Amarillo, TX — Common sense says you can’t push a piece of string to move it, you have to pull it. Almost the same applies in making copper rod — only it’s harder. You can’t push or pull a cast bar of copper when you’re making copper rod stock that will be manufactured into wire. Excessive tension in either direction has negative results on the quality of the final product. Managing this key problem was just one of the factors faced by the Rodline staff at Asarco, Incorporated as they planned mills now producing copper wire. It was a complex problem. In order to maintain high product quality, the company wanted far more extensive process, laboratory and shipping data than had been available before. Asarco faced the difficult choice of replacing older supervisory control and data acquisition (SCADA) equipment or finding a system that could collect and manage information from this wide range of different equipment.

They solved the problem in a timely and cost-effective manner by developing their own supervisory control and data acquisition system using the InTouch™ machine interface (MMI) application generator from Wonderware Corporation, of Irvine, California. The solution runs in Microsoft’s Windows for Workgroups operating system over a Novell Ethernet network of six PCs that operate as process, quality assurance and data acquisition workstations monitoring the operation of the 45-ton per hour rod mill.

The production line starts at the Asarco copper melting furnace, which feeds a holding furnace used to meter molten metal to the bar caster and into the rolling mill that forms the bar into 5/16ths inch rod. The PC-based InTouch worksta

The Asarco refinery in Amarillo produces up to 1,000 tons of copper per day, used in making wire.
tions monitor the operation of Allen-Bradley SLC500 programmable logic controllers (PLCs), Leeds & Northrup MicroMax local processing units (LPUs) and a Mistic 200 controller that supplies quality testing data from the lab. All information gathered from the plant floor and the laboratory is transferred into a database so that a complete audit trail is available for every customer shipment.

Development of the SCADA system at Asarco was spearheaded by Darrell Breitling, senior instrumentation technician, with support from Standard Automation & Control, the Wonderware distributor for Texas. “In past years, data acquisition was largely a manual effort,” Breitling explained. “Process information was transferred from one area to the next via diskettes or paperwork. Now, having all information available at any of the SCADA workstations means our people have more time to supervise the process. They can refine the process to improve product quality, we’ve cut back on a lot of unnecessary paperwork, and we’ve developed archival information in a database for tracking each 5,000 or 7,500 pound coil of copper rod shipped to customers.”

Integration of Diverse Operations

The production of continuous cast copper rod is literally a long process — capable of producing more than five miles of rod in each coil. The feedstock for the process consists primarily of Asarco’s own refined cathodes of 99.99 per cent pure copper, created in an 11-acre electrolytic refinery. This one operation processes nearly a half million tons of refined copper each year, in 2,400 tanks contained within a single building the size of 10 football fields. This pure copper, along with recycled material, is melted in a vertical shaft furnace that has three rows of natural gas fired burners. Controlling the hydrogen content on each burner is mandatory in copper melting because the draw ability of the copper increases as the oxygen content decreases. Too rich a hydrogen content can also cause gas bubbles that create holes in the copper when it’s cast.

“The InTouch furnace burner screen provides operators with a detailed view into the firing rate of the three rows of burners so that they can manage them better,” Breitling said. “The animated screen graphics show flame levels when the burners are on and the currently sampled burner data is highlighted. One digital window indicates the hydrogen content of each burner flame and another indicator box shows the firing rates of each row of burners so that exact temperatures and more precise melt rates can be maintained.”

After the copper is melted in the vertical furnace, at a rate of 45 tons per hour, it flows down an upper “launder” or trough into the holding furnace. It is maintained in a melted state here and the furnace is rotated to maintain a consistent flow into the lower launder, where it begins cooling to form a continuous cast rectangular bar measuring 125mm x 60mm.

“The holding furnace is a 15 ton ‘buffer’ vessel for the copper,” Breitling said. “It gives the operators a cushion of 7-8 tons of copper for maintaining consistent flow into the caster. Consistency of flow is critical to the quality of the copper rod. The holding furnace can be rotated up to 90° to increase or decrease copper flow into the lower launder and, by looking at the furnace position on the InTouch screen, the furnace operator can determine if he’s gaining or losing on the amount of copper flow and can adjust the shaft firing rate accordingly.

“The InTouch screen animates the exact position of the furnace and it also shows the status of the burner flame and upper and lower launder flames,” he added. “The lower launder graphic uses a vertical color fill to show the level of the copper and the stopper rod animation shows both position and movement. Digital indications of other significant values are shown along with a real-time trend of
the copper casting temperature.

“Laboratory analyses are performed on copper samples using Leco IR432 sulfur and HF400 oxygen determinators, and this data is fed back into the InTouch system as an ASCII string, via the Mistic 200 controller,” Breitling continued. “This data transfer is via a Standard Automation & Control DDE Server for the Mistic controller, written by Standard Automation using Wonderware’s DDE Server Toolkit. It gives operators good feedback on the quality of the copper being produced, as it’s being produced.”

Mill Speed is Critical

One of the most important parameters to be controlled for producing high quality copper rod is the mill speed. The cast copper bar formed in the Hazelett Twin-Belt Caster must be rolled into rod continuously, in reduction passes — and it should not be stretched during the process. Correct control is required for mill motor speeds, currents and loops as the bar is shaped into rod while passing through vertical mill stands. This control was difficult to manage without good operator interface data because as the cast bar is formed, at the front-end of the process, the metal moves at a rate of 36 feet per minute — yet the finished 5/16ths copper rod is moving at a 60 mile per hour speed at the end of the line.

“The operators can ‘click’ on the control screen for any of the 15 mill stands and see what the current, speed and temperatures are,” Breitling said. “This is a tensionless mill, so we have places in the rolling system where the copper loops up or droops down to keep from stretching it. We don’t want it to be pulled like taffy or we’ll get inclusions in it that will create problems for customers as they draw it into wire. We have a tensioning circuit that will monitor the pinch roll drive to sense any current increase, which indicates tension, and will decrease the rolling speed to relieve that tension.”

The use of the InTouch software also has allowed Asarco personnel to spot potential problem areas. As an example, they previously had not realized that there were temperature differences in the cast copper bar caused by the level of the molten copper in the caster pool.

“This presented problems because if the bar temperature varies too greatly the hot/cold variation can be misread as a higher current signal, causing the pinch roll to start to work — and changing the speed of the pinch roll can change the shape of the bar,” he explained. “We never saw this relationship between temperature and caster pool level until we installed a pyrometer and fed its output into InTouch. The trend showed up in historical data trends and we now know that if we hold the casting level in the same spot all the time, then we don’t get temperature fluctuations in the bar and problems with the tensioning. This is typical of the type of improvements we’ve been able to achieve since adding the MMI.”

As the bar is rolled and gradually cooled into 5/16 copper rod, it passes through several other processing stages. At the entry of the mill, the copper temperature is approximately 1,600˚ F; it drops rapidly to 1,000˚ near the middle of the mill line and it is less than 300˚ by the time it reaches the final cleaning and coating stages. It’s cleaned in a “pickle tank” or sulfuric acid bath and water rinsed, to remove surface oxides and rolling compounds. It then passes through a preservative coating bath, to prevent oxidation that could cause discoloration and to extend its shelf life. The MMI cleaning and coating windows indicate levels, temperatures and flows of these processes and supervisory control is provided through pop-up control faceplates. Ventilation flows are also shown so that critical safety indicators are provided.

The last step in production is automatic coiling of the rod into 5,000 or 7,500 pound stacks, banding and palletizing for shipment to the customer and application of batch bar code labeling.
Tailoring MMI to Application

All of this capability has been implemented very efficiently, according to Breitling. Since they can pull so much data off the 10 Leeds & Northrup LPUs, they have implemented the entire MMI application with only about 1,000 tagnames in the database. They have used five existing LPUs in the furnace area, three in the mill area and two in the pickling system at the end of the line, each controlling eight process loops.

“When we started on this application in 1992, we had the choice of buying an entire distributed control system from an outside supplier and replacing all our PLCs and LPUs, or of buying something like InTouch and doing it ourselves,” Breitling explained. “We had a limited budget, so we chose to spend it on software and make use of a half dozen existing PCs that we had been using in our engineering group. We’re also adding a lot of new sensor equipment to automate even more of the mill production.

“For example, this would include upgrading to an online, automatic oxygen control probe that would reduce our reliance on the Leco determinators and provide quicker checks on the oxygen content of the copper,” he added. “We’re also looking at adding digital servo control to the caster pool stop rod for more precise control of the casting level. We have an on-line, non-contact scan camera that tells us the level of copper in the caster pool and how close it is to the top. We use a PID loop to maintain the optimum level and more precise control of that level will further resolve the temperature variation problems encountered in the cast bar.

One system that has already been upgraded is the measurement of the continuous rod size. “We’ve added a Zumbach dual head laser micrometer assembly to take readings on the rod diameter and we bring those measurements up on a ‘target’ screen in the control room,” he added. “This screen uses perfectly concentric circles as the target and superimposes the rod cross-section image in bright orange so that operators can see at a glance what the rod size is. We just had to add the laser hardware and we got the view and data free with InTouch, instead of having to spend $30,000 for a micrometer with this capability.”

The fact that it all works is proven by the increased production of the mill and enhanced product quality. “Rod product quality characteristics have been defined with our customers and are now closely controlled to ensure a consistently high quality output,” he said. “We’re now producing a 5,000 pound coil of copper rod every 3.2 minutes, or about 45 tons an hour on average. We run about 22 hours of production a day, depending on what roll change outs we have to make, so we’re typically running at a rate now of 900 to 1,000 tons a day.”