Gleason 777 Hobber Control Retrofit

Customer: Borg Warner Automotive
System Integrators: MasterControls Inc., L.L.C. (MCI) and Southern Technical Services, LLC (STS)

Our customer has been a Tier 1 Supplier of parts to the automotive industry for many years. They build transmissions and transfer cases for Ford, GM and other large automotive companies around the world. We have supplied engineering services to Borg Warner for many years. As a part of these services, we have performed CNC retrofits on three of their older Cincinnati Milacron Centerless and Plunge type grinders which originally had obsolete proprietary controls. When they needed a CNC retrofit on one of their older Gleason 777 Hobbing Machines, they came to us to provide the solution.

As with many older machines, the Allen Bradley 8600 OSAI CNC control and the external Electronic Gear Box (EGB) had become outdated and hard to maintain. The machine had been down for many months while the customer did a major mechanical rebuild. They were not able to get the machine back in service after the rebuild, so they decided to have MCI retrofit a new **MACHINEMATE** eCNC Control onto the machine. They asked MCI and STS to provide a total control solution. This included all new CNC control hardware, new DeviceNet Flex I/O modules, a part program to handle their parts and training for their personnel. They asked MCI and STS to reuse their existing Indramat drives, motors and feedback devices.

MCI and STS studied the existing machine documentation and talked to Borg Warner's engineering staff and machine operators familiar with the machine and production parts. A complete Bill of Materials was created and new electrical drawings were drawn using AutoCAD for the project. A custom HMI was developed to make it easy for the operators to make the transition to the new control when the retrofit was complete. A comprehensive Operator's Manual was also completed during the project because the machine was more complex than the average machine tool.

It was important to the customer that we not change the machine footprint. MCI and STS designed new sub-panels offsite that would fit into existing cabinets mounted on the machine. This requirement added a little complexity to the retrofit; but in the end, the goal was achieved. The machine footprint was unchanged after the complete control retrofit. All field devices were reused. The I/O on the machine fed back to Allen-Bradley DeviceNet Flex I/O Modules mounted on one of the new sub-panels

All of the control engineering was done off-site. The sub-panel building was done on-site by the customer under the guidance and design of MCI and STS. When the retrofit package was complete, a time convenient for the installation was set. The retrofit package was delivered to the customer's site and the installation began. Installing the new sub-panels, CNC control, Operator's Panel and doing the wiring in the magnetics cabinet took about three days. When this work was completed, we began powering up

the machine to check it for functionality. We worked with customer personnel during this phase of the project so they would become familiar with the new control and get comfortable operating the machine from the new panel.

When we finished the machine checkout, we started running test parts. As we ran these parts, we continuously took them to the customer's QC Lab and had them inspected. The new **MACHINEMATE** eCNC Control had built-in functionality to replace the old Electronic Gear Box (EGB) which had controlled the synchronized motion required to Hob complex Gear Geometry. We noticed some slight variations in the gear geometry during our inspections. When we started looking at parts coming from other machines in the same plant with the same variations, we came up with an idea that we thought would correct the problem.

MACHINEMATE worked very closely with us during this phase of the project. They developed a custom "Compile Cycle" for us allowing us to manipulate the synchronization during the Hob cycle. By using machine parameters, we could change the geometry during the actual cut. After a few test parts, we had near perfect geometry. Our parts were as good as or better than parts coming off many of the newer machines in the customer's facility. Having the ability to create custom "Compile Cycles" makes the control very flexible and powerful. Further, having a vendor like **MACHINEMATE** willing to partner with us on complex applications makes us comfortable taking on these types of projects.

MCI and STS develop 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 get our projects done 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.

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

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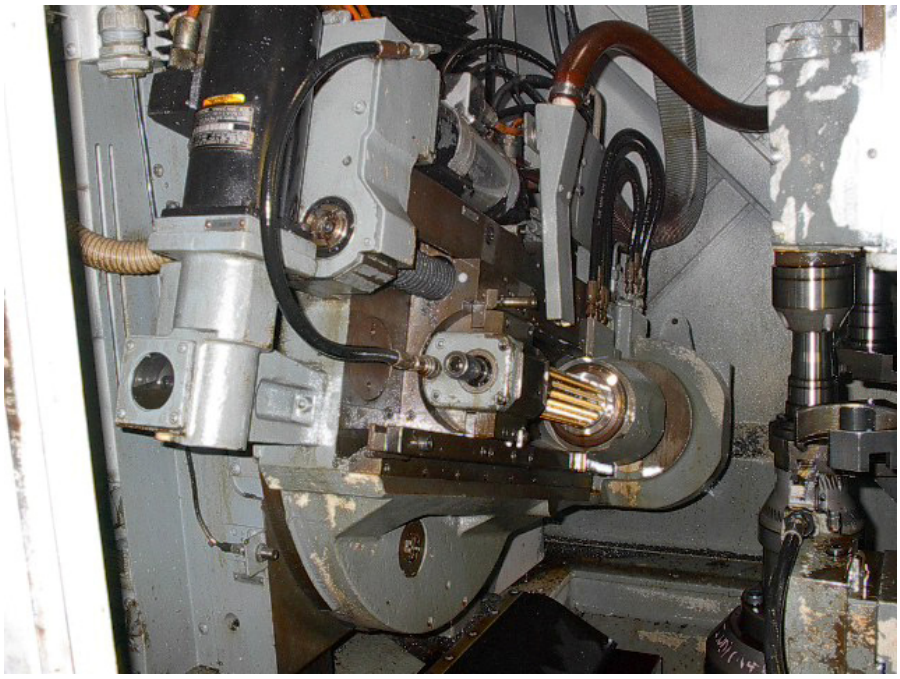
Application Pictures:

Operator Panel

Operator Panel with Custom HMI displayed on 15" Touch Screen. Large, bright, easy to read display and convenient placement of the Machine Tool Builder's panel.



Inside Machine

Here is a view from the Operator Panel with the door open looking inside the machine. You can see the complexity of the machine with all the axes and the hob spindle.

Part Carousel and Hob Spindle

The parts are continuously loaded and unloaded from the front of the machine. The Hob makes a quick pass through the part, then retracts to a clearance position and gets ready for the next part. The part is unclamped and the carousel indexes to move the finished part out and a blank part into position for machining. As soon as the blank is in place, it is clamped and the Hob Cycle starts again. All this is coordinated between the Control Logic and the part program. This functionality is quick and very reliable!

Quick Project Overview:

CNC

MCI and STS replaced the existing CNC control with a new **MACHINEMATE** eCNC Control. The new control represents the state-of-the-art in modern CNC controls with a software EGB. The control has an intuitive operator interface. This intuitive interface enables the operators to perform quick set-ups and adjustments.

The part program for this application made heavy use of the **MACHINEMATE** Paramacro Programming capabilities. By setting the part program up this way, the operator or utility person could simply fill in values in a table on the HMI. The HMI is flexible enough that it can be customized for specific applications. In this case, table values had descriptions next to them so it would be obvious what value was needed in each location in the table. Hob, part and clearance position data are all stored in the table. Descriptions of all these parameters were included in the final documentation provided to the customer.

Multiple parts could be stored in the control via the HMI. The control was set up to store multiple part set-ups so the machine could be easily changed over to run parts which had been previously run. After parts are proven, the control will allow these set-ups to be backed up using the hard drive or a USB memory stick.

Another important feature of the control was the ability to implement "AutoDrift Compensation". Older axis drives tend to have problems with motor drift. By setting up and enabling "AutoDrift Compensation", MCI and STS were able to eliminate axis drift and optimize drive tuning at the same time.

Operator Panel

A new Operator Panel was installed on the machine in place of the old panel. The operator panel includes a 15" touch screen with a Machine Tool Builder's Panel. An industrial keyboard and mouse can be connected to the control if necessary for convenience.

Drives

The customer kept the original Indramat Drives. These drives can be replaced later if necessary. The **MACHINEMATE** CNC is equipped to control a very wide variety of Analog and SERCOS Drives.

Position Feedback

This Gleason 777 Hobber has seven CNC axes. The machine was set up to have four decimal places of accuracy when running parts in the metric system and five decimal places of accuracy when running in the inch system.

Listed below is the feedback device for each of the seven axes:

X-Axis	Radial	50 Lines per mm	Heidenhain Scale
Y-Axis	Tangential	2500 Lines per rev	Encoder
Z-Axis	Axial	2500 Lines per rev	Encoder
A-Axis	Swivel	60 Lines per rev	Encoder
D-Axis	Hob Gage	50 Lines per rev	Heidenhain Scale
C-Axis	Work Table	1250 Lines per rev	Encoder
B-Axis	Hob	2500 Lines per rev	Encoder

Note: Resolver feedback is not compatible with the new **MACHINEMATE** CNC control. If resolvers are used for feedback, a converter must be added in the feedback loop to convert resolver feedback to encoder feedback.

Magnetics
The magnetics cabinet was mounted to the machine and remained in place. The control enclosure was also mounted to the machine. New sub-panels were built and added to the magnetics cabinet and control cabinet. Existing magnetics remained in place and were largely unmodified. Some small wiring modifications were required by the retrofit.

Field Devices
All existing field devices remained in place for the retrofit. None of the limit switches, solenoid valves, lamps, etc. required replacement. The I/O was connected to the new CNC through Allen Bradley Flex I/O on DeviceNet.

Hob Change / Hob Shift
Hobbing operations require close monitoring of the Hob Tooling. We built this monitoring into the part program and logic in the new control. The customer set the parameter values which controlled how often the hob was shifted and when it needed to be changed. Tight communications between the part program and control logic proved to be very robust and handled the tasks of Hob Change / Hob Shift very well. By controlling these tasks, tooling costs can be kept to a minimum. Hobs can be sent out for grinding and recoating many times before they are worn out.

Electronic Gear Box (EGB)
Many Gleason and Pfauter hobbers used Allen Bradley 8200 and 8600 controls with a "Black Box" to control Electronic Gearing functions (EGB). The **MACHINEMATE** CNC control performs this function in software. This reduced the complexity of the system and the number of parts to maintain.

Installation Time
The customer installed the new sub-panels and Touch Screen. After the new hardware was installed, machine power-up and testing began. The machine had been idle for many months prior to the retrofit, so testing had to be very thorough. After we were confident that the machine was running properly, we started testing the part programs and running parts to check for quality and consistency.

Replacing the Electronic Gear Box (used with the old control method) by software included in the new **MACHINEMATE** CNC required a lot of testing. **MACHINEMATE** was very helpful during this process. They wrote a special "Compile Cycle" for this application which allowed us to manipulate the Electronic Gear Box function during the actual hobbing cycle with a few parameters on the set-up screen. This was a very powerful feature which allowed us to hob parts with very high quality geometry on the parts coming off this machine.

The hardware was installed in two to three days. Power up and machine functional testing took the rest of the first week. We actually spent two more weeks on-site performing extensive testing of the part program and running parts and doing quality tests on the parts. During this time, we were training operators and set-up personnel as well as working with maintenance staff teaching them how to operate and maintain the machine and new control.

Integration time
Integration time included producing machine schematics, creating a Bill of Material, ordering and receiving all the hardware, building the required sub-panels for the CNC and the Operator Panel, 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
A complete Operator's Manual was produced for this application. Hobbing is a complex application and it needed to be well documented so the operators could set up and run the machine. In addition to the Operator's Manual, a full set of Electrical Schematics (AutoCAD Format) and documented part programs were provided to the customer. We typically store a copy of all documentation on the control. Operators, set-up and maintenance personnel have immediate access to all documentation right at the machine.