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VECTRA ROOM EXPANSION AND TOOLING REDESIGN AT DRESSER-RAND – OLEAN, NY

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ABSTRACT

The focus of this project was on the expansion, process improvement, and tooling redesigns within the VECTRA area at the Dresser-Rand facility in Olean, NY. Professor John Kaemmerlen, of the Industrial Engineering Department at the Rochester Institute of Technology, served as the faculty guide and the project was facilitated by Dennis Rice of Dresser-Rand. Aspects of the VECTRA area were divided such that the team could address each on an individual basis while taking into account the entire system as a whole. Each aspect was examined to determine the feasibility and difficulty of improving that particular feature. With the addition of one build stand, the expanded room consists of a layout that provides for optimal ergonomic movement of workers, sufficient storage for required tooling, and adequate work surfaces. Cranes have been placed throughout the room to ensure that any object can be moved to any crucial part of the room at any time. Furthermore, the team has designed a cart on which a compressor case can be mounted and moved throughout the plant, without the use of a crane. Along with the layout changes, final suggestions have been made to Dresser-Rand management with regards to the implementation of 6S and lean concepts following the departure of the RIT project team.

NOMENCLATURE

990 Area: Another are in the Olean plant which was formerly use to make and test the 990 turbine. This was a potential site for an expanded VECTRA room.

Build stand: A hydraulic stand to hold the VECTRA frame in which the rotor, bearings and other parts are inserted. All parts within the VECTRA final assembly are entered while on this stand.

Compressor Cart: Design for a large cart to carry compressors of various sizes around the plant instead of using the gantry cranes.

Cutover Plan: A transition plan that includes the removal of unneeded items, construction of the room and transition to the new design of the VECTRA room with minimum loss of productive days.

Gantry Crane: Overhead crane used to move products throughout the plant.

HVAC: Heating, Ventilation and Air Conditioning system placed on the top of the plant to supply clean air.

Jigs and Fixtures: Tools present in the VECTRA room, used to carry and move parts using the crane, buggy or forklift. These fixtures are also used in the assembly stages.

Testing Area: Area of the plant where the assembled VECTRA turbine is taken.

VECTRA: Turbine assembly developed by Dresser Rand set at 6200 rpm and shaft output of 40,200 HP. This is multimillion dollar equipment used in generators around the world.

VECTRA Area: A semi clean room environment to assemble and partially test the VECTRA Turbine.

VECTRA rotor: The main rotor with blades and a shaft. It is housed within the VECTRA frame.

WIP: Work In Progress area within the VECTRA area dedicated to the assembly of the VECTRA Power

1.0 INTRODUCTION

As the customer, Dresser-Rand would like to see an improvement to the VECTRA assembly process within the Olean facility. Originally, a reorganization of the current VECTRA area was the goal and after further investigation it was realized that there was more than one option available to the team. It was determined through engineering analysis that many aspects of the VECTRA assembly area could be enhanced while taking into account the safety of the workers and factory as a whole, as well as the overall organization and operation of the facility. Along with lean principles, different layout options were analyzed and suggestions were made on how to improve the layout of the current VECTRA area and also the 990 area. One option that was explored was to move the entire VECTRA assembly process to a different location inside the facility called the 990 area. Through additional engineering analysis with emphasis on process efficiency, lowest change over cost, safety, and minimizing down time, the team was able to thoroughly explore both options and decide on an option that was most beneficial for Dresser-Rand in all aspects of their organization. Along with deciding on a location for this process and its layout, many other areas of the process and facility were analyzed for improvements including storage analysis, ergonomic analysis, implementation of lean concepts, and part transportation exploration. A few goals were as follows: reduce cycle time by 25%, safe operational work areas, improve flow and eliminate problem areas. Other areas explored were 6S, parts inventory, visual controls, reducing waste, and improve overall transportation throughout the plant.

2.0 PROCESS

Based on the fact that aspects were divided and examined individually, the following sections contain the design and development process specific to each aspect.

2.1 Comparison between 990 and VECTRA Area

Initial interactions with the customer resulted in two different areas for VECTRA Expansion available for exploration by the team. The first area is the current VECTRA area with an expansion. The second option is moving the entire VECTRA assembly area to a different part of the plant. This part of the plant will be referred to as the "990 area." This is where the 990 documented needs of the customer as well as feedback from the D-R staff. Specific selection criteria were used to evaluate both locations. Based on the results of the selection matrix, the decision was made to expand the current VECTRA Room. There were a few major reasons for choosing the current VECTRA area. First, the construction cost to move to the 990 area would be significantly higher. Second, the most important concern of the D-R staff was the disruption to the current production. It has been assumed that the current room can be expanded with minimal impact to production.

		Concepts				
		VECTRA		990		Differential: VECTRA - 990
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	
Travel Distance to Test Stand	2.5%	3	0.08	5	0.13	-0.05
Travel Distance to Inventory	2.5%	4	0.10	2	0.05	0.05
Use of Existing Cranes	15.0%	4	0.60	1	0.15	0.45
Potential for New Cranes	5.0%	3	0.15	3	0.15	0.00
Existing Connections for Air and Nitrogen	2.5%	4	0.10	3	0.08	0.03
Safety and OSHA	10.0%	3	0.30	4	0.40	-0.10
Clean Room Capability	15.0%	5	0.75	2	0.30	0.45
Scale of Construction	20.0%	5	1.00	1	0.20	0.80
Relocation of Existing "990" Active Warehouse	5.0%	5	0.25	1	0.05	0.20
VECTRA Local Floor Storage	5.0%	4	0.20	4	0.20	0.00
Main Plant 2 Aisle Traffic	2.5%	4	0.10	2	0.05	0.05
Capability for Additional Expansion (3 or More Build Stands)	15.0%	2	0.30	5	0.75	-0.45
Total Score		3.93		2.50		
Rank		1		2		
Continue?		Develop		No		
Rating Scale: 0-5 0 = Worst 5 = Best						

Fig. 1. VECTRA vs. 990 Selection Matrix

It was requested that the 990 area be looked into and a schematic level design be completed. The second half of the project consisted of analysis of the 990 area. The team was able to provide a cost effective solution that had expansion capabilities greater than the current room. The final decision made by the D-R staff was to remain in the current area and expand the current VECTRA room. The main reason for exploring the 990 area further was to provide D-R with future expansion options (5+ years), which was outside the scope of this project.

2.2 Ergonomic Analysis

The Dresser Rand VECTRA turbine final assembly process takes place in a semi-clean room environment with access to its own air handling system, roll up door, white lights, and work surfaces. The primary operators in this area are between the ages of forty and fifty-five. They are required to handle the various inventory parts, tools, cranes, and the computer to access drawings and track progress. Presently, the room is largely divided into two sections: the area with the build stand and the work in progress area where the moveable tables and rotor stand are kept. Although there have not been any recordable incidents or accidents, the team observed actions within the processes that did not appear to be ergonomically correct. The following is a list of observations and recommendations:

- The operators spent many hours standing and walking around the build stand. There were also traces of oil spilled under the build stand due to lubrication of certain VECTRA parts during the build stages. In order to prevent this, the process
- of the VECTRA. The most feasible solution for this was to use a wheeled creeper with proper back support and lighting to work on the underside of the build stand.

- During some of the WIP stages of the assembly of the VECTRA, a short rotor table was sometimes used as a temporary work surface. This causes some amount of bending and kneeling to do work. The team suggested the use of a separate work surface for performing tooling work and then using the shorter table for more suitable applications.

- Oftentimes, the operators and engineers would trip on the base of the control panel next to the build stand. To avoid this hazard, the team suggested placing the build stand control panel on the wall in a location that would provide easy access to the controls and visibility of the build stand.

- In the current four week cycle of building the VECTRA, the operator makes frequent trips to the common supermarket to re-stock small parts. This increases walking time during the day and reduces productivity in the VECTRA room. The updated room expansion plan includes additional cabinets for storage of small inventory parts like screws, nuts, bolts, as well as a weekly or bi-weekly plan for scheduled refilling of these cabinets by the operators.

- The assembly of the VECTRA turbine while it is on the build stand involves the operators using a moveable stair and bending over the VECTRA casing to work on the parts. Furthermore, they oftentimes position themselves on top of the VECTRA casing during the assembly process. In the final design for expansion, the team has suggested using a dedicated tall stair with handle bars on the side in the VECTRA room and labeling it for use only for VECTRA assembly.

2.3 Storage

At present, there are three shelving units inside the VECTRA room with a total volume of 120 ft^3 (40 ft^3 x 3 units). These shelves consist of non-inventory items like tools, jigs & fixtures. Every shelf has an average shelf utilization of 67%. There were many items on the shelves that were not used very often and were

will be designed for an optimal seating position and an oil collection bucket/draining system will be used. The team later decided that using anti-skid/anti-fatigue mats around the build stand was the best option.

- The operators used a cardboard mat in order to slide under the frame and work on the underside

scheduled to be removed after the sort event. After analyzing the storage capacity and the size of various tools, jigs, and fixtures, the team suggested a total required space of 80 ft^3 per build stand. Therefore, the two build stands would require approximately 160 ft^3. The new storage option includes three shelving units with dimensions of 5ft x 2ft = 60 ft^3 X 3 units = 180 ft^3 of which one shelving unit has three shelves (2 ft. high) and the other two have four shelves (1.5 ft high). Height is from shelf to shelf; assuming shelves are 2" thick. The other storage item that the team focused on was the small parts inventory cabinet that included small part, nuts, bolts, screws and lifting straps. This 33 ft^3 cabinet was labeled for parts but not all drawers were organized well. Space analysis of all the drawers showed that 85% of the cabinet was utilized. The layout of the expanded VECTRA room includes 3 cabinet units of 15.5 ft^3 (30"x27"X33") each, which equals a total space of 46.5 ft^3 for space parts. These cabinets will not take up extra floor space as they will be placed under the work surfaces. The cabinets will have five drawers each, totaling to 15 drawers for the two build stands.

3.0 DESIGN METHODOLOGY

After gathering and interpreting the raw data from the customer, the team was able to move forward with the preliminary design phase. In order to determine the most feasible option based on specific criteria, a selection matrix was used. The main concern initially was the placement of the two required build stands, taking into account the additional space after expansion of the VECTRA area. Each criterion was given a weighted percent based on importance and each option was given a rating for each criterion. In the end, weighted scores were calculated and the best option was determined. This process was also done for the build stand orientation, crane type, and crane location. Each selection matrix and their result can be seen in the Appendices section.

3.1 Layout Concepts

The layout options that were explored for the VECTRA room had many different variables. As one can see from the selection matrix, the team had to first choose a location for the build stand. Once the location of the build stand was selected, the team then had to choose the orientation of the build stand. The choices made for these two selections were focused on providing the most workable floor configuration that allowed for layout space as well as creating safe working conditions for the workers.

The next choice to make was which type of crane to use, how many to use, and where to place them. These choices had selection criteria that were focused heavily on safety and cost while at the same time providing the workers with enough lifting capacity. A challenge for this selection was the fact that there were two existing cranes, one of which does not have the capacity needed. The final decision on cranes provided one of the lower cost solutions but more importantly provided the safest working crane configuration.

After selection of the cranes and build stand, all locations of major pieces of equipment were fixed. The remainder of the design process entailed determining the type and quantity of storage required. These items were placed in the room, taking into consideration size and frequency of use. A 3D model was used to verify the dimension of all of the elements designed. The model was also used to provide detailed drawings for use with the prospective contractors as well as for in-house D-R use.

Fig. 2. VECTRA Area Expansion Design

3.2 Oven Removal

In order to expand the VECTRA room one bay in the West direction, a large oven would need to be moved. D-R anticipated this happening and had long been looking for a replacement, but still needed justification and a decision to replace the existing oven or move it. The existing oven had approximately 400 cu. ft of capacity and was used to dry out desiccant bags used in shipping. With at least 15 years of use, the oven is inefficient, oversized, and a burden on employees to use. The team soon saw the need to replace the old oven with a new model.

Far more risk was associated with moving the old oven than replacing it. Economically, the oven replacement also looks impressive. An estimated simple payback of 3 years is very reasonable.

3.3 Cart Design

The team was given a number of sub-projects that were addressed after the design of the VECTRA area expansion was complete. The sub-project that held the most importance was the design of a mobile device on which a compressor case can be mounted and moved within the plant, without the use of a crane. The cart also had to be used in the hydro area of the plant for rotating the casing to the vertical position. The team began by researching and gathering any data and requirements necessary from the engineers at D-R. Next, concepts were brainstormed based on each of the individual aspects of the design. With these concepts in mind, the team moved forward with a three-dimensional design using Pro/ENGINEER. This design was then submitted to the engineers at D-R and feedback was given.

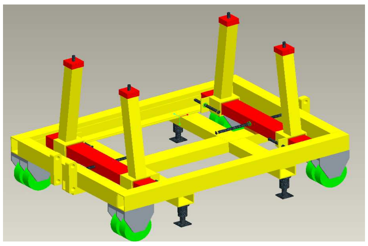

Fig. 3. Final Compressor Cart Design

A second sub-project was addressed pertaining to the lack of suspension on one of the current VECTRA carts. After benchmarking and research was performed, the team was able to submit a solution to D-R. The current VECTRA rotor transport cart uses simple casters. The current suspension system does not absorb vibrations or impacts as the cart is toted around. This results in a risk for potential damage to the VECTRA rotors as it is transported from Plant 1 to the VECTRA assembly room in Plant 2. To rectify this situation, casters with built in spring-like suspension will replace the existing casters. The VECTRA assembly cart currently employs this type of caster. The replacement is manufactured by R.T. Laird, Inc of Plymouth, Michigan. For the VECTRA rotor cart, the R.T. Laird, Inc caster, 38-3 Series Steel will be the replacement.

3.4 Crane Selection

Cranes are necessary for production of the VECTRA unit. A double pick is required once during each production cycle. This does not include moving and assembling any parts or assemblies. The current crane setup in the VECTRA room is as follows: (1) five ton free standing jib crane and (1) two ton mast style jib crane. This is sufficient for access to one work station and one WIP area. Upgrading to two work stations and WIPs will require additional cranes.

Four types of cranes were looked at for service in the expanded room; gantry, free standing jib, mast style jib, and wall mounted jib. A matrix was created to make a decision on the best crane for the application at hand. The biggest limitation for this particular application is lack of external support for the mast style and wall mounted jib cranes. The existing columns are not strong enough to carry the required load safely. It was also critical to keep the disruption of manufacturing processes to a minimum. It was important to consider any and all work and cost associated with crane installation. For example, installation of a wall mounted jib crane would require strengthening of the columns.

The results of the matrix are very clear; a free standing jib crane should be used whenever possible. This style excelled in ease of installation and disruption of current process. A mast style jib crane would be the next best choice.

4.0 FEASIBILITY & DESIGN VERIFICATION

Due to the fact that D-R will be implementing the recommended layout changes months after leaving, the team will be unable to test the final design against the current layout. The most effective way to test to see if the new layout is better than the last is to compare the engineering specs that are important to D-R, which include: recordable injuries, near miss incidents, VECTRA production time, economic payback, unit setup time delay, non ergonomic movements, and usable work surface. In order to determine if the new layout is more effective and efficient than the old layout, the specifications that were collected for the area twenty weeks ago should be compared to the specifications that will be gathered when the new layout is complete.

The goal of the team is to have no recordable injuries or near misses with the new layout design. A major emphasis from D-R was to cut down on the time the turbines actually spend in the VECTRA area, which right now is at least four weeks. This time is described as production time. The goal was to decrease the amount of weeks spent in the VECTRA area to no more than three. With the extra build stand and the improved accessibility, the production time will most certainly decrease by a significant amount. Next, the team focused on reducing the set up time. Currently, the set up time is roughly five days and the goal with the new layout is to reduce that to two days. As far as the ergonomics of the new layout, after the room is complete it will be easy to see if there are less ergonomically incorrect or harmful movements.

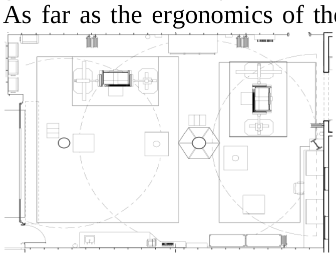

Fig. 4. Overhead View of Expansion

Due to the changes made to the room it is almost certain the amount of non ergonomic movements will decrease. After gathering the data on the new area in the manner described above and comparing the new data with the data that was collected on the old room, the numbers should show the success or failure of the new layout.

5.0 IMPLEMENTATION OF DESIGN CHANGES

The team initially planned a cutover plan to include the construction and transition of the VECTRA room from one build stand to a fully functional expanded VECTRA room consisting of two build stands within the time frame of Senior Design II. Unfortunately due to budget constraints, changes in management, and asbestos concerns under the oven that was removed, the project was set back by a couple months. Although the team will not directly monitor the progress of the VECTRA room, the cutover plan created will help management at D-R to manage the transition to the new design layout.

According to the cutover plan, the oven removal process including the containment and removal of asbestos would be taken care of in the month of February. At the same time, all the long lead time items could be ordered to start construction on time.

Management sent requests for withdrawal of funds for this expansion project and expects the funds to be released by the end of March.

6.0 TESTING OF FINAL DESIGN

By implementing a 6S plan for D-R, from a layout and process perspective, the quality of the work and the efficiency at which it is done will increase drastically. 6S is a lean concept that not only large companies like D-R can utilize but can be implemented into the everyday life of each worker.

By accomplishing the first S, “sort”, D-R took their first step in the direction of a lean environment. A red tag event was completed and all part utilizations were analyzed. A guide manual has been created to lay out the next steps for D-R in the 6S journey. This guide book describes how D-R will need to review the analysis of the tool utilization and decide which tools stay in the room/area and which tools need to be removed from the room/area due to underutilization. After D-R personnel complete the “sort” step, they will move onto the “straighten” aspect of the activity. This is where the workers give all parts and tools specific locations where they will always be. Some go to the extreme of taping an outline of where each tool should be so you know when that tools is there and when it is in use. An audit system will have to be set up in order to ensure that tools are where they are supposed to be. After all tools are allocated to their specific locations, a “shine” activity needs to take place where everything in the room is cleaned and set in order; the way it should look everyday from that point on. After the room is set in order, they will need to "standardize" the areas in the room. The process itself that the workers are doing everyday cannot be standardized due to the nature of the work that is being done. After all items are standardized, the team has developed an auditing system that will allow D-R to audit the room for compliance every day. This step is called "sustain". After "sustain" is the most important S of all, "safety".

The following are examples of questions D-R personnel will be asking themselves: Are appropriate controls in place to identify safety equipment? Is all safety equipment unobstructed and accessible? Do we need to implement a safety board where all safety issues can be addressed?

7.0 CONCLUSIONS & RECOMMENDATIONS

Based on the results from the team's analysis, conclusions have been drawn for many of the design parameters. Through the use of many decision matrices and other decision making strategies, the team has produced a thorough final design for each of the deliverables to D-R. The major deliverables to D-R include the development of the VECTRA expansion and the design of the compressor casing cart. Minor projects include the justification to remove the oven and the suspension design for the VECTRA rotor cart.

Looking back, a few minor mistakes were made which resulted in additional work down the road. One specific example of this was the build stand location and orientation. The first approach was to try to set up a selection matrix and assign value to various criteria. Analysis resulted in a selection of using the Southeast and Northeast quadrants of the room for build stands. If the operators of the VECTRA room were included in the discussion before making this decision, it would have been learned that there would be insufficient space to walk between the build stands. This came about during the design review with D-R, and resulted in the team having to go through the analysis again to change the selection criteria.

Another small mistake made was the decision to develop the VECTRA expansion without proper consideration for the 990 area. When the team first arrived to work at D-R, it was interpreted that expanding the current VECTRA room rather than building a new facility in the 990 area was the best option. Rather than take full consideration of the 990 area, the team overlooked many advantages of moving to the 990 area. Some of this was due to misconceptions of the customer needs, such as budget and the importance of minimizing manufacturing downtime. Other advantages were overlooked because initial thoughts were that moving to the 990 was not the better solution. Once the VECTRA room expansion was fully developed, the team started to realize many of the advantages of moving to the 990 area. Some examples of this include not requiring a load bearing wall (less cost) and far more space for future expansion. After finding out that the proposed cost for expanding the VECTRA room exceeded the available budget, the team took a step back and looked at the development of the 990 area. The team quickly learned to confirm a specific budget in order to prevent any further delays. Since very low importance was put on the cost difference between the two projects, the team failed to properly evaluate in depth which would be more cost effective and to what extent. Overall, the project was a success. Although mistakes were made by the group, the only repercussions involved additional work for the team.

Because so many small projects were proposed, the team had to select projects to work on that could be best completed and would give the most benefit to the customer. This is why some small projects, such as designing the pumping cart and redesigning the bundle cradle, were not completed and more effort was placed on higher priority projects such as the design of the compressor casing cart.

8.0 FUTURE WORK

First and foremost, it must be assumed that the ideas and designs completed will be carried out after the departure of the RIT team.

After construction is complete, both lean concepts and 6S must be put in place and followed to improve production within the VECTRA area and any processes associated with it. Lean manufacturing involves continuous improvement, eliminating waste, as well as utilizing tools and techniques to maintain an efficient and safe work environment. Furthermore, a 6S plan has only been recommended and will take the efforts of a future team as well as D-R management and personnel to ensure that the plan is enacted and followed. Visual controls must be implemented both inside and outside the VECTRA room.

It has been determined that there will most likely be a need for more than two build stands to work on and assemble the VECTRA Power Turbine. The team began analyzing a move to the current 990 area where more space is available for this. If a move to the 990 area becomes a priority down the road, development and construction of this may be handled by a future MSD team.

In addition, the compressor cart that the team has designed must be built and tested to verify performance and robustness.

A modification to the current drill press table may also be considered to eliminate transportation of the VECTRA frame to and from different plants. Also, the current oil pumping system used in the VECTRA room may be redesigned such that it may be more easily transported or even placed in a permanent location.

After discussion with engineers and management from D-R, customer needs were prioritized and a few items did not fit in the scope of the project. These items can be focused on by future MSD groups. These include but are not limited to developing a more robust means to transport rotors and internal assemblies to/from Plant 2, developing an adjustable bundle cradle support that can be used during laser concentricity verification, as well as an adjustable bundle cradle for insertion/removal of the bundle into/out of the case.

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