and Inverse kinematics (option).

Indexing The Working Planes
Enable drilling holes on inclined surfaces.
Compensating machine accuracy changes.
Correcting workpiece position.

Conversational.

Simple implementation of Ready-to-use Macro procedures and Custom-made subroutines.

G-code, M-functions and Subroutines, on-line Wizard with Graphics, Pictures and Text.

On-line reading, writing (storage) and transfer information in alpha-bet and numerical formats into files.

Clear colored messages including Customization of messages by operator.

Extended Libraries of Measurement procedures.

Automatic and Manual measurements of tool offset, length, diameter and wear.

Touch probe allows designation of real part home position, part orientation, machine calibration and position offset of work-piece.

Part digitizing with touch and laser non-contact devices.

Servo Tuning tools for Machine builder.

Circularity test utility ("Ball-bar") - effective way to adjust and optimize servo system performance.

Motion Analyzer - real time oscilloscope for optimizing motion performance.

AxisMotion, MotionViewer, EncoderTest, CommutationTest, CompLoader, NotchFilterCalc.

Phase-Amplitude and FFT Analysis Calculation (optional).

ON LINE MAINTENANCE

Remote System on-line support (via available communication channels, incl. LAN and Internet).

Maintenance, diagnostic tests and parameters change can be performed during machine operation.

Specifications

Specifications	Standard	Option	Description
Components	V		Main control unit
		V	I / O extension boards
	V		Industrial PC
	V		Communication Server
	V		Operational Panel + MPG unit.
	V		Operation Panel Enclosure
Operation System	V		Real-time Direct Interrupt on DSP
	V		Windows XP, 7, 8
		V	Windows 10
Memory	V		Hard Disk with 40 GB minimum
Input resolution and display step	V		Axes 0.001 mm
		V	Axes 0.0001 mm
Input Range	V		Maximum 10000.000 mm
	V		Minimum -10000.000 mm
Interpolation	V		Line in 4 axes
	V		Circular in 2 axes
	V		Helical in 3 axes
Block processing time	V		0.1 ms
Axes Feedback control	V		Position Loop resolution – up to 0.001 mm
	V		Maximum frequency – up to 10 MHz
	V		Cycle time of position control 0.5 ms
		V	Cycle time of position control 0.25 ms
	V		Cycle time of speed control 0.5 ms
		V	Cycle time of speed control 0.25 ms
	V		Cycle time of commutation current control 0.16 ms
		V	Cycle time of commutation current control 0.08 ms
Range of travers	V		Maximum 100 m
Spingle speed	V		Maximum 120000 RPM
Error compensation	V		Linear and non linear axis error
	V		Cross-axis
	V		Temperature expansion
	V		Reversal spikes during circular movements
	V		Backlash
Data interface	V		2 x RS232 (up to 115 Kbps) / RS422 / RS485
	V		2 x USB
	V		2 x 100BaseT Fast Ethernet
Diagnostics	V		Simple messages presentation
	V		Graphic presentation
Ambient Temperature	V		Operation: 5° C to 40° C
	V		Storage: -20° C to +60° C
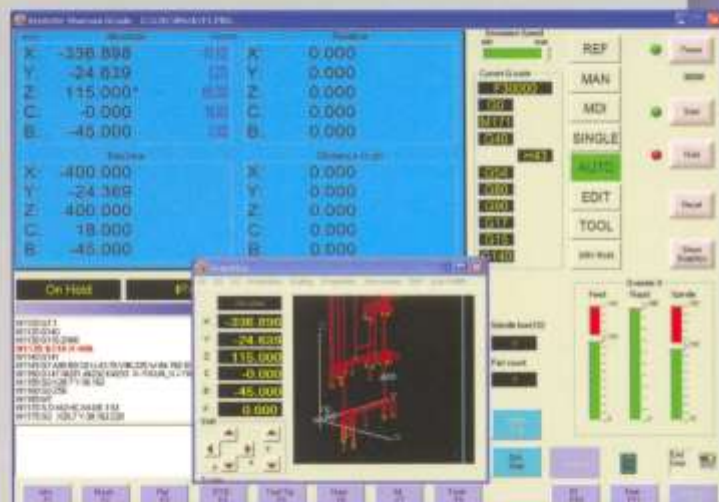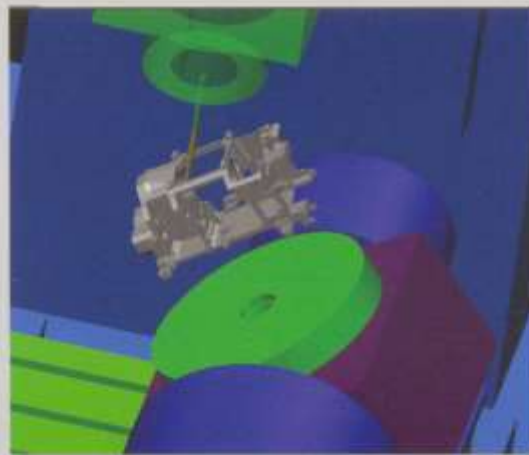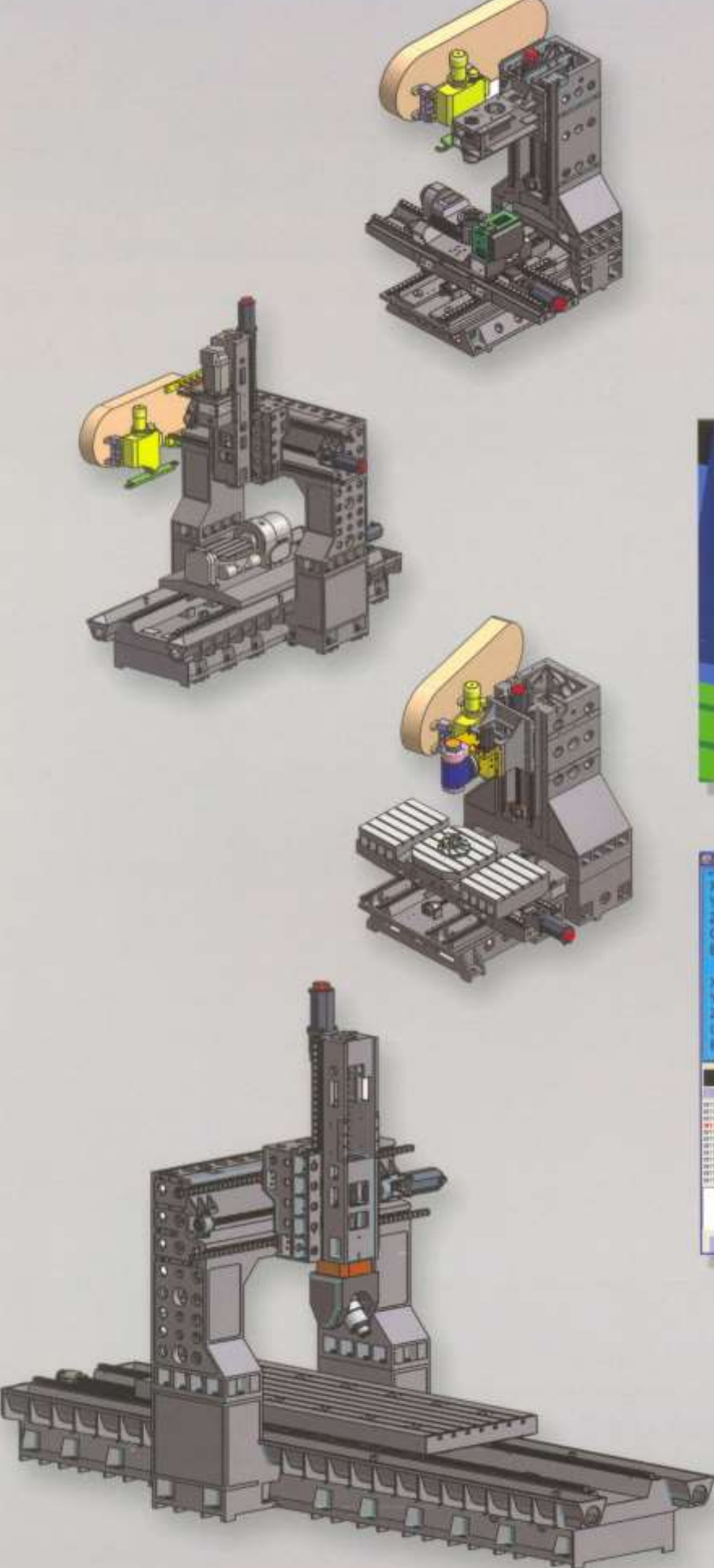
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