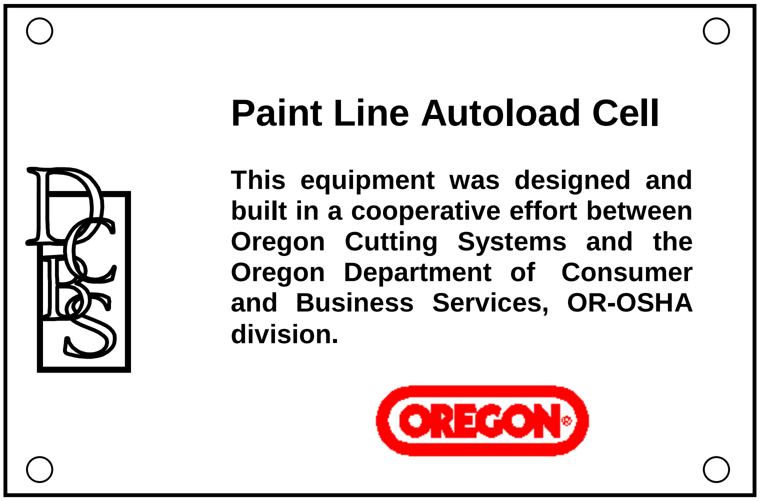

Worksite Redesign Project - Paint Line Autoload Cell

"Automated System to Load Chain Saw Guide Bars on a Paint Line Hook"

Final Project Summary

June 15, 2001

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Worksite Redesign Project - Paint Line Autoload Cell
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Table of Contents

Worksite Redesign Project - Paint Line Autoload Cell
"Automated System to Load Chain Saw Guide Bars on a Paint Line Hook"

Project Synopsis

In September 1997, OR-OSHA and Oregon Cutting Systems (OCS) entered into an agreement to develop a "design for hanging chain saw guide bars on a paint line". Historically, the manual hanging of guide bars had resulted in numerous repetitive-motion injuries. It was determined that this activity was an excellent candidate for automation. Research by OCS had indicated that there were no commercially available solutions for hanging bars and it would be necessary to develop a prototype to accomplish this task.

Such equipment was developed. With its successful implementation, all handling of guide bars associated with hanging them on the paint line will be eliminated.

Ergonomic Considerations

This project was aimed at eliminating the repetitive-motion injuries associated with manually hanging chain saw guide bars (bars) on the powder paint line at the Portland facility of Oregon Cutting Systems. Hanging involves these sequential steps:

1. Move bar-tub into place.
2. Remove stack of bars from bar-tub.
3. Place bars on hooks one at a time.
4. Repeat process until bar-tub is empty.
5. Move a new bar-tub into place and repeat the process.

During the course of hanging bars certain risk factors are present. These include prolonged forceful gripping of bars, highly repetitious reaching above shoulder level, and sustained forceful flexion of the elbow. Additionally, steadying of the wire hooks requires repetitive ulnar deviation (bending to the little-finger side) and flexion of the wrist. Removing bars from the bar-tubs involves forceful pinching with the fingers and thumb. This can overload small muscles of the hand and thumb that are physiologically intended for light or fine work.

As originally outlined, the project did not address trauma caused by removing bars from bar-tubs. OCS decided to expand the scope of the project to address this issue and covered the additional cost ($243,806). In its final form, the project goal was to fully automate the hanging of bars by developing prototype equipment to pick up and place bars directly on the paint line hooks.

At this point, a follow up ergonomic evaluation has not been completed on this equipment. Such an evaluation will be performed and OR-OSHA will be notified of the results, as this information becomes available. However, judging from the fact that the bar hanging activity has been completely eliminated, it is likely that the degree of operator discomfort will be reduced significantly.

Worksite Redesign Project - Paint Line Autoload Cell

"Automated System to Load Chain Saw Guide Bars on a Paint Line Hook"

Project Timeline

Project approval was received in September 1997. Work began on phase I of the project in November 1997. Phase I dealt with whether a previously "positioned" bar could be mechanically hung on a paint line hook.

From the start, progress was slow because of competition for resources at Oregon Cutting Systems (OCS). A line of revolutionary new (Intenz) guide bars was being introduced. Engineering and machine shop resources were focused on this activity. Later in the project, competition for resources would cause further delays as OCS strived to increase production capacity to support growing sales.

By September 1998, a mockup had been designed and built. This piece of equipment demonstrated that a properly positioned chain saw guide bar could be hung by mechanical means.

Design began on the prototype, a production version of the mockup. This piece of equipment came to be known as the *pickup carousel*. Just as the design was nearing completion, the decision was made by OCS to purchase a new paint line and obsolete the old line. Because of differences between the old and new lines, some re-design of the pickup carousel was necessary. The final design was completed in November 1999. By June 2000, the pickup carousel was built. The carousel was tied into the paint line in January 2000.

While the carousel was being designed, a team of engineers was working on Phases II & III of the project, how to "singulate" bars from a stack and move them into position for pickup by the carousel. Two pieces of equipment were identified to accomplish these tasks. The first piece of equipment, a pair of *scara-style robots*, would be purchased and modified. The second piece of equipment, a *shuttle system for bar-tubs*, would need to be designed and built by OCS.

The robots were purchased and passed qualification testing in July 2000. Required robot modifications were completed by October 2000.

Design of the *bar-tub nest* portion of the bar-tub shuttle was completed in June 2000. This equipment was built in August 2000. With this equipment in place, robot program development could begin. A complete design of the *bar-tub shuttle* was finished in November 2000. Construction of the bar-tub shuttle was completed in February 2001. A straddle lift was purchased and modified as part of this activity.

The final phase of the project was to assemble the entire system. This required the design and fabrication of guarding and other safety apparatus, such as interlocks. An electronic control system was developed to tie all the components together. Assembly of the *paint line autoload cell* was completed in June 2001. Debug and development activities will continue for several more months. The focus of these activities will be to optimize equipment reliability and to simplify and streamline the operator interface.

Worksite Redesign Project - Paint Line Autoload Cell

"Automated System to Load Chain Saw Guide Bars on a Paint Line Hook"

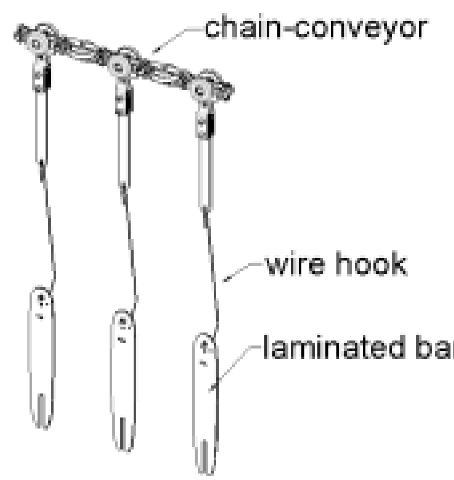
About Oregon Cutting Systems

Founded in 1947, Oregon Cutting Systems (OCS) is a major producer of chain saw products, predominately cutting chain (saw chain) and chain saw guide bars (bars). These products are produced in several plants worldwide, but the largest facility is in Portland, Oregon. This is where laminated chain saw guide bars are produced. This style of bar is used on light to medium duty chain saws. Millions of these bars are produced annually at the Portland facility. In order to meet customer demand, the Portland plant operates around the clock.

Saw chain being placed on a laminated chain saw guide bar

The Worksite

One of the processes used to produce the laminated guide bar is electrostatic powder painting. In this process, the guide bar is hung on a wire hook that, in turn, hangs on a motorized overhead chain-conveyor. This chain-conveyor moves the bar through several stations where the bar is chemically cleaned, air dried, spray coated with powder paint, and finally heat cured in an oven to produce a baked-on enamel finish. The metal wire hook is an important component because it "grounds" the workpiece (bar) so that it can be evenly coated with the electrically charged powder paint.



This project deals specifically with the process of hanging the guide bars onto the wire hooks in preparation for powder painting.

Worksite Redesign Project - Paint Line Autoload Cell

"Automated System to Load Chain Saw Guide Bars on a Paint Line Hook"

The "Before" Process

Historically, chain saw guide bars have been hung manually on wire hooks in preparation for electrostatic powder painting. In order to keep pace with the paint line conveyor, the operator is required to hang one bar every two seconds. At this rate, 10,000 or more bars might be hung in a single shift.

The Manual Hanging Procedure

An operator reaches into a storage container (bar-tub) and gathers a handful of bars. The bars weigh between 1 and 3 pounds each and range from 8 to 24 inches in length. The most common bar length is 15 inches. Each bar is 2 to 3 inches wide and about $^{3}/_{16}$ of an inch thick. For smaller bars 7 to 8 bars are held at once; for larger bars as few as 3 bars might be held at once.

The bars are held in one hand and fanned out like cards. The other hand is used to steady the $^{1}/_{8}$ inch diameter wire hook so that the bar can be hung. The hooks move along on a motorized conveyor so they are in constant motion. The operator is required to grab the hook, steady it, and then pass it through a ¼ inch diameter hole in the bar.

The Manual Hanging Procedure (continued)

Once the hook is threaded through the small hole in the bar, the hook and bar are released and allowed to hang freely. The process is then repeated for the next bar. The repetitive nature of the operation has resulted in numerous repetitive-motion injuries. Each year about 60 employees spend time hanging bars on the paint line.

Project Goal

This project is aimed at eliminating the repetitive-motion injuries associated with manually hanging chain saw guide bars (bars) on the powder paint line at the Portland facility. In this case, the goal is to fully automate the hanging process by replacing the operator with prototype equipment to pickup and place bars directly on the paint line hooks. The operator's duties become those of an overseer and coordinator. However, some manual movement of bulk product into staging areas is still required as in the previous procedure.

Design Parameters for Paint Line Autoload Cell

The following is a list of those requirements deemed necessary for the prototype equipment. These were developed prior to the commencement of any design work.

1. Bars will hang tail end down. The 0.250" diameter nose tooling-hole will be used to hang bars.
2. Equipment will handle bars of length 8" to 25", width 1.8" to 3.0", and thicknesses of 0.120" to 0.190".
3. Equipment will occupy maximum floor space of 8' x 8' (excluding area for staging carts, etc.).
4. Existing hooks will be utilized with modification if necessary.
5. No additional cost will be added to the operation. (Existing hooks cost $0.135 each and have a life expectancy of 30 cycles. There is space for 868 hooks on the line. This equals 26,000 bars per set of hooks.)

Design Parameters for Paint Line Autoload Cell (continued)

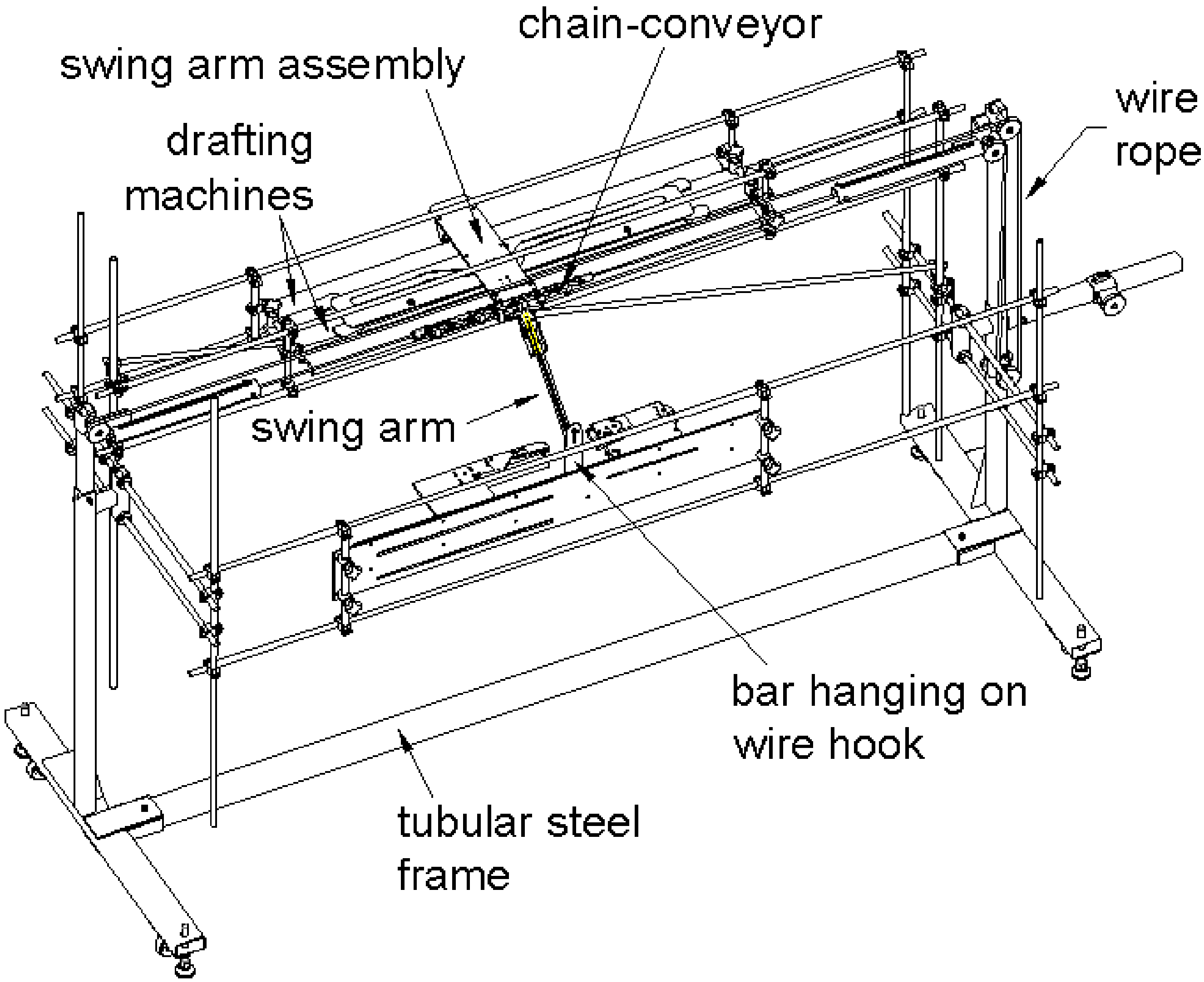
6. There will be no negative effect on part quality.
7. Equipment will be capable of running continuously for one full week, at which time it will require no more than 2 hours of planned preventative maintenance.
8. The current conveyor will be utilized with the option of modifying its height.
9. Part change over will be accomplished in five (5) minutes or less. Setup can be done while paint line conveyor is moving.
10. Cycle time will be at least 24 bars per minute (2.5 seconds per bar). This may require that bars be hung "two at a time".
11. Equipment must accommodate the future addition of pin stamps or a marking laser for ID marking.
12. Equipment will allow bars to be staged for hanging without stopping the line.
13. Equipment must accommodate manual hanging as desired.
14. Equipment must be capable of running for at least 15 minutes without operator intervention (adding more bars, etc). This could translate to a 30" tall stack of bars.
15. Equipment will allow bar stacks to be loaded (if necessary) at a constant (or restricted) height.
16. Hooks will be replaced whenever paint "build up" on hooks causes diameter of hooks to exceed 0.220". (New hook is 0.105" diameter).

Project Phase I – *Bar Pickup*

The project was defined in three phases. The phases represent, in reverse order, the motions required to hang a guide bar on the paint line. The goal of phase I was to identify and develop an automated method to pick up and hang a previously "positioned" bar. In the beginning, no consideration was made for how bars would get into position. The focus was merely to see if a properly positioned bar could be picked up. At the time, automated pickup was perceived as the most difficult task to accomplish.

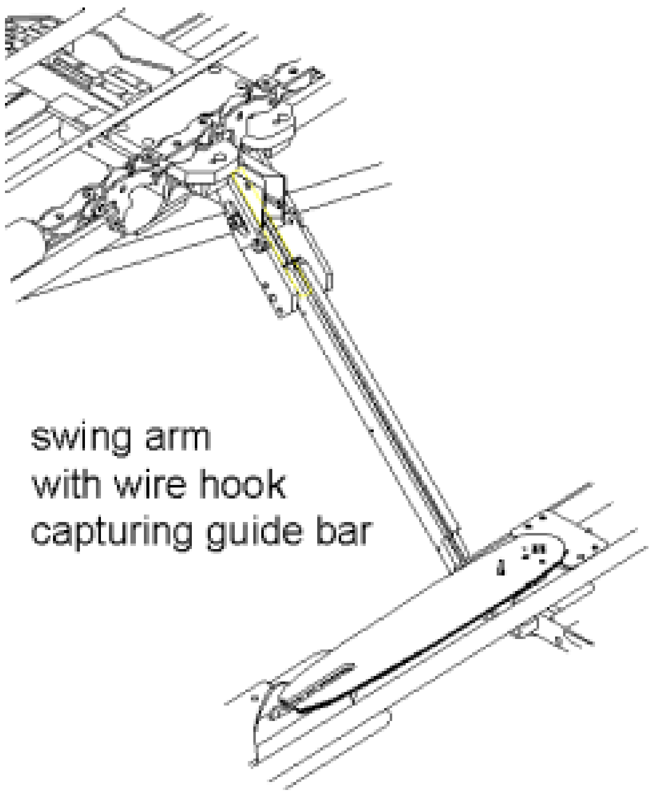
Several concepts were explored and crudely tested. One concept appeared to be viable enough to warrant the building of a mock up.

The Mock Up

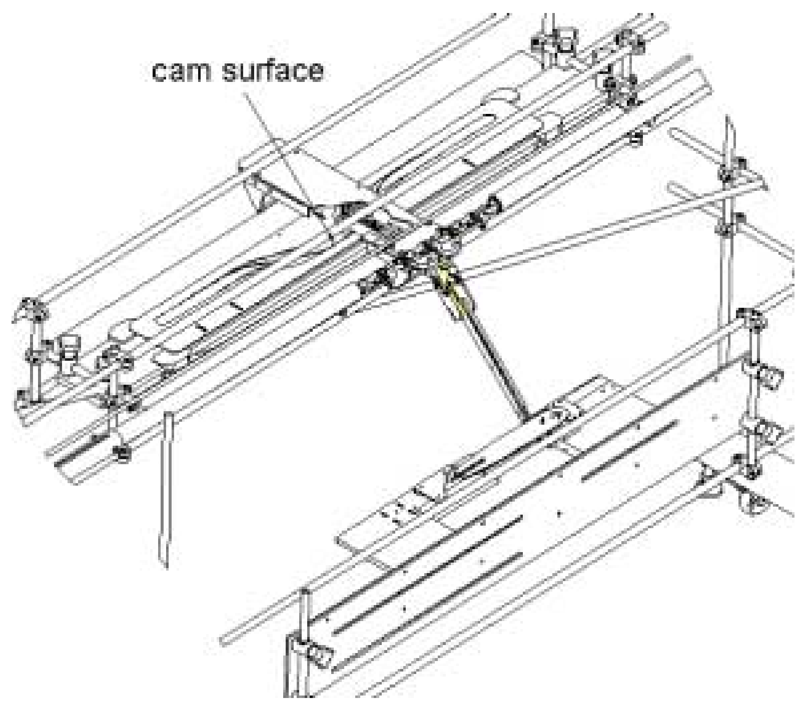


Using a pair of old drafting machines, some tubular steel, wire rope, and some fabricated components, a mock up of the pickup operation was built. The mock up consisted of a tubular steel frame with a piece of paint line chain-conveyor running along the top length of the frame. A swing arm assembly (consisting of a swing arm, a cam follower and a pusher) was attached to a pair of drafting machines. The two drafting machines acted as a large, dual linear slide. The swing arm assembly meshed with the chain-conveyor and moved with it. A wire hook was hung from the chain-conveyor as it would from the paint line. To either end of the chain-conveyor was attached a single length of wire rope. This rope ran through a series of pulleys, culminating in an exposed loop of rope for the operator to pull on.

The Mock Up (continued)

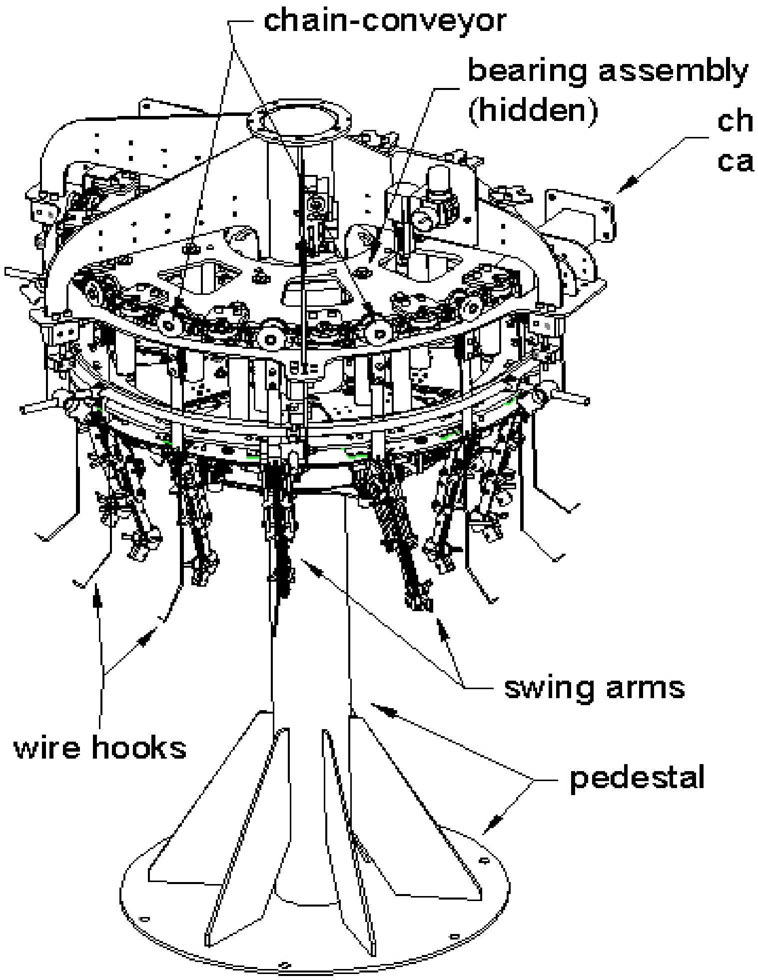


Using a motion similar to that used to open heavy window drapes, the rope could be pulled to move the chain-conveyor along horizontally, imitating the motion of the moving paint line conveyor. As the chain-conveyor moved it dragged the swing arm assembly along with it. At one point in this motion, the cam follower would engage a cam surface that would move the pusher outward. This would cause the swing arm to rotate outward and upward. The wire hook would then become "nested" in the swing arm and be guided towards an awaiting chain saw guide bar.



Provided the bar was properly positioned on the staging platform, the end of the wire hook would be threaded through the small tooling-hole in the bar. The captured bar would then swing away from the staging platform. As the swing arm returned to its vertical position, the bar would hang from the wire hook.

The Pickup Carousel



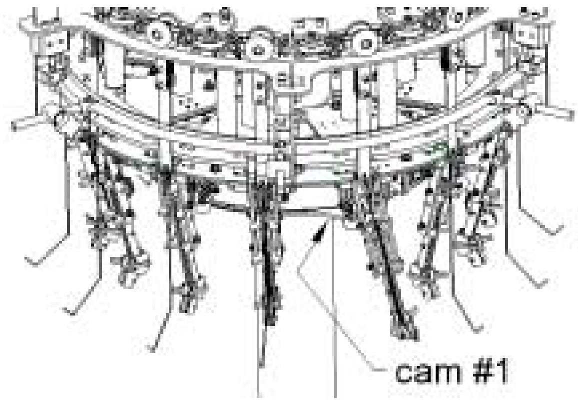
A guide bar being hooked through its tooling-hole.

After verifying that the mock-up concept would work, the focus shifted to the design of a prototype (production) bar pickup station. The mock-up concept was expanded to include thirteen additional swing arm assemblies arranged in a circular pattern (not linear). The two drafting machines (which acted as a large, dual linear slide in the mock up) were replaced with a sixteen-inch diameter Rotek series 2100 gearless bearing assembly. The tubular steel frame was replaced with a massive pedestal.

This fourteen-station unit came to be known as the **pickup carousel**. In principle, the pickup carousel works exactly like the mock up in the way it picks up the bar. The swing arm swings outward and upward threading the end of the wire hook through the small tooling-hole in the bar. Besides being circular and multi-stationed, a major difference between the two units is that the pickup carousel is driven by the powered paint line chain-conveyor (rather than by hand as in the mock up).

The Pickup Carousel (continued)

The chain-conveyor meshes with the pickup carousel and, as the chain-conveyor moves, the pickup carousel turns. At a specified point in its revolution, the cam follower (a component of the swing arm assembly) engages a cam surface displacing the pusher and moving the swing arm out and upward, threading the wire hook through the awaiting guide bar. Two cams are incorporated in the design to accommodate two pickup locations.



Project Phases II & III – *Pick & Place*

The goal of phase II of this project was to identify and develop an automated method to position a guide bar for pickup.

The goal of phase III was to identify and develop an automated method to "singulate" a guide bar from a stack of bars so that it could be presented for positioning.

Collectively, these two phases represent the material-handling component of the paint line autoload cell.

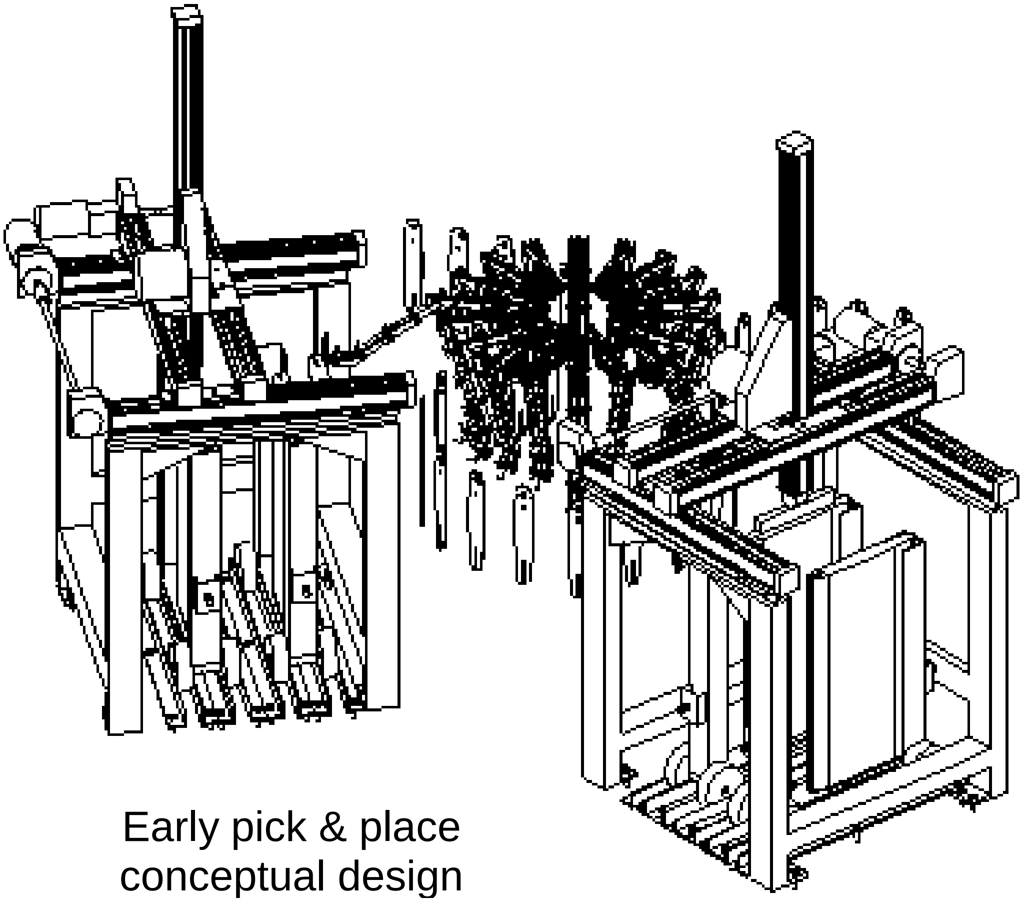
When this project was conceived, two pieces of equipment were envisioned. It was felt that one piece of equipment would be required to singulate bars from a stack and a second piece of equipment would be needed to position bars for pickup.

As the project progressed this view changed slightly. Two pieces of equipment were ultimately employed but their roles changed slightly. The first piece of equipment, a pair of **Adept Cobra 800 scara-style robots**, was actually capable of both singulating and positioning bars. Collectively, these two operations (singulating and positioning) came to be known as the "pick & place" operation. However, a second piece of equipment known as the **bar-tub shuttle**, was required to present the bars to the Adept robots.

Worksite Redesign Project - Paint Line Autoload Cell
"Automated System to Load Chain Saw Guide Bars on a Paint Line Hook"

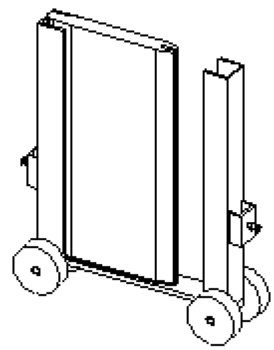
Early Concepts

Before the decision was made to utilize the scara-style robots, several pick & place alternatives were pursued. These are some of the ideas that never made it off the drawing board:

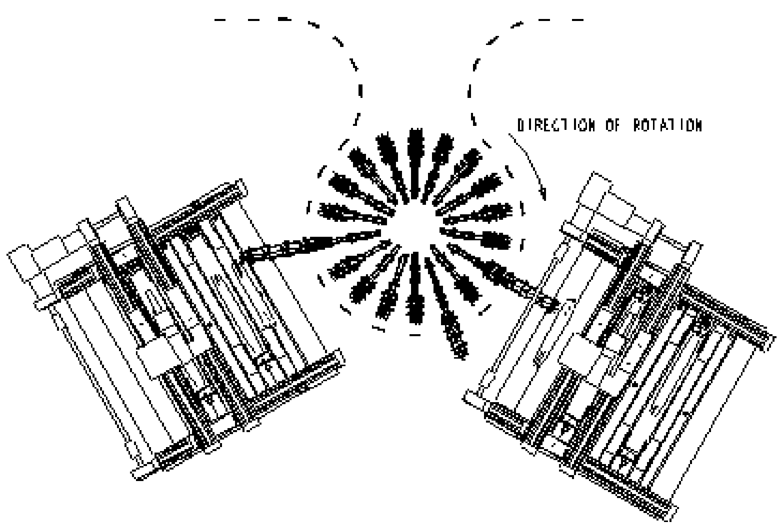


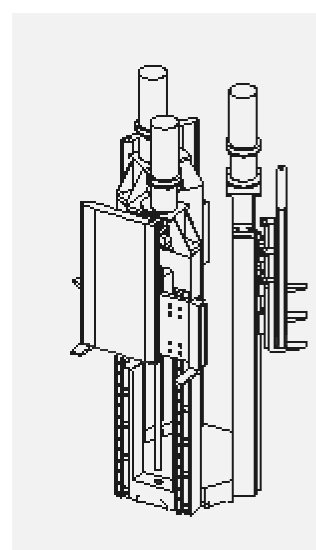
Early pick & place conceptual design

Guide bar "cassette"



"Turret" lifts





Worksite Redesign Project - Paint Line Autoload Cell
"Automated System to Load Chain Saw Guide Bars on a Paint Line Hook"

Why were Scara-Style Robots Chosen?

- This equipment is able to meet the cycle-time requirements.
- Robots are relatively inexpensive compared to developing new technology.
- Development lead-time could be greatly reduced compared to developing new technology.
- Robots have great flexibility and can accommodate different product configurations.

Acceptance Criteria for Adept Cobra 800 Scara Robots

1. Equipment is expected to perform per manufacturer's published specifications with respect to reliability and performance. Equipment must pass manufacturer's certification program. Documentation to that effect shall be provided with equipment.
2. The following are considered to be critical manufacturer's specifications:
   - Equipment life: 60 million cycles (approximately 65,000 hours based on a 4-second cycle).
   - Mean time between failures: 15,000 hours.
   - Repeatability: X & Y ± 0.025 mm (0.001"), Z-axis ± 0.02 mm (0.0015"), Theta ± 0.05^{o}.
   - Reach 800 mm.
   - Joint speed (max.): joint-1 360^{o}/sec, joint-2 672^{o}/sec, joint-3 200 mm/sec (43 in/sec), and joint-4 1200^{o}/sec.
3. In addition to meeting manufacturer's specifications, a performance evaluation will be conducted by Blount, Inc. once equipment is received. This evaluation will measure cycle time through a specified sequence of movements. Positioning repeatability will also be evaluated. Tests will be performed with a 20" guide bar "bolted" to the robot z-axis (no vacuum cups) with additional weight added to total a 3.0 kg (6.6 lbs.) payload.
4. Equipment must meet all the requirements listed above. Blount, Inc. will perform an evaluation of equipment capability within 30 days of shipment of the equipment to confirm that it meets these requirements. Equipment must pass this acceptance evaluation before payment is made. If equipment fails performance testing, payment will be held until equipment demonstrates capability.
5. Equipment will be under manufacturer's warranty for 18 months from acceptance of equipment per Acceptance Evaluation described above.

Pick & Place **Implementation**

Implementation of the Adept Cobra 800 scara-style robots presented some special challenges:

- The manufacturer had never used this equipment to move product this large at these speeds. Nor had this degree of precision been required with product this large.
- There were no commercially available (off-the-shelf) end-effector solutions that would meet our needs.
- The rotary travel requirement for the end-effector exceeds 360 degrees (end-effector must turn all the way around and more). Conventional rotary-style air couplings were too bulky or otherwise dimensionally unsuited.
- Vacuum generators need to be small enough to mount inside the robot, close to the end-effector. Vacuum cups, although available in numerous styles, had not been previously utilized in an application exactly like ours.

The End-Effector

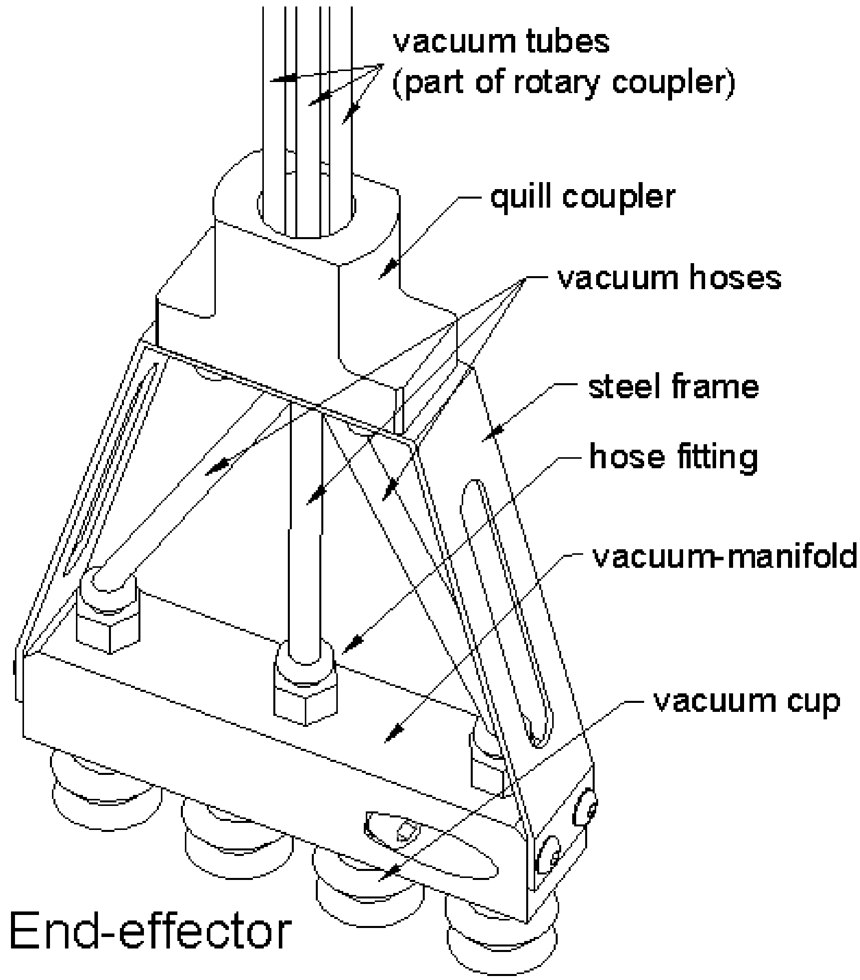
The end-effector is the robot "gripper" that captures the object to be picked up, the laminated guide bar in this case. Several options were considered.

"Mechanical" gripping was considered a good option but seemed unnecessarily complex. In this case, mechanical "fingers" grip the bars by their sides. Custom mechanical grippers would need to be designed, built, and tested. Further development would likely be required, as well. The mechanical method lends itself to a cassette-style presentation of the bars to the robot where the sides of the bars are accessible. In a bar-tub scenario where the sides of the guide bars touch vertical partitions, gripping the bars by their sides becomes more challenging.

"Magnetic" gripping was also considered. In this method an electromagnet is turned on and off to pickup and release a magnetic object. There are some drawbacks with this system that make it an unacceptable option. The weight of the electromagnet is excessive, approaching the payload limits of the robot. There were also concerns about residual magnetism, response time, and possible part scratching.

The End-Effector (continued)

"Vacuum" gripping was finally selected. Vacuum gripping utilizes suction to grasp an object. This method was chosen because of its simplicity and flexibility and because a wide variety of vacuum cups and vacuum generators are commercially available. Additionally, the vacuum end-effector is lightweight, placing it well below the payload limits of the robot.



A vacuum end-effector was designed and built. The end-effector is made up of several components. At the top is the quill coupler for attaching the end-effector to the robot quill. Below this is the steel frame. At the bottom is an aluminum block with threaded holes and vacuum ports. This is the vacuum-manifold. Attached to the vacuum-manifold are vacuum cups and hose fittings. Vacuum hoses are attached to the hose fittings. These run up the robot quill to the rotary coupler and finally to the vacuum generators.

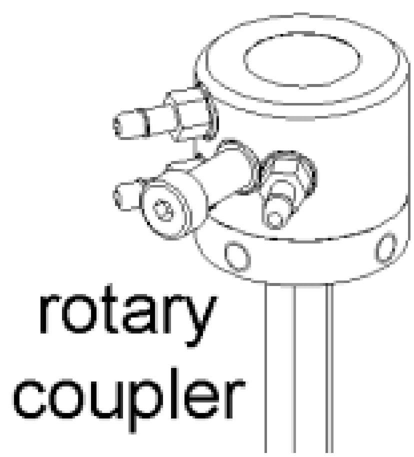
Vacuum Generators

Three miniature vacuum generators are mounted inside the robot upper arm, near the quill. To ensure that a strong vacuum is maintained, the distance from the vacuum generators to the end-effector is kept to a minimum. The use of multiple vacuum generators also ensures a stronger vacuum.

These particular vacuum generators are extremely small and lightweight. The vacuum is created by the *venturi effect. W*hen compressed air is passed through the vacuum generator, a vacuum is induced. It is, therefore, a fairly simple matter to turn the vacuum on and off using compressed air and an air valve or solenoid.

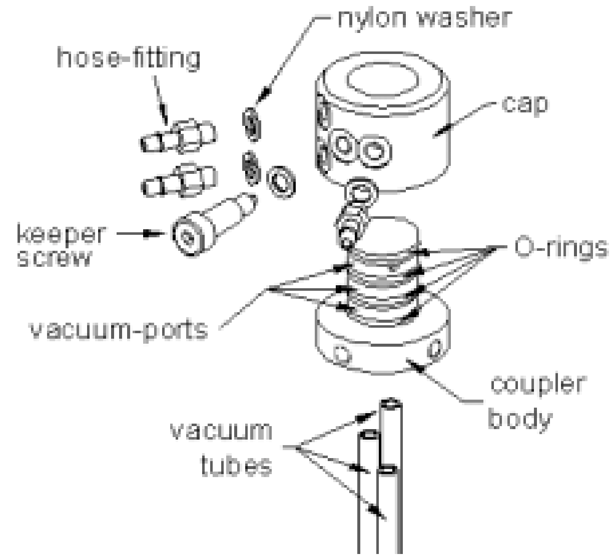
The Rotary Coupler

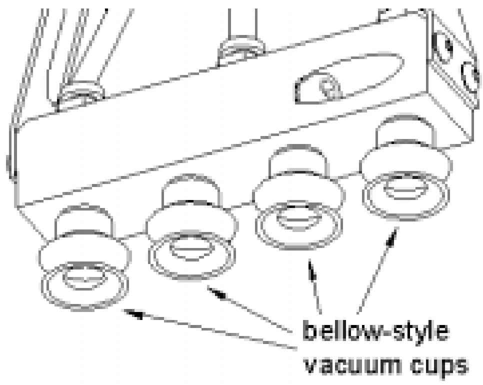
In order to fit the three required vacuum lines through the robot quill and allow for end-effector rotation of greater than 360 degrees, it was necessary to design and build a special rotary coupler. This device, which ties the vacuum generator hoses to those of the end-effector, consists of several components.



The Rotary Coupler (continued)

A cylindrical cap with three compression-style hose-fittings and a keeper screw fits snugly over the ported coupler body. The coupler body has four O-rings, one on either side of each of the three vacuum-ports. Each of these vacuum-ports connects internally to a vacuum tube. The vacuum tubes run through the center of the robot quill to the end-effector.

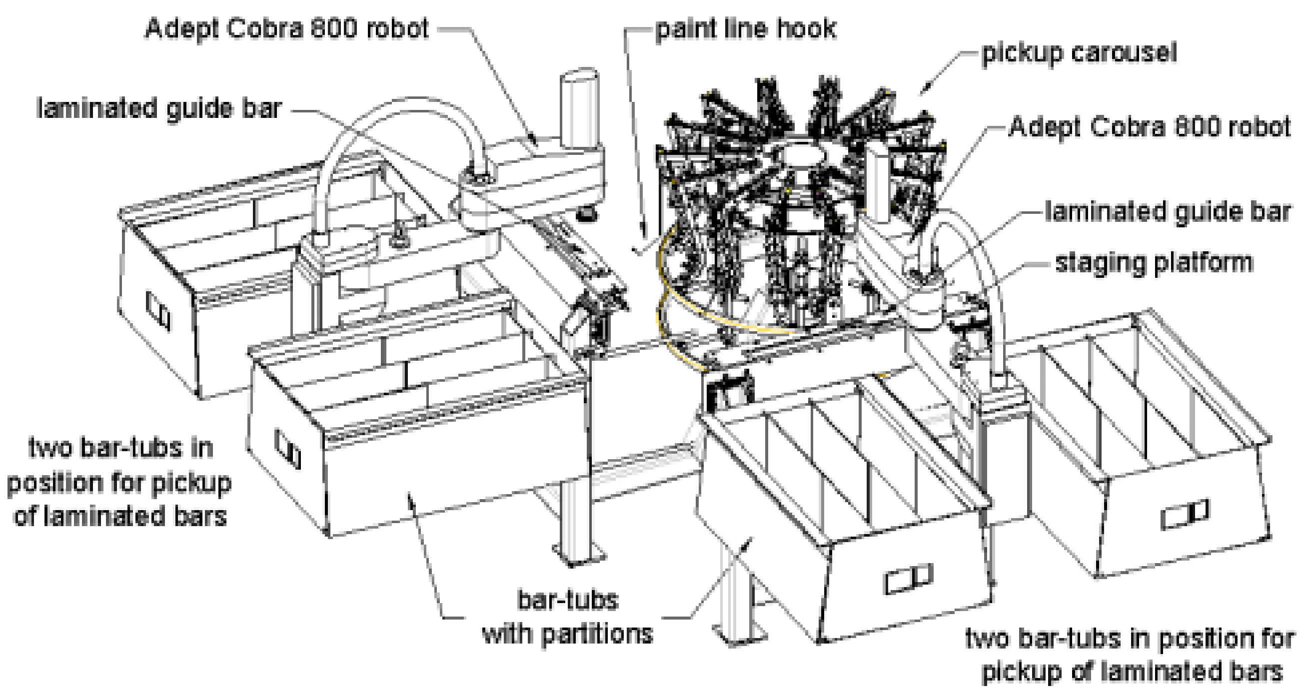




Vacuum Cups

Four bellows-style vacuum cups are mounted on the bottom of each end-effector. The bellows-style cups work best because the laminated guide bars are presented to the end-effector at a slight angle. This style of vacuum cup is extremely pliable and forgiving of surface irregularities.

Integration of the *Pickup Carousel* and *Pick & Place Robots*



Design Parameters for Bar-Tub Shuttle

1. Equipment must handle bar-tub weight plus a bar weight of 2,000 pounds.
2. Operator must be protected from robot movement.
3. Equipment must be capable of safely changing an empty bar-tub while robot unloads a full bar-tub.
4. Design must consider limits of robot travel (all axes). Limit z-axis required travel from "pickup spot on false floor of bar-tub" to "highest point on bar-tub" to 7 ¾ inches.
5. Bar-tub exchange requires no more than 5 minutes of operator time.
6. Limit cost of equipment to $40,000 (target is $28,000).
7. Bars are located within $^{1}/_{8}$ inch repeatability.
8. Utilize bar-tub "false-floor with partitions" design to limit the location of bars.
9. Partitions stay in the bar-tubs. Bar-tubs are dedicated to the paint line.
10. Bar-tubs should shuttle "out-the-front" not "out-the-sides".
11. If carts are used, these could be dedicated to this operation. Sixteen carts would be needed.

Why Use Standard Bar-Tubs?

- Since these are already used to hold laminated guide bars, they are readily available and inexpensive.
- The capital investment to add partitions is small versus developing and building cassettes.
- Use of bar-tubs has a low impact on other operations within department (versus introducing a cassette).
- Bar-tub configuration fits the robot travel envelope:
  - Robots have large horizontal travel-limits.
  - Robot vertical travel limits are restricted.
- Bar-tubs are stable (safe) and can be handled with pallet handling equipment.

***Bar-Tub Shuttle* Implementation**

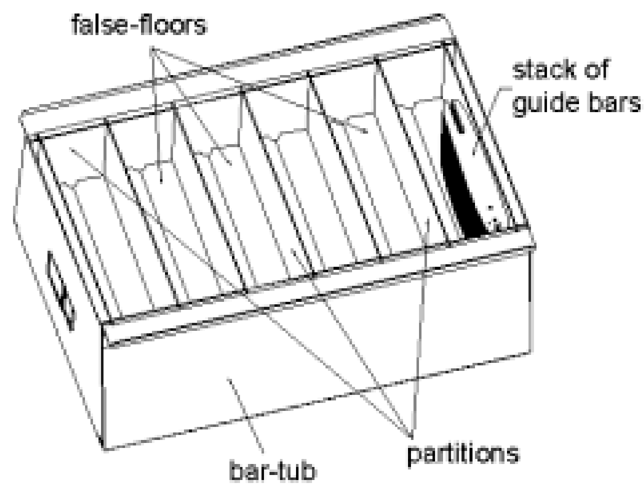
A simple design scheme was developed to present "full" bar-tubs to the robots. The equipment and process, referred to here as the bar-tub shuttle, consists of the following elements:

- Several modified bar-tubs
- A modified, Rol-lift brand straddle lift
- Two table-like structures to support and locate the bar-tubs (bar-tub nests)

Modified Bar-Tubs

Partitions and false-floors were built and installed in the bar-tubs. These partitions limit the position of bars within the bar-tub, making it possible for the robot to reliably capture each bar.

bar-tub configured for sixteen-inch or shorter bars



Two configurations of bar-tub partitions are used. One configuration is used for bars that are sixteen inches or shorter in length. A second configuration is used for bars that are longer than sixteen inches in length.

Additional information required for positioning the robot to capture and place the bar, such as bar length, width, and the location of the tooling-hole (the hole used to hang the bar) are provided to the robot controller through operator input.

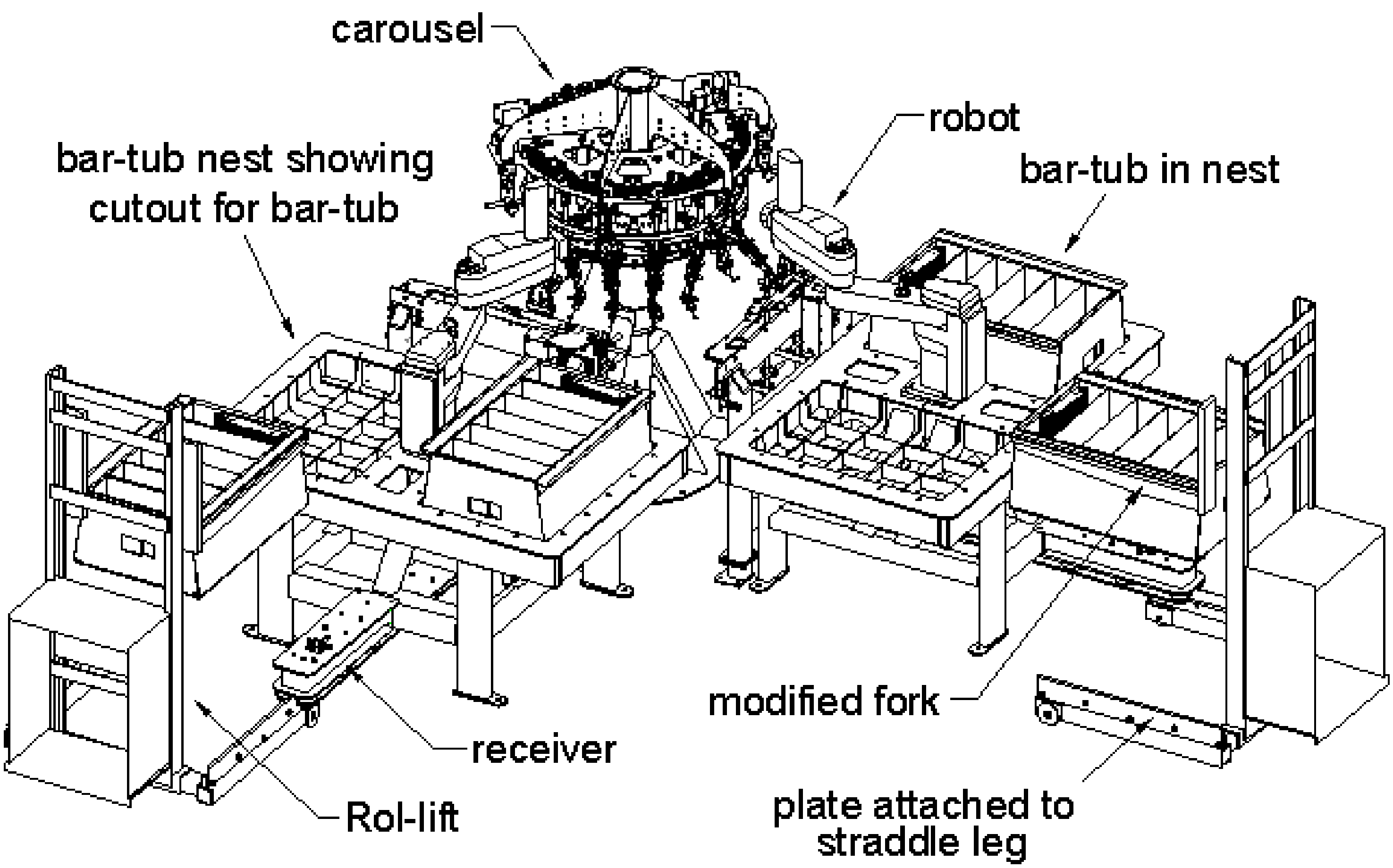
Modified Rol-Lift

A Rol-lift brand straddle lift was purchased and modified. This equipment, which is dedicated solely to the paint line autoload cell, is used to move the bar-tubs into a position where the robots can remove the bars from them.

The Rol-lift is similar to a forklift in that it is has forks, and these forks do the lifting. In this case, the forks have been altered to better accommodate a bar-tub. The Rol-lift can lift a bar-tub from a stack or from the floor and deliver it to the bar-tub nest. In order to operate the Rol-lift, the operator stands behind the unit, protected by a safety screen.

Modified Rol-Lift (continued)

The Rol-lift differs from a forklift in that it has two, long straddle legs that extend out the front of the unit, straddling the load. These straddle legs were altered by attaching a plate to the top of each leg. This plate is used to guide the Rol-lift into a receiver on the bar-tub-nest structure. Once guided into position, the bar-tub is directly over its "nest" and can be dropped in place.

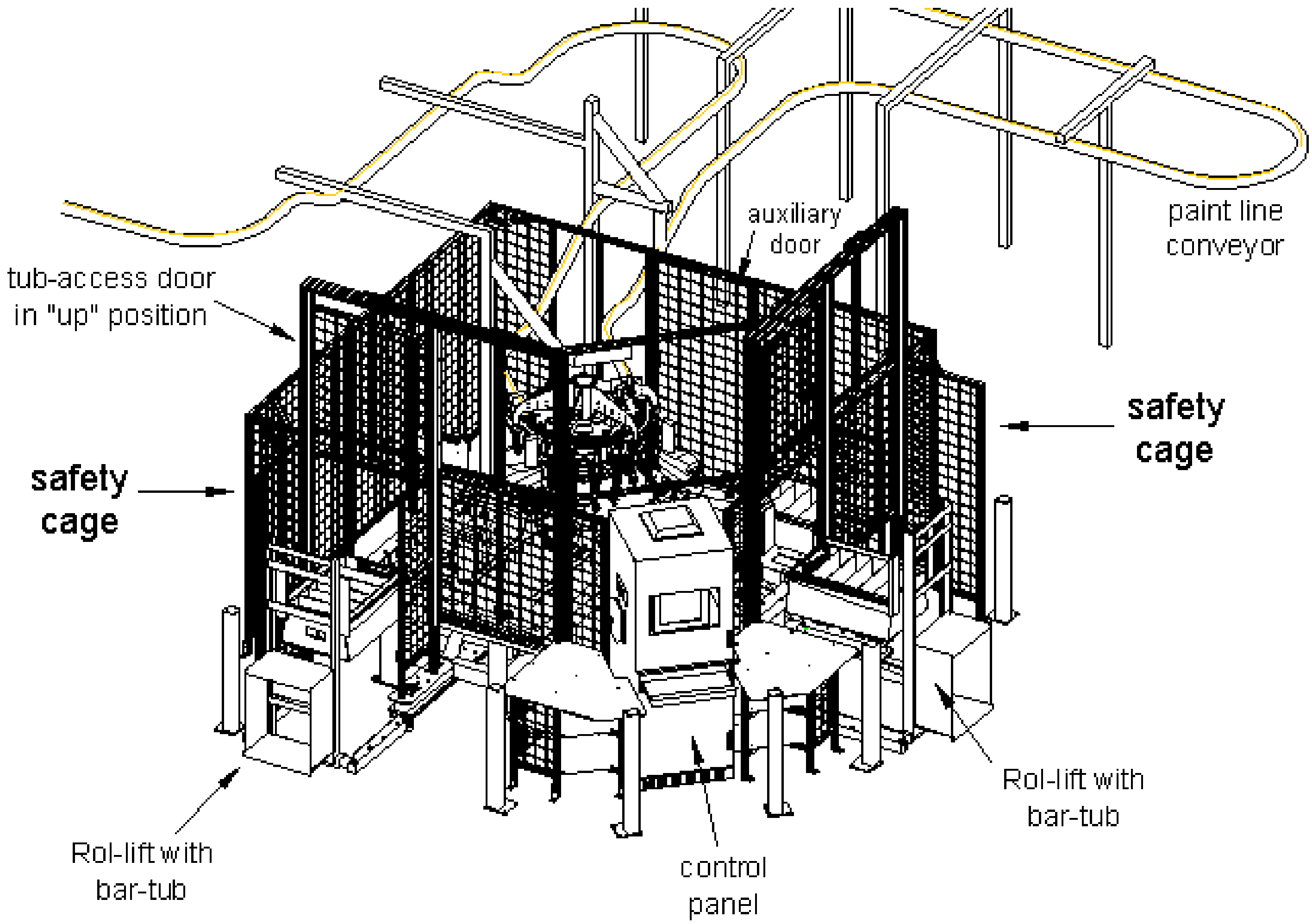


Bar-Tub Nests

The bar-tub nests resemble a pair of large tables. Each table has a pair of cutouts. These cutouts are the "nests" for the bar-tubs. A robot is attached to each table, centered between the nests. Under each table, there is a receiver assembly, consisting of a series of heavy-duty rollers that guide the Rol-lift into position. The Rol-lift is used to load a full tub of bars into the nest. Once the robot has emptied the bar-tub, the Rol-lift is used to remove the empty bar-tub from the nest.

The Final Product: The Paint Line Autoload Cell

The paint line autoload cell consists of the pickup carousel and two identical material-handling structures. Each material-handling structure consists of a staging platform, a pick & place Adept robot, and a dual-station bar-tub shuttle. A safety cage surrounds the cell. Electronic sensors and safety interlocks, which are an integral part of the cell, also ensure operator safety.



The Safety Cage & Interlock System

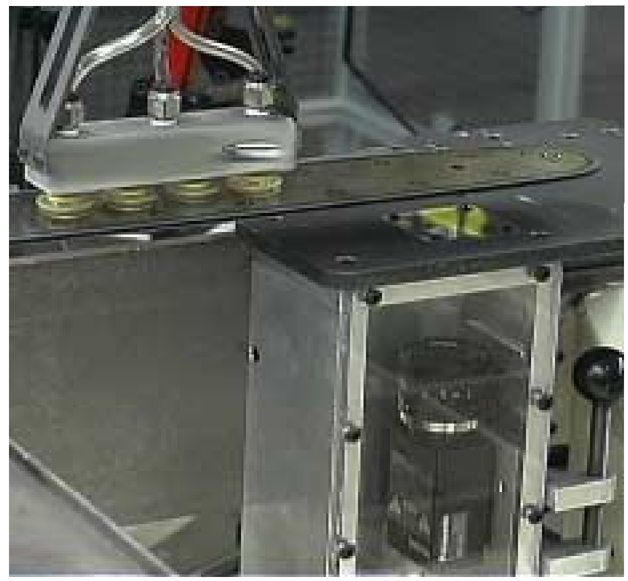
The safety cage that surrounds the cell protects the operator from the moving carousel and robots. The framework, which is made from 80/20-brand, extruded aluminum, supports a series of PVC-coated wire-mesh panels. These panels provide a physical barrier to potentially dangerous areas.

The Safety Cage & Interlock System (continued)

The tub-access doors allow bar-tubs to be shuttled in and out of the cell. These doors are controlled by an interlock system that limits access while providing the convenience of automatically opening and closing the doors as needed. Sensors located on the auxiliary doors inhibit robot movement if the door is opened.

The Vision Camera

Tooling-hole of bar positioned over vision camera.



A high-resolution, industrial camera is used to aid in bar placement. Mounted below the surface of the staging platform, the camera is used to determine the exact location of the tooling-hole.

After the guide bar is captured, the robot moves to a position where the bar tooling-hole is positioned over the camera. A digital image is then made of the tooling-hole and its exact center is found, using a method known as machine-vision. Using this centerline information, the robot is able to accurately place the bar in position for pickup by the carousel.

The Laser Displacement-Sensor

In order to capture a guide bar, the robot must know its exact location within the bar-tub. This is somewhat predictable since position is limited by the location of the bar-tub partitions. However, bar stack-height can vary.

The laser displacement-sensor allows the robot to gauge the distance to the top of a stack of bars. The sensor utilizes a Class 2, red semiconductor laser (wavelength 690 nm, output 0.95 mW). By directing the laser beam to the top bar of a stack, the distance to the bar can be determined.

Worksite Redesign Project - Paint Line Autoload Cell

"Automated System to Load Chain Saw Guide Bars on a Paint Line Hook"

The Control Panel

A central control panel provides the user with an interface to the cell via keyboard, mouse, or bar-code scanner. A single enclosure houses a PC, two robot controllers, and all the necessary electronics. Adept's AIM software resides on the PC. Besides controlling the robots, the software (with the addition of a few V+ subroutines) controls all other functions of the cell, including I/O processing, machine-vision, and laser displacement calculations.

Equipment Cost

This equipment can be reproduced for an approximate cost of US$180,000. Oregon Cutting Systems will provide interested parties access to prints (hard copies) or to ProEngineer design files. Requests should be made to:

ken.neuschwanger@ocsblount.com