Implementation of an Automatic Storage and Retrieval System at Klein Steel in Rochester, NY

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Abstract
Automated Storage and Retrieval Systems have many benefits to different manufacturing systems. The benefits of Automated Storage and Retrieval Systems include better inventory control, larger inventory and storage capacities, and faster and more effective materials handling. Materials handling has always been a challenge in any manufacturing environment being a non-value added process and potentially unsafe in certain industries (ex. steel, chemical, aerospace). An example of the benefits provided to a manufacturing facility by an Automatic Storage and Retrieval System is Klein Steel in Rochester, NY. This paper will overview the before, during, and after aspects of the choices, responses, and improvements throughout the implantation of the Kasto Linear Bar System at Klein Steel.

Keywords: Automated Storage, Automated Retrieval, Materials Handling, Klein Steel, Kasto

1. Introduction [1]
Organized and automated warehouses enable companies to handle many orders quickly and correctly. With the evolution of technology, automated storage and retrieval systems (AS/RS) allowed for products that can be moved by the AS/RS to get larger heavier and exponentially smaller. The possible products moved by AS/RS range from pieces of metal weighing multiple tons to computer components that are as small as a flake of pepper. Online ordering also increased demand for AS/RS, they increased the order numbers so that a manned operation could not keep up. AS/RS can read an order number, look up what items are needed and retrieve them. It then can send the package on its way to receive a shipping label. At the same time, AS/RS can receive incoming orders and place them back in the warehouse to their specific location. This paper will look into the history of AS/RS, how AS/RS systems work, configurations of AS/RS, and the optimization of AS/RS in a manufacturing environment.

1.1 History of AS/RS
Modern storage use warehouses to store goods and products. Warehouses are big open buildings in which companies organize products for easy input and output. They are put into aisles and racks to increase storage area. Aisles need to be wide enough to accommodate forklifts to access both sides of each aisle. People that can drive forklifts typically man them. Products come in by tractor-trailers arriving in loading docks. These products need to be logged and monitored for usage.

Exponentially growing populations meant more products needed to be moved. This also forced standard warehouses to be faster, more efficient and hold more products. Trucks were bigger and stronger. Warehouses struggle to keep up with the demand. Automation was added to keep up with the orders. Automation allows tighter and taller aisles. Every product is label with a Stock Keeping Unit (SKU) [2]. Each item is given its own unique SKU, which allows a master computer to stock and track each item. Incorporating a computer into a warehouse can greatly improve its efficiency. A SKU combined with a computer can provide wonders for those who run the warehouse. It can produce statistics to forecast future sales, it can also eliminate jobs by keeping and monitoring the inventory in real time. It can also automatically order new product to keep a constant inventory. Now automated systems are found in just about every warehouse that can afford it.

1.2 How AS/RS Work
AS/RSs act as a giant three-dimensional grid. Within this system, there is a series of aisles, rows and shelf levels. Each aisle is estimated to cost between $103,000 and $634,000 [2]. Each item has a specific aisle row and level it belongs to. At every location there is a sensor in which the tram has a reader that communicates with each sensor to determine if it is at the correct location. Once the pallet or item is picked up out of its location, it is brought to the
ground floor of the warehouse. Once there, a series of rails rollers and conveyors brings the pallet or item to a pickup area where the item is brought to a machine or to the sales floor via human interaction.

AS/RS come in many different forms and sizes to serve different functions. They can vary in size from picking up giant pieces of steel to tiny surface mount technology components. No matter how big they are they all serve the same function. They all pick up items from a designated area and place them in an assigned place. Every AS/RS machine has three drive systems; one to drive the ground movement, another to drive the vertical movement and a third to pick up or drop off the unit. The motor that drives the horizontal ground movement can move at speeds up to 600 ft/sec. The vertical movement system moves at speeds up to 150 ft./min. In order to retrieve the unit many different systems may be used. Some of these systems include forks, conveyors, suction, magnets and automated shelves. Depending on the type of unit being retrieved or placed the company will need to decide which system fits their needs best. The input/output (I/O) points are places where an item is either delivered to be taken out of the warehouse or to be taken into inventory. Bigger and more effective warehouses have more I/O points to allow more products to be moved [2].

1.3 AS/RS Setup
The basic setup of the aisles, rows and shelves is standard building. Where the difficulty comes is with the incorporation of computer and automation setup. Tolerances need to be set for each axis of movement. Each location needs to be identified. Speeds need to be determined so that products may be moved safely and more efficiently. Storage assignment is an important factor that needs to be decided upon when designing an AS/RS. There are five different types of storage assignment, dedicated storage assignment, random storage assignment, closest open location, full turnover and class based storage assignment. Dedicated Storage Assignment gives each item a fixed location on a rack. All refills of the same product will be placed at the same space as they occupied before. Dedicated storage assignments are best utilized when large inventories. Larger and heavier items are stored on the bottom and the smaller, lighter items towards the top. Random storage is completely the opposite of dedicated storage, any item can be put anywhere. This would be more suited to smaller inventories or inventories that are temporary. Closest open location storage functions just the way it sounds. The nearest slot to the I/O point will be the first to be used. This would suit a small variety inventory. Full turnover storage assignment is the system in which the most thought needs to be put in. The most used items are stored closest to the I/O point and the slower moving items are stored towards the back. This system would benefit larger inventories that have many orders coming through the warehouse. Class based storage is the most widely used system of storage. All the items are broken up into classes. Classes can be determined by selling rates, item size, and quantity in stock. The AS/RS designer will select the number of classes, the size each class and where each class will be in the warehouse. Effective planning of the warehouse will allow for proper use and easy upgradeability. An effective system will most likely be an efficient one [3].

2. Design Considerations for AS/RS [1]
There are many design considerations in implementing an AS/RS into a manufacturing environment. First, and most importantly, is the need for an AS/RS. Typically, a capacity and capability analysis is needed to justify the improvements of an AS/RS into a manufacturing process. The time and cost savings of the system must be justified for a company to invest in such a large capital expense.

Plant layout and the physical design of the AS/RS are needed in order to determine what type of AS/RS will be implemented (ex. vertical or horizontal system). The plant layout will help to decide important design factors into the system, such as the number of containers or bins and the aisles layout for the system. These systems usually have a large footprint on a manufacturing floor and in certain case, an engineer may have to redesign a manufacturing process around the AS/RS system. In order to validate such a large plant change engineers choices will be made using, capacity and capability analysis, historical and forecasted product data, production output requirements, available floor space, and available budgeting[3].

In tandem with these considerations, an engineer must decide what type configuration the system will have. While choosing the physical layout and design of the system, the engineer must take into consideration, the input and output configurations of the system. First, there are the electrical and software setup of the system in order to functionally run and keep up with the high demand of the manufacturing process. Second, the physical input and output points of the system must be setup to be in a central location for all storage and retrieval requests.
As these system considerations are designed and decided upon, an engineer must then decide what type of storage, batching and sequencing operations will be used to most effectively use the AS/RS in the manufacturing process. Design decisions include storage positioning, batch size of storage containers, and the sequencing methods of the systems. Storage and retrieval operations are typically broken into classes based on the material, size restrictions, or storage location. This allows the system to be able to optimize the time for storage and retrieval throughout the system.

Once the system has been implemented and built into the manufacturing process, the design portion may be over, however the system must be continuously improved over the implementation of the AS/RS on the manufacturing floor. Optimization of bin organization, timing of each bin, and bin location must be studied in order to have a cost saving and effective AS/RS. Performance metrics for AS/RS are usually based on time studies, as the systems are implemented to help save time in materials handling. Metrics used to measure AS/RS systems include, storage and retrieval travel times and wait times for storage and retrieval [3]. Other metrics that will be used will evaluate the capability and capacity of processes before and after the implementation of an AS/RS.

With proper design, the return on investment of an AS/RS system will be met with the improvement of the manufacturing process, inventory control, and time savings in materials handling. The high initial costs of the system will be offset when implemented correctly and effectively, while always improving the system to meet the needs of production. There are many factors to take into effect, but when done correctly an AS/RS can help improve production yield, increase storage space, and improve quality of finished goods.

3. Implementation of AS/RS at Klein Steel

3.1 Company Overview and History [4]
Klein Steel Service specializes in providing a wide variety of steels to the northeast United States. Klein is based in Rochester, NY and has three more locations in New York. The other locations are in Buffalo, Syracuse and Albany. Klein provides metal solutions specific to customer needs for a wide variety of industries including automotive, aerospace, and consumer goods. Klein is committed to continual process improvement and growth throughout the northeast United States. The company’s mission statement reads, "Klein Steel strives to be the premier supplier of metals by providing solutions to meet our partners’ needs. We attract and engage the best teammates, suppliers, and customers while embracing innovation and continuous process improvement."

Klein Steel Service is a family business. Klein Steel was founded by Arnold Klein in 1971 after recognizing the need for a small order steel wholesaler. Klein Steel started in a 3-garage warehouse, and has grown to four facilities covering a combined 360,000 square feet. Klein has state of the art metal processing and distribution equipment. This includes magnet cranes, plasma cutters, water jet cutters, and a Kasto Automated Storage and Retrieval System. Klein serves over 2,400 customers in the northeastern United States region. Currently, Joe Klein is the chairman of the company and has led Klein Steel to be one of Upstate New York’s top employers and has been elected as the best place to work four years in a row.

3.2 Services and Culture [4]
Klein Steel provides many services ensure that customers get the correct product on time, every time. The Company has numerous machines that provide cutting and material processing capabilities. Klein Steel also has a quality lab that ensures that only the best metals are sent to customers. Klein prides the company in being a safe. It is the belief of the company and employees that the reward for safety today is tomorrow. Klein embraces teamwork and innovation. The company is constantly improving to stay on the cutting edge to maintain stature in the steel service industry. Klein gives back to the community by involving employees 30 professional and educational affiliations.

Klein Steel’s storage system could not meet the demands placed upon it by their customers. Klein is a growing company and is always looking for ways to improve. As customer numbers grew so did the amount of inventory. Klein was using racks and floor space to hold inventory. In order to improve efficiency and storage capacity, Klein looked into two different options to improve their new facility, side loader and automate storage and retrieval methods.
4.1 Major Problems and Reasons for Implementation
The storage system Klein Steel used originally could not hold enough material to fill the demands of customers. At the time, Klein Steel saw a growth in its business by 200% to 300%. Their system at the time was not capable of holding the volume and weight of these orders, so they explored the possibilities of increasing their system. At the same time, the company’s policy was to eliminate jobs that were dangerous or taxing by implementing automation and reassigning the workers to new areas of the plant. As such, the matter of worker safety was a determining factor in decision process.

Because of the growth the company experienced, Klein had the resources and ability to implement one of several different options. In addition, the cost per square foot of new building additions was significant enough to warrant the use of more complex, space-saving technologies such as Automatic Storage & Retrieval Systems.

After considering alternatives, Klein chose to implement two systems; a Raymond Side-Loader system which uses a modified forklift design to load material into racks from the side and a Kasto Linear Bar Storage System – the focus of this study. The Kasto system proved able to hold large amounts of material in a small footprint – saving nearly 20,000 square feet of building space. In addition, the system was – theoretically – safer than their original system and could expand to meet additional storage need which Klein has done twice; once from 850 storage compartments to 1850 and again from 1850 compartments to 2350, bringing their square-foot savings to 170,000 square feet.

4. Pre-Implementation [5]

4.1 Previous System
The original storage system Klein used consisted of a crane with a set of chains operated by two people. These cranes moved material to a series of racks separated by cross members. To access lower-level material, cross members on higher levels had to move (by way of the aforementioned crane). From there, the material moved using manual effort - 8 people to move material to the loading dock, with another 6 to move the material onto trucks. Klein still uses a modification of this system - using only the crane – for extremely large stock such as the 50 foot stock pictured below.

![Original Storage System](image)

Figure 4.1: Original Storage System

4.2 Challenges & Difficulties
In addition to the expected difficulties with new equipment related to training, building, and worker-acceptance, the only major difficulty Klein encountered during implementation consisted of a six-month period where Klein opted to change the locations of the two crane systems used to access the storage. One of the two cranes used magnetic lifts to move material while the other used a standard chain-loading method. Klein felt the magnetic crane served better when closer to the sawing operation and the chain system better utilized closer to the loading dock. After six months of this operation, Klein reversed the decision, having encountered unforeseen difficulties with the exchange.
Outside of implementation, the system proved unable to accomplish certain tasks well. Certain material types – such as extremely long stock, angle-bars, and sheet stock would not fit in the compartments in the system. In addition, Cold-Rolled and short stock material required modification of the compartments to add base-plates and side-plates to prevent cold-rolled lubrication from leaking onto other material and small stock from falling through the holes in the device.

Due to the size of the material, one of the features of the system – a self-bundling application – resisted implementation. Finally, Kasto installed the retrieval system cranes too close to each other. As a result, when the cranes attempt to access the material at the same time, they trigger limit switches; slowing the system significantly. As such, Klein has limited use of the two unloading stations at the same time.

Klein Steel determined the best two options for storage and retrieval systems for the plant. Both options involved different methods of storage and retrieval, and each had advantages and disadvantages for the facility. The first method was the use of side loading system. The second method was the implementation of a fully automated storage and retrieval system.

5.1. Side Loading Storage and Retrieval System
The side loading storage and retrieval system utilizes a forklift on rail or wire guides down a storage aisle. The side loading systems is a semi-automatic system that involves the need for a human operator to operate the forklift. Although the side loading systems can handle similar capacities compared to some automated systems, the forklift storage and retrieval is typically a slower process, leading to extended materials handling time. Advantages of the side loading system include a lower initial cost for the system; however, the disadvantages include higher maintenance and lower reliability in the long term. For Klein, the side loading system was a great choice for the low startup costs, however for the new facility, Klein wanted to plan for long-term goals of growth and not worry about the replacement and maintenance costs in the future.

5.2. Kasto Linear Bar Storage and Retrieval System
The Kasto linear bar system is similar to a vertical lift storage and retrieval module. The Kasto system is a fully automated storage and retrieval that offers space savings and increases storage utilization for a facility. The advantages to the Kasto fully automated storage and retrieval system includes decreased materials handling time, inventory control, and increased storage space. Disadvantages to the system are the larger up front capital costs. This option appealed to Klein because of the advantages it could offer to the factory floor in loading and unloading from inventory.

Between the two systems, Klein chose to implement the Kasto Linear Bar System because of the many advantages the system offered to help increase delivery yield to customers. Even with the high initial capital costs, the long-term reliability and repeatability the system presented aligned with the corporate goals of growth for the future of Klein Steel.

The Kasto system that was implemented into Klein was built in phases. At the time the system was implemented, Klein was also expanding the current facility in Rochester, NY. This allowed for both engineers from Klein and Kasto to design the facility around the Kasto system and to permit the system to be designed around the needs of Klein. In phase one, technicians from Kasto built the honeycomb structure of the system and started to assemble the cranes to be installed in the facility. In total phase one gave Klein a total of 1700 storage spaces. Phase two included an expansion of the facility and the addition of 700 storage spaces to the honeycomb structure. Along with the additional storage space and third and fourth pulling station were added for increased space to retrieve materials. The completed Kasto Linear Bar system at Klein can be seen in Figure 2.

Throughout the implementation process, both Kasto and Klein subject matter experts were involved in each step of the build. This allowed for the experts from Kasto to not only build the system designed for Klein, but for them to teach the experts from Klein to learn how to use and maintain the system properly. Kasto and Klein went back and forth discussing possible designs, visiting companies with existing systems, and going over every "what-if" scenario
to create the best design to fit Klein. Kasto was used to building custom designs for the needs of the customer, and Klein was able to design the system with Kasto to meet the needs of the facility.

During the implementation, Klein and Kasto faced some challenges and benefits throughout the build of the system. One of the challenges was the crane design. Kasto went ahead and installed a magnet style crane without the green light from Klein. Klein did not like the magnet style pickup crane and asked Kasto to convert the crane back to a chain style pickup. In the early months after implementation, Klein found that the magnet style crane showed more benefits and converted back to the original crane layout and style. One benefit during the build that Klein and Kasto found was the building was constructed on bedrock. The concrete structure needed to support the Kasto system is rated to handle earthquakes as extreme as ones seen along the San Andreas Fault. Finding bedrock meant less excavation and not as much concrete was needed to create a stable and suitable structure for the system. The utilization of the bedrock for the structure allowed for time, money, and material savings for Klein.

![Figure 2: Kasto Linear Bar System at Klein Steel](image)

**7. Response to Kasto Linear Bar System Implementation [5]**

After the design and build phases, the Kasto system contained 850 cassettes for storage and retrievals. As the years progressed and as demand increased, Klein increased the number of cassettes in the system. Due to company growth and increase in the number of products to be stored, Klein added cassettes to the system; going from 850 to 1850 cassettes, and today having 2350 cassettes in the system. The overall system in the factory has a total footprint of 10,000 square feet. The system is built vertically and is 60 feet in height. If each cassette in the system were laid out horizontally, it would have a total footprint of 180,000 square feet, showing the space savings in the vertical design. The system consists of 42 compartments long and 27 compartments high for storage of all types of stock steel. The cassettes are designed to hold sizes ranging from 20 to 24 foot steel stock and other bins have been designated for shorter and smaller parts. The system can retrieve and store up to 42 cassettes per and hour which allows Klein to fulfill customer orders on time, every time throughout the northeast United States.

**7.1. System Learning Curves**

With the introduction of a new product or system, comes a learning curve for operators and engineers. For operators and engineers the learning curve was minimized for learning the operation of the system due to the integration of Klein and Kasto during the design and build process. Engineers from Klein state that this system involved three major learning curves, which helped to solve utilization issues within the system. The first learning curve coming six months after implementation; the engineers were watching what products went in and out of the system, only allowing a certain variety of products to be utilized in the system. The second was two and a half years after
implementation when the engineers decided the machine could handle all full-length steel products to increase utilization of the system. The third learning curve happened six years after when the engineers decided to put all shape and size steel stock into the system to maximize the utilization of the system. These helped the engineers at Klein to develop and robust storage and retrieval process for the high variety of material that passes through the facility.

7.2. Workplace Changes
One of the larger changes in the implementation of the AS/RS at Klein Steel was the culture in the introduction of a new technology. Engineers at Klein made it a goal to eliminate jobs that were harmful or dangerous to the operators, and the introduction of the AS/RS allowed for the manual materials handling jobs to be eliminated. Due to the fact that the engineers planned ahead, and allowed the current operators to train with the design team from Kasto, no layoffs were made at Klein because of the introduction of automation. With the new system in place, operators were brought up to speed quickly on how to use the system, and engineers and supervisors claim the user interface of the system is easy for anyone to learn with proper training. Engineers stated that currently that have operators who have been working from 3 months to 30 years at Klein who are capable of working the Kasto system.

7.3. Inventory Control
One of the greatest benefits of the implementation of the Kasto system at Klein steel was the increase in inventory control. The Kasto system uses weight as the control system for inventory in each cassette that is loaded and unloaded. By knowing the theoretical weight of what is added or taken out, the Kasto system compares the actual weight of the cassette to the theoretical weight and will accept or reject based on a 2 to 3% tolerance range. The system is sophisticated enough to know the weight of the cassette and any added supports on the cassette to tare the scale properly as to only weigh the product on the cassette. Six years after the system implementation, Klein did an additional confirmation study to ensure the inventory control was accurate. When all inventory was counted by hand, Klein found that the total cost was off by less than $2000, and that 99.96% of all inventory was accounted for. This showed an improvement over inventory control that was around 90–95% accurate before implementation. The added security knowing that millions of dollars of inventory was controlled and accounted was validation that the AS/RS system improved the Klein facilities.

7.4. Safety Improvements
A number one priority and goal in any manufacturing or work environment is safety. With manual loading and unloading of large slabs of steel, people were more prone to injury on the job. Even with all safety precautions in effect, accidents will still happen. Engineers at Klein explained that there were many back injuries due to the heavy lifting required, and cases where fingers and hands were severed from the sharp corners or the steel slabs. The implementation of the Kasto AS/RS system eliminated many of these jobs that could cause bodily harm to the operators. With a storage and retrieval crane and heavy-duty cranes on the floor to pull parts from cassettes, the number of injuries was reduced significantly. Klein now has one of the best safety records in the Upstate New York area with the implementation of the Kasto system.

7.5. Cassette Utilization
Each cassette that Klein has in the system is rated to hold up to 11,000 pounds of material. However, the engineers at Klein found that putting the maximum weight into each cassette would not work well when it came to unloading and loading away from the system in packaging. The engineers had to find a balance point, not only for the system, but also for the operators who take the product from the system to packaging station. The engineers aim for filling each cassette with an average of 4,000 pounds per a cassette. The system currently stands at an average of 3,100 pounds per a cassette.

Another important aspect of cassette utilization is the storage of all the varieties of steel processed through Klein. The cassettes were originally designed to carry bar and round stock of 20 to 24 foot steel lengths. As the variety of customer demands increased, Klein retrofitted the cassettes to hold shorter lengths and various shaped parts. Along with a color-coded system for visual grouping, the new cassettes allowed for a wider range of product variety to be stored in multiple cassettes and in turn a shorter time to the production floor.

Another feature added to the system was storage buffers. Slots in the system are left open so that if the crane has idle time, it will gather the next items in the queue and place them in a central location for easy access when that specific cassette is called upon. The built in storage buffer allows for faster delivery of the product waiting in the queue.
7.6. System Reliability
Reliability of a system is always a concern when implementing new equipment, especially systems that involve large capital investments. For Klein to meet that long term goals planned for the Kasto system, a preventative maintenance program was setup to ensure the system would have minimal down time and to not effect customer deliveries. The system is maintained and preventative maintenance tasks are performed daily, monthly, quarterly by operators and technicians at Klein. Along with the preventative maintenance by Klein, Kasto visits semi-annually to do diagnostics and maintenance checks. Klein also does not wait for failures of parts and components of the system and has critical components replaced after a set number of hours used. Throughout the 10 years the system has been implemented in the facility, the system has had two breakdowns causing downtime. The recovery time for the system in both cases was one day, which allowed Klein to make up and continue fulfilling customer orders.

8. Other Considerations in Study
Another area considered in this study was the optimization of the storage locations to the demand of Klein Steel. The engineers states that this has been a topic that had been discussed, however it was not a high priority or critical in moving forward. The authors have expressed interest in a continued study to see if the system can be optimized to increase storage and retrieval times for Klein.

9. Conclusion
The automated and storage retrieval system was a great improvement for the materials handling needs of Klein Steel. The Kasto Linear Bar system allowed Klein to increase customer delivery yields and to grow overall as a company. Klein saw an opportunity for growth and chose the right system, which aligned with the corporate goals of the company. Today, the automated storage and retrieval system that was put in place at Klein Steel holds approximately 60% of the company’s revenue, which continues to grow as more satisfied customers return for business with Klein Steel. Just as Arnold Klein saw the need for a steel service in the early 1970’s, the current team at Klein saw a need for newer technologies to continue the company’s growth and to progress the vision of Arnold Klein.

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