The coil handling and inventory system at AK Steel Corporation's Rockport Works was conceived and designed concurrently with the design of the buildings and process facilities for the new plant. Simulation was used to define the size of coil locations and the flow of the coil movement. The Coil Handling In Process System (CHIPS) was designed to be a central computer system to manage the coil movement in the Rockport facility. CHIPS includes two Automatic Storage and Retrieval Systems (ASRS). An Automatic Guided Vehicle System (AGVS) also communicates with CHIPS to manage the coil movement between coil fields.

Automated Coil Handling and In-Process Inventory System

Mark J. Thieman
Senior Staff Automation Engineer
AK Steel Corporation, Rockport Works

Roger L. Murphy
Senior Electrical Engineer
AK Steel Corporation, Rockport Works

Coil movement is managed at AK Steel Corporation's Rockport Works by a computer system known as CHIPS (Coil Handling In Process System). CHIPS communicates with each process computer to handle coil delivery and coil removal. CHIPS communicates with the business system to manage receiving and shipping coils. CHIPS communicates with an Automatic Guided Vehicle System (AGVS) to manage the movement of coils between coil fields with fourteen vehicles.

Five automatic cranes are controlled by the system. Hand-held and cab-mounted radio terminals allow manual crane operators to communicate with CHIPS.

Designed With the New Facility

In the early stages of design of Rockport Works, there were several goals defined for the Coil Handling In Process System: Know the location of every coil at all times; Direct the movement of coils to, from, and between processes; Automate as much of this movement as possible; And have a flexible system in order to handle changing requirements for routing and storage.

Coil tail orientation requirements at each process entry and exit conveyor were considered in order to minimize rotating coils with a crane. This study extended to coil orientation on each AGV coil stand, transfer car, and included each combination of source and destination.

Static math models were built to evaluate crane speeds and acceleration/deceleration rates in terms of move cycle time. Several scenarios were studied for varying coil field sizes and locations of process conveyors.

Combinations of required crane and AGV moves from area to area with varying frequencies were simulated. The frequency of moves was based on coil sizes, process production rates, and combinations of concurrent operation of processes.

Two dynamic computer simulations were built. One was created using SLAM and the other was built in ARENA. These models include detail for each process, crane, AGV, transfer car, truck, rail car, and inventory field. Time study data was used for the manual cranes. Static model data was used for the automatic cranes and AGVs. Many scenarios were run for combinations of processes in operation. The effects of each process consuming and producing coils at maximum frequency were determined, including all processes running maximum at the same time.

All this simulation data was used for: Determining the required number of coil locations in each building; Determining the required crane speeds and acceleration rates in order to meet throughput; Determining how many AGVs are needed and how many AGV coil saddle stands are required at each station; And determining the optimum locations for process entry and exit conveyors with respect to crane utilization and coil flow.

A very important use of the simulation was to determine the best method of moving coils during the various stages of construction of the Rockport Works. There were five evolutions of coil movement identified as the facility and processes were completed.

For each coil movement, the required automation steps were defined. These details included the data that is transferred between systems, decisions CHIPS and AGVS need to make, and device safety interlocks to insure equipment won't move while a crane is picking or delivering. All coil movements were examined with normal and multiple exception conditions.

CHIPS was designed to be a central system that communicates to all other systems. It coordinates delivery and pickup of coils to and from process lines. It keeps the Business Level 3 system up to date on coil inventory. It coordinates coil receiving and shipping with the Level 3 system. CHIPS feeds commands to the automatic cranes and the AGV system. CHIPS feeds jobs to manual crane operators and processes operator input. Also the system manages safety interlocks through PLCs and remote I/O.

Suppliers

VAI Automation, Inc. (formerly Digital Interface Systems or DIS) was chosen to supply the CHIPS system. DIS also supplied the Level 1 PLC systems for the automatic cranes.

Control Engineering Company (CEC) and Elwell Parker Ltd. (EPL) were chosen to supply the automated guided vehicles and the AGV system.

Alliance Machine supplied the automatic cranes which include Electromotive Systems drives and Geotronics laser positioning systems.

Each supplier was required to assemble the system as much as possible and perform a systems integration test prior to shipping the equipment to the plant site for installation. This testing scheme contributed to the early startup of each process in the Rockport facility.

System Components

Automation hardware and software was chosen with an emphasis on reliability. Since CHIPS and AGVS are plant-wide systems, they must be able to run 7 days a week, 24 hours a day. Coils will always need to be moved. Even if all the process lines scheduled maintenance downturns for the same time, there would still be coils to move for shipping, receiving, or optimizing a coil field.

CHIPS is actually four computer systems. There is a CHIPS Supervisor system which controls one automatic crane, manages the operator interface for the manual cranes, and maintains an inventory and event database for coil movement. There are two CHIPS Automatic Storage and Retrieval Systems (ASRS) each of which controls two automatic cranes. A CHIPS Development computer includes a full simulator environment so control software changes may be fully tested prior to use. A fifth computer system controls the movement and traffic flow of the 14 AGVs.

Computer System—

DEC/Compaq Alpha computers running OpenVMS operating system and utilizing Disk Shadowing provide the platform for the Level 2 system. Each system has a backup Alpha computer which can be brought online without any cable changes in the event there is some problem with the primary processor. These systems are of the rackmount style and include redundant power supplies.

Application software on these systems was written using Fortran and C languages. DECmessageQ is the tool used for communication between systems. DataConcepts PDS software allows the Alpha computers to communicate with the Siemens PLCs on the automatic cranes and the PLCs used for safety interlocks. The database on the Supervisor system is Oracle. Each of the Alpha computers has Liebert software to monitor the state of the Uninterruptable Power Supply (UPS) and to bring the system down gracefully in the event of a power loss but before the UPS runs out of battery backup power.

MMI System—

Intellution FIX32 is used for operator screens. A pentium class PC is used for the Supervisory Control And Data Acquisition (SCADA) server node. There are 9 VIEW nodes for operator use at various locations in the plant. The FIX screens allow the user to see an overview of the inventory, find a specific coil, monitor automatic cranes, add moves, re-prioritize moves and view the event log.

In addition to the FIX screens, there are many ANSI screens which may be run on any network PC with a terminal emulation package such as Reflection. Many of the FIX screen functions are duplicated in these Reflection screens for redundancy. CHIPS includes maintenance screens for changing routing and other coil movement parameters. This table-driven scheme allows on-the-fly modifications to be made without software program changes

Manual crane operators use Teklogix hand-held terminals with an integrated barcode scanner. These terminals can run ANSI CHIPS screens. There are unique screens for each manual crane, customized to the functions specific to that crane's operation. The barcode scanners are used to update a coil's location. Each coil at Rockport Works has a barcode identity label. Each coil location also has a barcode identity plate. Scanning the barcode on the coil and then the barcode at the coil location will update the CHIPS inventory database.

The Teklogix terminals communicate to one of five receivers in the plant via narrow band licensed frequencies. The hand-held units will communicate to the strongest signal at any given time. The receivers are network devices connected to a Teklogix controller which actually controls the TELNET login sessions.

Automatic Cranes—

There is one automatic crane at the exit of the Cold Mill, two in the Packaging Warehouse, and two in the Distribution Building. Positioning lasers at each end of the crane bridge are aimed at huge reflective targets at the end of the buildings. There is a positioning laser on the crane end truck aimed at a target on the trolley. These lasers constantly report distance to the crane PLC. The hoist has encoders to measure the position of the tongs. On the tongs are toe-pad and leg-plate switches to signal contact with the sidewall and inside diameter of the coil for safe pickup.

Each coil location under an automatic crane has a set of bridge, trolley, and hoist coordinates. CHIPS sends these coordinates to the automatic crane PLC in steps to perform a move. The ASRS buildings have two cranes sharing a runway so each of these cranes also have positioning lasers aimed at the other crane. These lasers are tied to anti-collision E-stops. There are several layers of Level 2 software protection to prevent the cranes from getting close to each other. ASRS control also uses several No-Fly and Bridge-Only zones where it is critical to keep the automatic crane out of the way of people and equipment which may interfere.

The crane PLCs reside on the CHIPS network through the use of Aironet wireless ethernet bridges. There is one of these spread-spectrum radio devices on each crane and several redundant base station units on the ground which feed into the Level 1 network hub.

The crane PLC software is nearly identical from crane to crane. Once the software was fully commissioned for the first crane. there was minimal software checkout required for the remaining cranes.

AGV System

Simulation indicated the need for 14 vehicles and 35 drive-through coil stands. Each coil stand has redundant coil presence sensors and an interlock light. Optomux remote I/O communicates coil presence and interlock signals to the AGVS Alpha computer. The AGVS computer also communicates to the vehicles via a redundant base station radio.

The AGVS computer receives job commands from the CHIPS computers. AGVS manages the vehicle selection for each job, routing of vehicles from place to place, and control of traffic.

The AGVS operator screens are accessible from network PCs running Reflection terminal emulation. These screens allow viewing vehicle and job status. There are also screens to enable and disable stands and vehicles. The AGV system keeps track of move events, statistics, and alarms in logs which may be viewed from the screens.

Guidepath and Chargers—

The vehicles travel along a guidepath which has passive transponders embedded in the floor about every 25 feet. Each transponder tag has a unique identity which allows the vehicle to verify location as it passes over it. The path is built with AutoCAD and downloaded to each vehicle. Logical points on the path control traffic stops and vehicle functions such as turn signals and speed changes.

The system includes 15 opportunity stations for charging vehicle batteries. Vehicles are routed to these chargers when there is no work to be done. There is a special charger for performing equalization charging in order to reset battery memory after every 100 hours of use.

Vehicles—

Each AGV can carry a 60 ton coil. Empty travel speed is 200 feet per minute along a straight and 120 fpm on a curve. Loaded speed is 120 fpm straight and 80 fpm on a curve. The vehicles are four wheel drive with four wheel steering. A hydraulic system handles the steering, the lift deck and the stabilizer arms. Each vehicle has four sealed lead-acid gel-cell batteries for a total of 2000 amp hours. These batteries, when fully charged, allow the vehicle to operate continuously loaded for up to 4 hours before requiring another charge.

Each vehicle has an on-board radio for communication to the AGVS computer. An on-board processor controls the movement and devices on the vehicle. There is a control panel on each vehicle with a status display and keypad for performing diagnostics.

Vehicle guidance is managed by the on-board processor which handles signals from several devices. A trackwheel encoder measures distance between path points. A solid state gyro measures inertia as the vehicle turns. A transponder reader sees coded magnetic tags in the floor and converts the code into a guidepath location. The vehicles have in-position optics which give the vehicle positive indication that it is at a coil delivery location. On either side of the lift deck there are optics which allow the vehicle to center under the coil it is picking up.

The AGVs have a number of safety devices. On the front and rear, there are seven object detection sonics which will bring the vehicle to a controlled stop until the object is removed. Compressing the front, rear, or side bumpers will cause the vehicle to perform an E-stop. There is an E-stop mushroom button on each corner of the vehicle and one on the diagnostic panel. Also on the panel is a button for a controlled stop. The vehicles have flashing lights front and rear, turn signals on each corner, and a multi tone horn for indicating various stages of movement. There are additional optics on the sides of the vehicle which also cause an E-stop to prevent the wheels from rolling over top of an object approaching from the side.

Summary

Automated coil movement systems at Rockport Works were custom designed for the layout and flow of material. The five automatic cranes typically move about 1200 coils per day with a capacity of about 2000 moves per day. The 14 AGVs move about 600 coils per day with a capacity of about 1000 moves per day. The automation systems in place for all this coil movement were designed to be flexible and reliable.