



Gray Floor Mill Control Retrofit

System Integrator: MasterControls Inc., L.L.C. (MCI)

MCI was contracted by a Machine Tool Rebuilder for a control system retrofit on a Gray floor type mill. This rebuilder did a complete mechanical rebuild on the Model XX Gray, but needed an integrator to do the control replacement. MCI was selected to provide a complete control replacement.

The Floor type mill was purchased and rebuilt for a major machinery remanufacturer in the mining industry. The machine had been converted from a manual machine to CNC in the 70s. The first recontrol had been done using a GE550, which at the time was state of art. Upon rebuilding the machine it was determined that the GE550 system was not a viable control option.

The GE 550 CNC system consisted of:

- Incremental feedback
- Inductosyn scales
- DC servo motors
- Multiple control panels
- Single rack drive on X axis
- Limited CNC functionality
- No networkability
- Memory size limitations

Based on the original system limitations MCI set out to provide the customer with a solution that would address the short comings of the original CNC system. Additionally, the customer had specific control requirements that needed to be met for the application. MCI's solution consisted of a turnkey retrofit using a NUM CNC system. The NUM CNC system allowed MCI to provide a high end CNC solution that boasted the following machine enhancements:

- Low maintenance costs
- Onboard user help files
- Easy to use system
- Short setup times
- Variable spindle speed control
- Selectable CNC or manual machine functionality
- The addition of a portable handpulse generator pendant for manual positioning and machining
- RS274 programming standard (G-Code) allowing for no limitation to programming flexibility
- Unlimited program storage and drip feed capabilities
- Anti-backlash system on main axis (X- tandem function)
- Smooth operation of main axis bearing total machine weight (over 100,000 lbs)
- High resolution digital servo system with absolute feedback
- Axis pitch error compensation for axis accuracy (laser compensation table entry)
- Axis backlash compensation
- Full system documentation with new prints developed for system retrofit
- Probing functionality
- Easily networkable through PC front end. Industrial PC front end with Flash memory



All of the control engineering and panel build was done off site. When the retrofit package was complete, a time convenient for the installation was set. The retrofit package was delivered to the customer rebuild site and the installation started. Installation of the new control system took about three days. When this work was completed we began powering up the machine and checking it for functionality. We worked with customer personnel during this phase of the project so they would become familiar with the new control and become comfortable operating the machine from the new panel. This portion of the project was the first phase as the whole machine had to be disassembled and shipped to the end user.

MCI develops solutions with the future in mind. We develop machine logic and machine functions in a way that can be reused on new applications. This helps us complete our projects on time. We also go to our customers with code which has been tested for reliability over and over. Our approach is what sets us apart from other system integrators. Additionally, having a vendor like NUM willing to partner with us on complex applications makes us comfortable taking on these types of projects.

Please see the following pages for photos of the installation and a quick overview of the specific project tasks performed by MCI.

For more information, please contact:

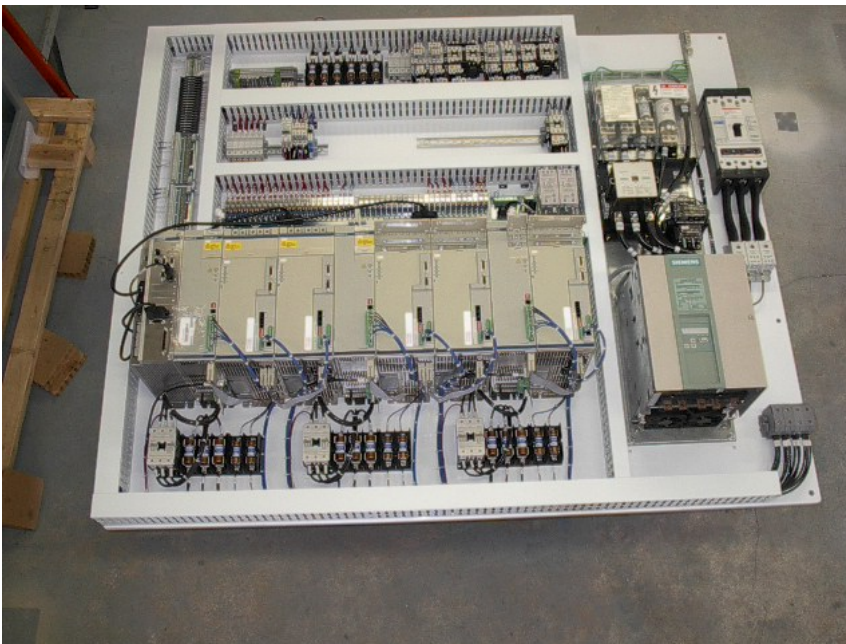
MasterControls Inc., L.L.C.
10951 S. 100 E.
Pendleton IN 46064
(765) 533-6719 Office
(765) 425-4249 Mobile
MasterControls@peoplepc.com
<http://MasterControls.us/>



NUM Corporation
603 East Diehl Road, Suite 115
Naperville, IL 60563-4909
Tel. +1 630 505 7722 x228
Fax +1 630 505 7754
[mailto: steve.schilling@NUM.com](mailto:steve.schilling@NUM.com)
www.num.com

Application Pictures:**Operator Panel**

Operator Panel/pendant with 15" Screen with full membrane keyboard, Machine Tool Builders Panel, and MPG pendant.

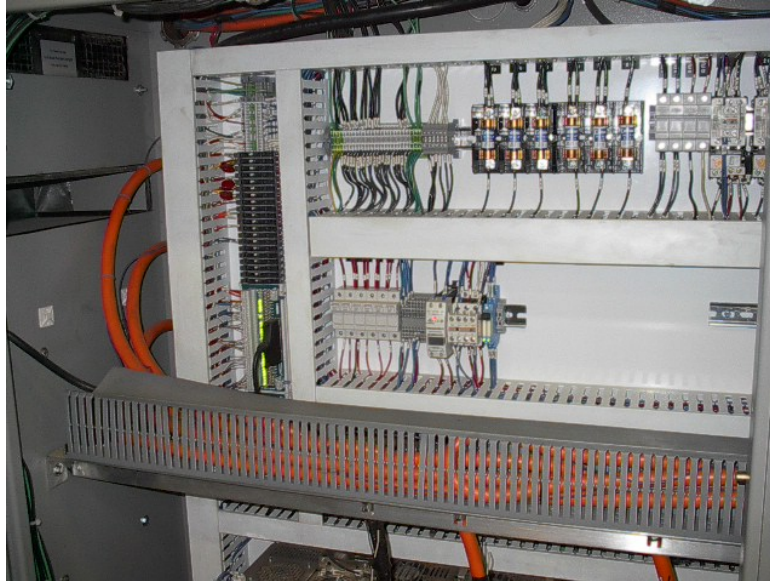
**Main panel prior to installation in enclosure**



Inside Main Enclosure- lower left after install



Inside Main Enclosure- lower right after install



Inside Main Enclosure- upper left after install



Main enclosure install on back of machine.

Tandem installation on X axis.



Completed machine











Quick Project Overview:

Installation Time

The initial installation took place at the machine rebuilder. This consisted of wiring, power-up, and initial axis calibration over a 3 day period. Once the machine was installed at the end customer an additional week was needed to wire, power-up, and laser calibrate axes.

Integration time

Integration time included producing machine schematics, creating a Bill of Material, ordering and receiving all the hardware, building of main enclosure, writing all the machine logic, and configuring all the machine parameters. This typically takes six to eight weeks from the time an order is placed to installation.

Documentation

NUM produces complete documentation for integrators and end-users. A complete set of manuals was provided to the customer. In addition to the Operator's Manual, a full set of Electrical Schematics (AutoCAD Format) were provided to the customer. We can store a copy of all documentation on the control. Operators, set-up and maintenance personnel can have immediate access to all documentation right at the machine. Additionally, MCI provided onsite program training to meet the end customer's requirements.

CNC

MCI replaced the existing CNC control with a new NUM CNC control. The new control represents the state-of-the-art in modern CNC controls allowing for standardized RS274 programming. The control has an intuitive operator interface. This intuitive interface enables the operators to perform quick set-ups and adjustments. Programs can be written at the machine or transferred via network or USB stick.

Operator Panel

A new Operator Panel was installed on the machine in place of the old GE550 display. The operator panel includes a 15" Monitor with full membrane keyboard, MTBP, and handheld MPG. This panel allows the operator to select modes, execute operational functions, modify offsets, edit/execute programs, and complete support functions.

Magnetics

A complete magnetics cabinet was provided. New power distribution, circuit protection, power transformation, IO, and cooling system were included in the offering.

Field Devices

Almost all existing field devices replaced during the retrofit.

Spindle

The spindle used a 100 hp DC motor and digital spindle drive. The spindle drive was supplied by the rebuilder. The spindle drive allows for on-the-fly spindle speed control. The NUM CNC supplied the automatic gear change function via the PLC.

Drives

The system used the NUM digital drive system. Absolute feedback was provided; therefore there was no homing required on the machine. This keeps the user from having to reference the machine on power loss or machine shutdown.

Axes

The Gray mill had at total of 5 axes. Two axes were used on the X axis for the tandem function.

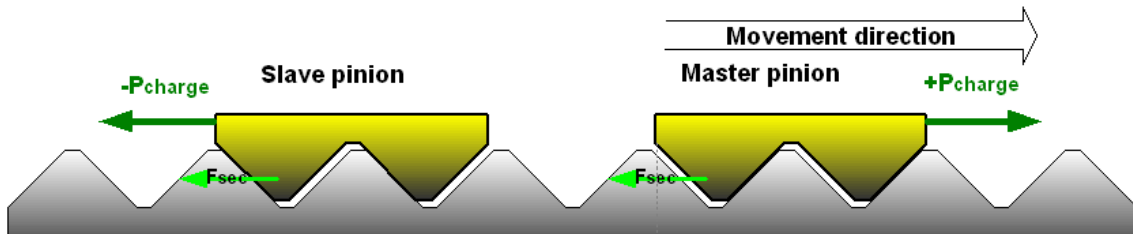
X1-Axis	Traverse Left/Right
X2-Axis	Traverse slave
Y-Axis	Vertical Up/Down
Z-Axis	Spindle In/Out
W-Axis	Column In/Out

Tandem/Anti-backlash system

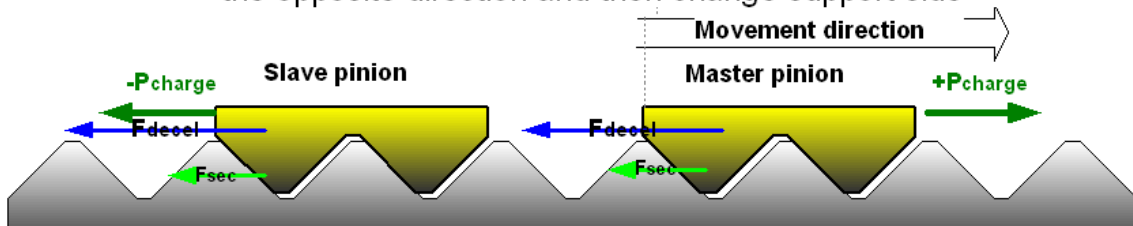
This function generated twice the torque in the X axis (minus preload). The axes (X1 & X2) were mechanically coupled together via the gear rack, and electronically coupled via a master slave design. The influence of backlash was reduced via the master/slave opposition or preloading. Smooth operation of the traverse axis was accomplished by dampening compensation in the preload regulator.

NUMDrive Functionality - Anti backlash

- To eliminate back-lashes in case of rack and pinion solutions (or any similar)



At constant speed, the teeth of the slave pinion cover the lash in the opposite direction and then change support side



During the braking phase, the teeth of the master pinion cover the lash and change the support side on the opposed tooth of the rack



Supplied Control Options

G-Codes:

- G00 High-speed linear interpolation 4 - 23
- G01 Linear interpolation at programmed feed rate 4 - 26
- G02 Clockwise circular interpolation at programmed feed rate 4 - 31
- G03 Counterclockwise circular interpolation at programmed feed rate 4 - 31
- G04 Programmable dwell 4 - 256
- G06 *****Not Available*****-Spline curve execution command 4 - 247
- G09 Accurate stop at end of block before going to next block 4 - 60
- G10 Interruptible block 4 - 208
- G12 Overspeed by handwheel 4 - 260
- G16 Definition of tool axis orientation with addresses P, Q, R 4 - 79
- G17 XY plane selection 4 - 10
- G18 ZX plane selection 4 - 10
- G19 YZ plane selection 4 - 10
- G23 Circular interpolation defined by three points 4 - 45
- G29 *****Not Available*****-3D tool correction (3 axes or 5 axes) 4 - 99
- G31 *****Not Available*****-Thread chasing cycle 4 - 137
- G40 Tool radius offset (cutter compensation) cancel 4 - 86
- G41 Left tool radius offset (cutter compensation) 4 - 85
- G42 Right tool radius offset (cutter compensation) 4 - 85
- G43 *****Not purchased*****-3D correction with cylindrical tool 4 - 107
- G45 Simple pocket cycle 4 - 146
- G46 *****Not purchased*****-Pocket or facing cycles with any contours 4 - 155
- G48 *****Not purchased*****-Spline curve definition 4 - 247
- G49 *****Not purchased*****-Spline curve deletion 4 - 247
- G51 Mirroring 4 - 283
- G52 Programming of movements in absolute dimensions with reference to the measurement origin 4 - 229
- G53 DAT1 and DAT2 offset cancel 4 - 232
- G54 DAT1 and DAT2 offset enable 4 - 232
- G59 Program origin offset 4 - 235
- G70 Inch data input 4 - 262
- G71 Metric data input 4 - 262
- G73 Scaling factor cancel 4 - 279
- G74 Scaling factor enable 4 - 279
- G75 *****Not purchased*****-Emergency retraction subroutine declaration 4 - 215
- G76 Transfer of the current values of «L» and «E» parameters into the part program 6 -59
- G76 +/- ISO program or block creation/deletion 4 - 224
- G77 Unconditional branch to a subroutine or block sequence with return 4 - 193
- G77 -i Call of a subroutine return block 4 - 222
- G78 Axis group synchronization 4 - 300
- G79 Conditional or unconditional jump to a sequence without return 4 - 203
- G79 +/- Temporary suspension of next block preparation in a sequence with movements 4 - 213
- G80 Canned cycle cancel 4 - 112
- G81 Center drilling cycle 4 - 113
- G82 Counterboring cycle 4 - 115
- G83 Peck drilling cycle 4 - 117
- G84 Tapping cycle 4 - 120
- G84 Rigid tapping cycle **(with floating tap head only)** 4 - 122
- G85 Reaming cycle 4 - 126
- G86 Boring cycle with indexed stop and clearance at hole bottom **(orient is not programmable due to spindle feedback)** 4 - 128
- G87 Drilling cycle with chip breaking 4 - 130
- G88 Boring and facing cycle 4 - 133



G-Codes Continued:

- G89 Boring cycle with dwell at hole bottom 4 - 135
- G90 Programming in absolute dimensions with respect to the program origin 4 - 7
- G91 Programming in incremental dimensions with respect to the start of the block 4 - 7
- G92 Program origin preset 4 - 233
- G92 R Programming of the tangential feed rate 4 - 72
- G93 Feed rate expressed as inverse time (V/L) 4 - 66
- G94 Feed rate expressed in millimeters, inches or degrees per minute 4 - 62
- G95 Feed rate expressed in millimeters or inches per revolution 4 - 70
- G97 Spindle speed expressed in revolutions per minute 4 - 14
- G104 *****Not purchased*****-3D curve smoothing 4 – 292
- G154-G159 optional DAT1 offset enable (see special document)
- G997 Enabling and execution of all the functions stored in state G999 4 - 289
- G998 Enabling of execution of part of the functions processed in state G999 4 - 289
- G999 Suspension of execution and forcing of block concatenation 4 – 289

M-Codes:

- M00 Program stop 4 - 267
- M01 Optional stop 4 - 269
- M02 End of program 2 - 11
- M03 Clockwise spindle rotation 4 - 12
- M04 Counterclockwise spindle rotation 4 - 12
- M05 Spindle stop 4 - 12
- M06 ******Not available**
- M07 ******Not available**
- M08 Coolant 1 on 4 - 266
- M09 Coolant off 4 - 266
- M10 ******Not available**
- M11 ******Not available**
- M12 Programmed feed stop 4 - 258
- M19 Spindle index ******Not available**
- M30 ******Not available**
- M40 ******Not available**
- M41 to M44 Spindle speed ranges 4 – 16
- M45 ******Not available**
- M48 Enable overrides 4 - 274
- M49 Disable overrides 4 – 274
- M101-M150- application specific
- M150 Probe start- processed after probe is turned on via MP03 panel
- M997 Forced block sequencing 4 - 273
- M998 Reactivation of edit (EDIT) and manual data input (MDI) modes and subroutine calls by the automatic control function 4 - 271
- M999 Programmed cancellation of the edit (EDIT) and manual data input (MDI) modes and subroutine calls by the automatic control function. 4 – 271