

SERCOS interface based Shoe mold machine

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Hannover

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KOLLMORGEN

Presentation overview

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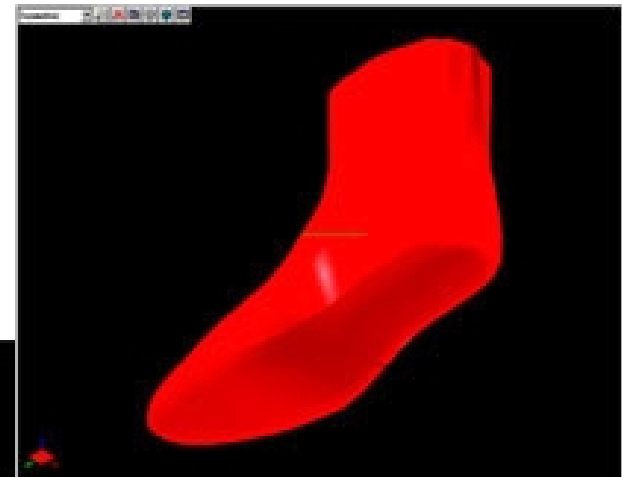
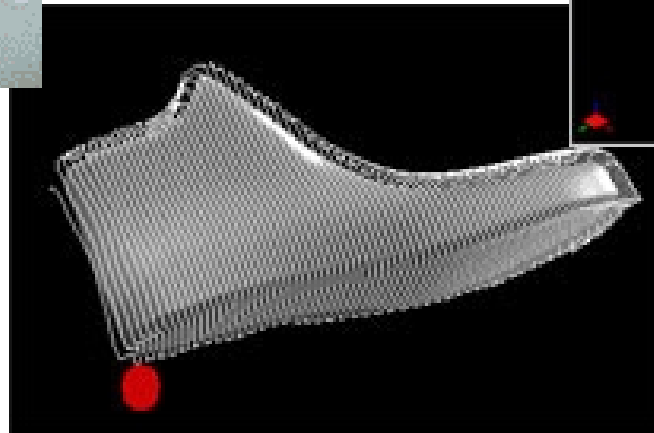
Application description

Shoe lasts are plastic or wooden forms made in the shape of a foot. Shoes are made by placing material over a mold, or a last, and then sewing or gluing the material to the sole. Shoe lasts are used as a template to ensure that the proper shape and size is obtained as the material is stretched and stitched. Although a single last may be used to produce hundreds of shoes, typically only one shoe is made per mold in the custom shoe industry.

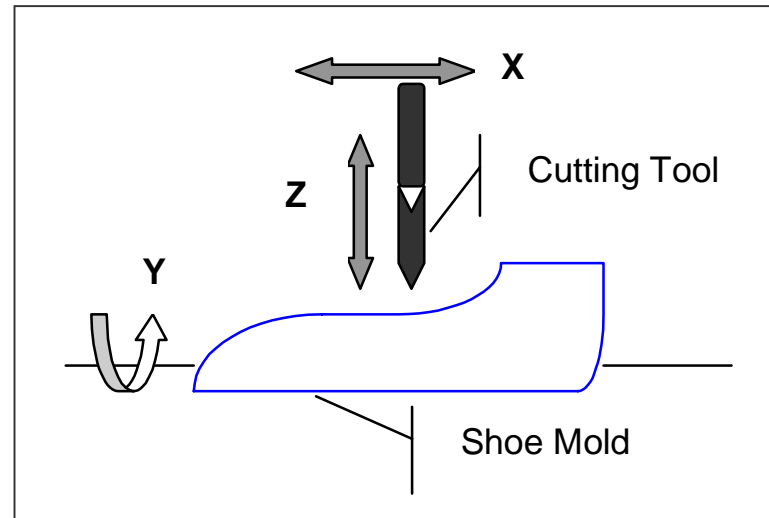


Mold design

The mold is machined according to a set of points defining a 3 dimensional tool path along the mold surface, which has been digitized from a master mold or designed using a CAD tool.



Machine structure



The mold-making machine consists of three servo axes, X, Y and Z.

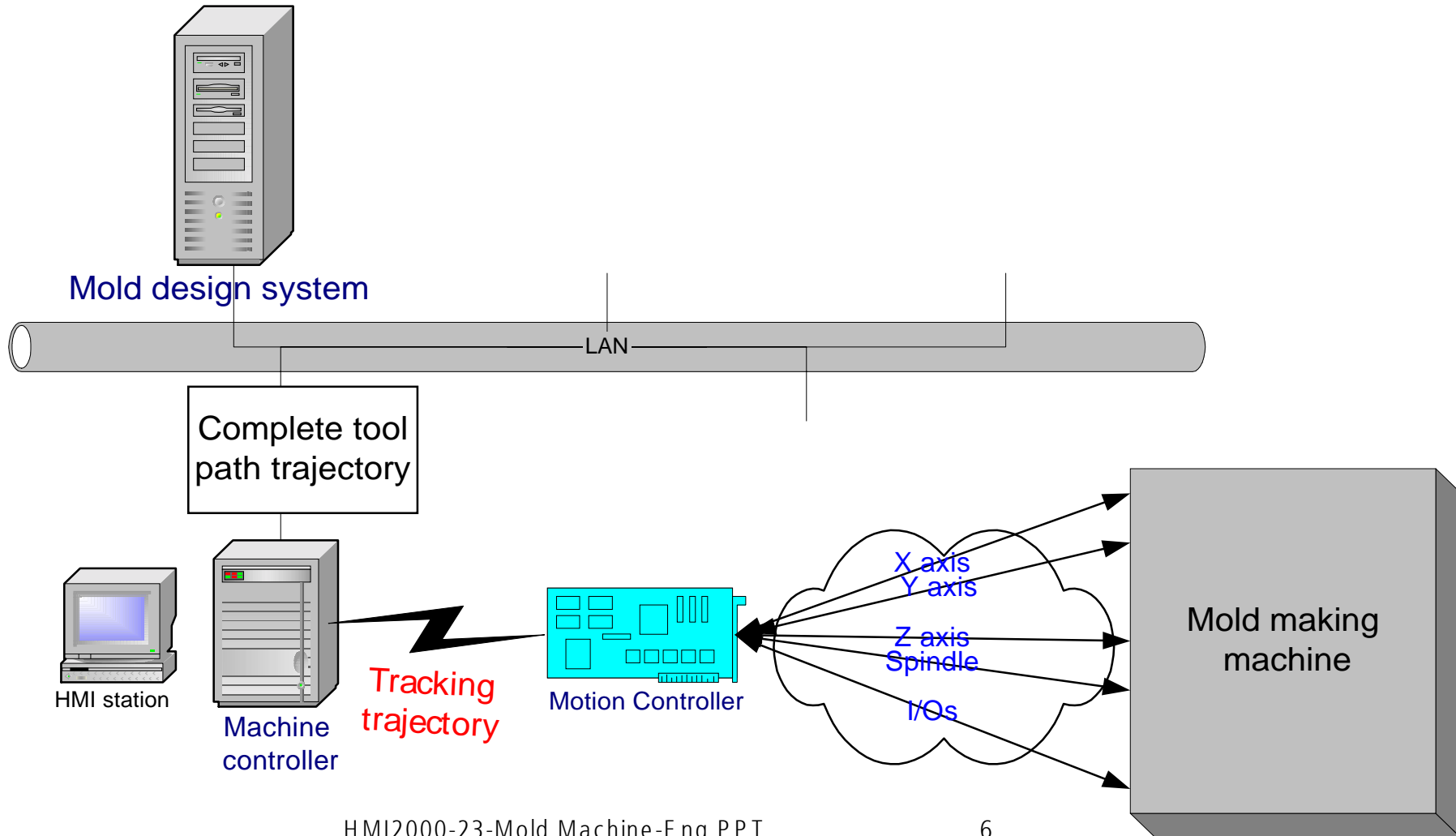
Y – The Y axis is used to turn the mold.

Z - A spindle motor is used to turn the cutting tool, which is mounted on the Z axis.

X - The Z axis is mounted on the X axis, which then moves the cutting tool along the face of the shoe.

The machine thus has the structure of a lathe.

Previous system architecture



Previous Machine Configuration

The machine uses one of the most common multi-axis controllers on the market* in a PC-card configuration, with the Kollmorgen ServoStarTM drives and Kollmorgen brushless motors.

The motion controller commands each axis with a +/-10V analog velocity command. It works in a Tracking mode of operation, whereby the host computer sends X, Y, Z position and time data, to the controller. The task of the controller is to achieve the new positions within the specified time.

* The exact details are available at Kollmorgen.

Problems with the previous machine

This configuration suffers from two major problems

- **First**, because the motion controller is working in tracking mode, the host is occupied much of the time sending new data. Therefore It does **not have the ability to query and analyze the process** while it is underway.
- **Second Poor quality of the finished product**. After machining, the mold was seen to have some marks of discontinuity which have a very significant affect on the quality of the shoe. The machine manufacturer tried for a long time to fix the problem, to no avail. It was noticed that the marks occur mostly at the points where the Z axis changes direction, and it was surmised that this was due to noise on the analog velocity command signal being generated by the motion controller.

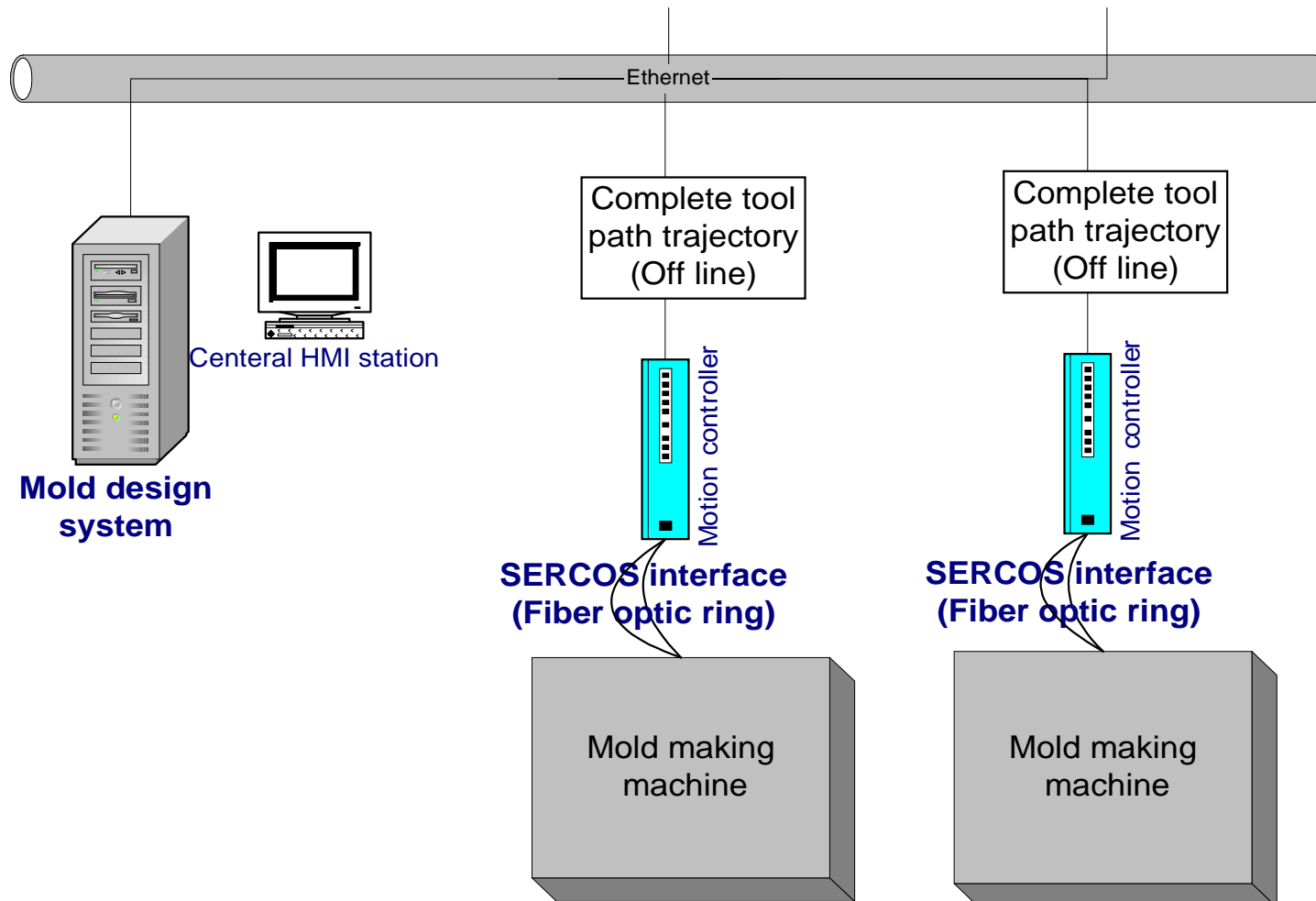
Downsides of the analog solution, which lead to the new design

- Limited control of the process – due to limited system resources.
- **Low quality end products**

Goals for the new design

- High quality products.
 - Precise trajectory
 - Smooth finish – Number of tool passes per inch.
- Cycle time reduction
- Increased reliability
 - Controlled process
 - Noise immunity.
 - Reduce **Time To Repair** - easy field replacement.
- Cost reduction.

New system architecture – Distributed processing



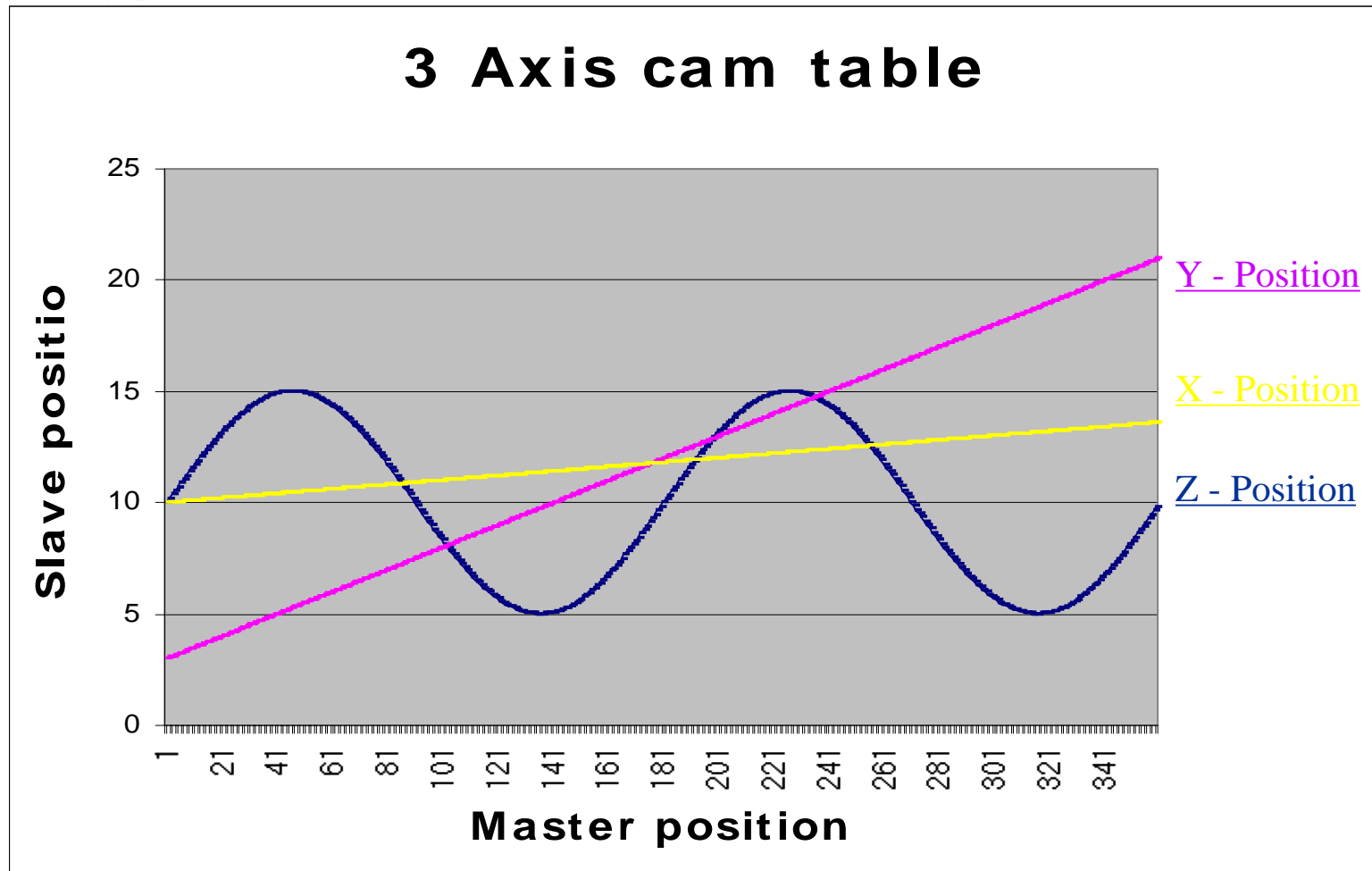
Description of the SERCOS interface based solution

Kollmorgen presented the SERCOS interface based solution, which involved replacing the existing analog motion controller with the ServoStar MC, and enabling the SERCOS interface on the ServoStar drives. This solution is attractive, since being a digital system using fiber optic cable as the physical medium of communication, the information transfer is virtually immune to externally imposed noise. The information itself is digital, and so it does not suffer from the noise effects inherent in analog signals.

The ServoStar MC has very flexible **electronic camming** support which was selected to implement the desired machine function. This requires the host to load the entire machining profiles into the MC before machining actually begins, but it enables the host to query the status of the machining process while it is underway.

Electronic camming is a form of master-slave operation, where the slave follows the master according to some predefined pattern. The electronic cam is a two-dimensional table consisting of master and slave positions. The pattern is defined within this table.

The following curve shows a plot of master versus slaves values in a typical cam table.



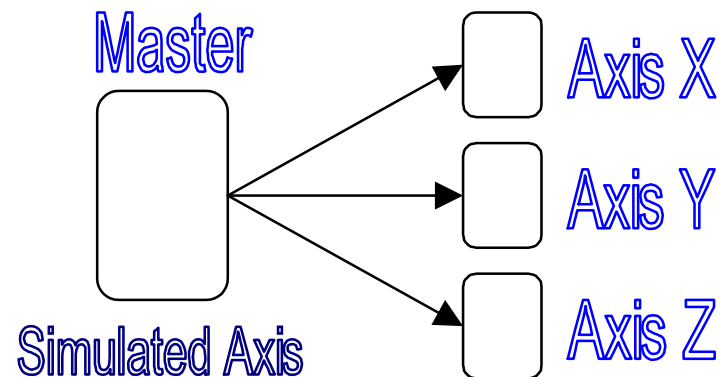
Cam tables

The required cam tables are of varying size, depending on the size and shape of the mold to be machined. Cam tables are potentially huge memory consumers. At a maximum a mold cam table will hold 150,000 entries = 300,000 points = 2,400,000 bytes (8 bytes per double precision floating point value).

Having the motion controller generate the trajectory using a Spline function may dramatically decrease the number of points describing the required tool path. However, in this case it was decided to maintain the large tables since the controller is capable of storing this amount of data.

Cam tables are assigned to a single axis, so the tables are assigned to axes X, Y and Z respectively. The Master data in each table are identical. The master axis is either a simulated axis or the spindle feedback, to which axes X, Y and Z are slaved.

Cam operation



Running the machine, requires jogging the master axis, and the slave axes follow the master according to the contents of the cam table. The processing feed rate is controlled in real time by changing the velocity of the master axes. Using this mechanism produced a **perfect mold** to the satisfaction of the customer.

Benefits of the new design

Performance.

- Reduced cycle time – Accurate & smooth profile allows high feed rate.
- Smooth trajectory – Having the drive micro interpolating the given trajectory, results a smooth profile even with a low SERCOSⁱ update rate (4 milliseconds).
- Controlled number of tool passes per inch - when the camming master is the spindle feedback.
- Distributed processing allows the host to analyze the ongoing process.
- The cam trajectory is not limited by tracking resolution (No minimum distance between adjacent points at a give feed rate).

New capabilities

- Real time control of the process (All machine & trajectory parameters can be queried and programmed while processing the mold).
- On line & Off line process analysis - SERCOS interface enables access to servo parameters and real time recording of system behavior.

Benefits of the new design

Reliability

- Electromagnetic noise immunity.
- Reduced amount of wires – Both analog and digital I/O devices are wired to the drives and are transferred to the motion controller via the SERCOS interface.
- Reduced Time To Repair :
 - All components are being diagnosed constantly by the motion controller, which immediately identifies failures upon a failure, indicating which device is faulty.
 - Field replacement of a device on the SERCOSⁱ ring is a trivial operation (No room for wiring mistakes).
 - No need to configure the new drive after the installation – The motion controller sends the complete parameter set via the SERCOS interface, upon “blank” device recognition.

Benefits of the new design

Cost effective solution - Cost reduction factors

- Reduced wiring – Motor command & Feedback * 3 + Spindle feedback + Analog & Digital I/Os → 2 fiber optic cables.
- Motion controller is the machine controller - One Host (HMI station) per production line, instead of a host station per machine.
- No defective products.

Thank you for participating.

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