MECH-4860

FACULTY OF MECHANICAL ENGINEERING

HyLife Conveyor Design Report

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Executive Summary

HyLife is Canada's largest pork processing company. They utilize many conveyor mechanisms and systems to transport pork product inside cartons at their facility in Neepawa, MB.

This Conveyor Design report details a solution to HyLife's conveyor line needs. HyLife's current issue consists of too many cartons flowing through the conveyor lines resulting in bottle necks at strapping and labelling machines. An overflow line is the current solution to this problem. While this overflow line accounts for the high volume of product flow, it creates a new issue where it fails to redistribute products onto their respective conveyor lines.

Our objective is to create a solution that eliminates the bottlenecks while maintaining the correct final location for each carton by reworking the current conveyor lane layout.

The proposed design in this report retrofits the overflow line to be able to redistribute products onto their respective lines. This design includes two linear pneumatic diverters, one angled diverter, two merging lanes, and 118 feet of linear conveyor lines. The total cost of this design is \$286 200. The total number of cartons that this design processes on average is 100 cartons per minute. This solution was chosen based on parameters such as efficiency, cost, size, and risk.

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1 Introduction

Hylife is one of the worlds largest suppliers of pork product, the Neepawa location processes an average of 600 hogs per hour when operating to ship around the world. This results in average of 33 000 cartons every day[1]. The cut floor is where all the hogs are processed and cut down into individual pieces and packaged for shipping. Before any carton can be palleted and prepared for shipping, each carton needs to be strapped, weighed, and labeled. Strapping is done at one of five strapping machines. Weighing and labelling is done right after the strapping operation at one of five Organizational Change Management (OCM) machines Hylife uses. Figure 1 shows an image of one of the strapping machines in use.

[redacted]

Figure 1: Box strapping machine[1].

Each strapping machine is able to strap a carton in just under three seconds[1]. After cartons are strapped, they continue on their path to be weighed and labelled. Then they are put on pallets and finally shipped out around the world. Shown in Figure 2 are each of the lanes and the names they have been given. This is how the lanes will be referred to throughout the report.

Figure 2: Naming conventions for the conveyor lanes[2].

From Figure 2 the far left red lane is the MZ2 lane, the middle left yellow lane is the MZ1 lane, the middle right light blue lane is the PZ2 lane, the far right blue lane is the PZ1 lane, and the overflow lane shown in purple. Product flows in the direction of the red arrows above, being split onto each line and ending in the MZ/PZ areas. Each lane is limited by the strapping and labeling machine which can process up to 20 cartons per minute.

1.1 Problem Statement

Currently, Hylife is experiencing troubles with bottle necking in the main four lanes, MZ1, MZ2, PZ1, and PZ2 as the strapping machines are unable to keep up with the peak demands of incoming cartons that need to be strapped, weighed and labeled. The current solution to this problem is making use of fifth strapping machine in the overflow lane. This allows the lanes to no longer experience bottlenecks. This introduces new problems as now the cartons do not reach the correct lane to be placed on pallets.

Figure 3: Conveyor belt lanes with the over flow lane highlighted[2].

As shown above in Figure 3 the overflow lane sends all cartons to lane MZ2 and requires employees to manually walk cartons to the correct palleting area.

Our given design space is shown in Figure 4 below. This is an area of $6800ft^2$ with a length of 134ft and a width of 50ft [1].

Figure 4: Design space highlighted in yellow[2].

2 Requirements and Constraints

This section will present the constraints of the problem first. The needs and specifications will follow. Finally the deliverables that will be provided to our client will end the section.

2.1 Constraints

The project at hand although open to lots of possibilities comes with a few constraints and limitations that must be met for the success of the project. These constraints include:

1. Budget
2. Installation Time
3. Space
4. Staff
5. Food Safety

The budget requirement for this project was specified by Hylife and a dollar value of $300 000 was given to complete the project.

Although no direct time limit to implement the design was given, Hylife has made it clear that the cut line cannot be closed for any reason in the set up for any new design. This means implementation must be done on the off hours of the facility.

As shown previously in Figure 4, the space constraint for this project is an area of 6800 square feet. Anything larger than this will result in overcrowding of other areas of the cut line.

The idea behind this whole project is to improve productivity and eliminate the bottle necking that occurs in the conveyor lines, so adding more staff would defeat the purpose of the improvement.

Food Safety is taken seriously at Hylife and any contaminated product must be dealt with properly. This means that if any contaminants get introduced in any of the new concepts the design will not work as the products will be ruined. Because all products will be in boxes by the time they reach the strapping and labeling stations food safety can be accomplished by ensuring that no damage to the cartons occurs.

2.2 Needs and Specifications

Below are the needs and specifications that the design must meet. These are ranked in order of importance.

2.2.1 Design Improves Production

2.2.1.1 Cartons are delivered on correct conveyor line

Designs must have a carton flow where each carton travels corresponding to it's desired destination

2.2.1.2 Products flows without bottlenecking

No more than 20 cartons/min may flow through any given OCM machine

2.2.2 Design fits in specified area

Design fits within an area of $6800ft^2$ with length of 134ft-6inches and a width of 50ft-6inches. Strapping machines require 36inches on either side for maintenance

2.2.3 Design Implementation Prevents Production Delay

2.2.3.1 Machinery is easy to operate

Training on new design can be done within three hours

2.2.3.2 Machinery installation is expedient

Installation can be done withing a 48 hour period

2.2.4 Design is Safe

2.2.4.1 Safe for packaging

Conveyors operate less than 1.64ft/s

2.2.4.2 Safe for food

Contact surfaces are made out of stainless steel

2.2.5 Design works for all current packages

Width of conveyor line belts are a minimum of 1ft-8inches

2.3 Deliverables

The goal for this project is to find a solution to the problem laid out in the introduction and create a design that will achieve these objectives. This design will include

- 2D AutoCAD model
- Cost Estimate/Bill of Materials (BOM)
- Design component selection reasoning
- Risk Analysis assessment

3 Final Design

After going through a concept development phase, the design chosen was a design that uses new components on the current conveyor lane equipment. The design works by allowing cartons from any conveyor line to make use of the overflow lane and then sorting them back to the correct final destination. This solves the problem of lanes bottle necking by using the fifth lane any time it is needed. The design also solves the issue of cartons ending up in the wrong final destination by making use of diverters to merge cartons back with their correct final lane. By incorporating the overflow lane properly, 20 more cartons can be processed every minute which is more than enough to tackle the current issues. Figure 5 highlights all the new components needed to implement the design and how they would be set up on the cut line floor.

Figure 5: New components highlighted in blue as they would be implemented.[2].

The new components include two linear pneumatic diverters, one angled diverter, two merging stations and 118 linear feet of conveyor line. Each lane can now make use of the overflow line while also having the cartons sent to the correct destination.

The new MZ2 lane can be seen in Figure 6 and makes use of the overflow lane by using the first diverter allowing cartons to then be merged with the rest of the MZ2 cartons before reaching the MZ2 palleting area.

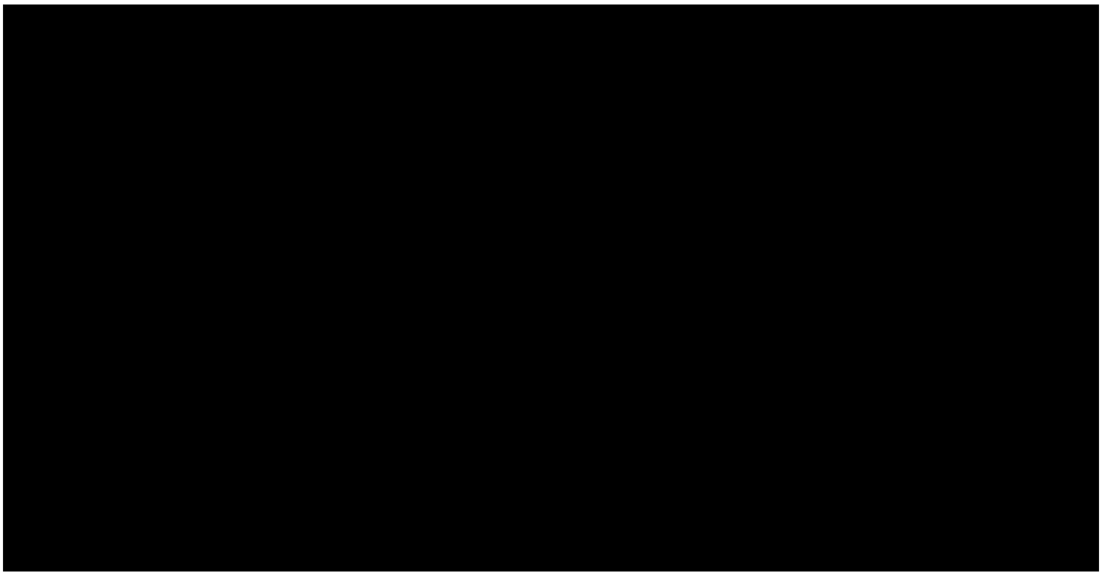

Figure 6: PZ2 lane shown along with the overflow lane.[2].

MZ1 can now make use of the overflow lane in similar fashion to how the original layout was used, however the cartons flowing through the overflow lane now require being diverted by the angled diverter to return to the correct path. The layout can be seen in Figure 7.

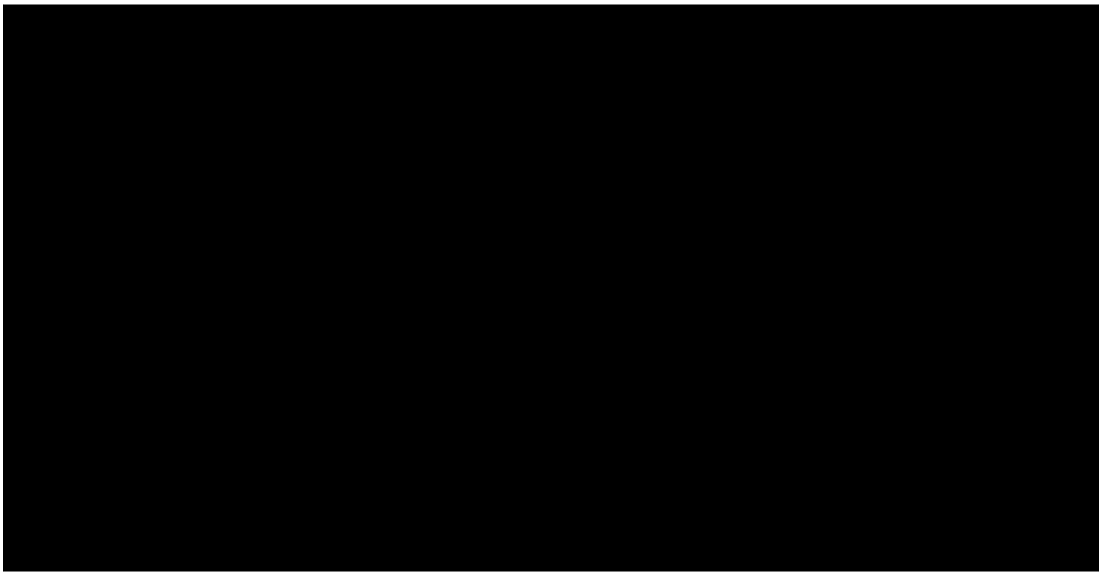

Figure 7: PZ1 lane working alongside the overflow lane highlighted in magenta.[2].

Cartons that belong on the PZ2 lane can now make use of the overflow lane by following the same route as the MZ1 overflow cartons before finally being diverted back to the correct PZ2 palleting lane by the second linear pneumatic diverter. The new PZ2 lane is shown highlighted below in Figure 8

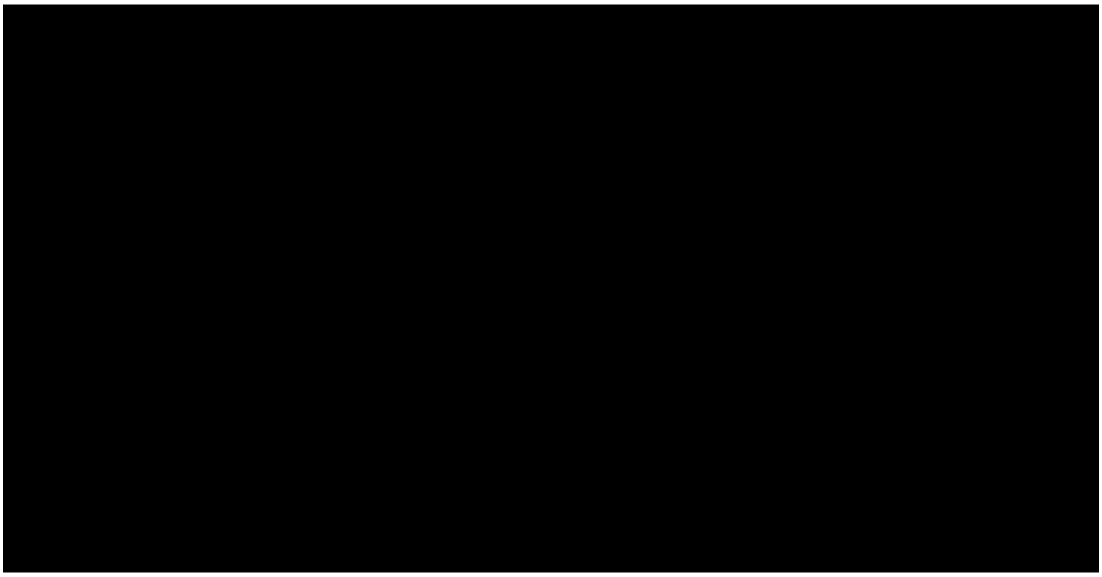

Figure 8: MZ2 lane shown with the overflow lane shown in green.[2].

Finally the PZ1 lane will have any overflow cartons sent back to the correct palleting lane by avoiding both the first linear pneumatic diverter and the angled diverter and continuing on the path to be merged with the rest of the packages on the PZ1 lane as shown in Figure 9. The overflow conveyor remerges with the PZ1 lane by traveling over both the PZ2 and MZ1 lanes before returning to ground level to be merged. Conveyor belts are able to increase or decrease in height as long as they increase and decrease at an angle of 30 degrees or less.

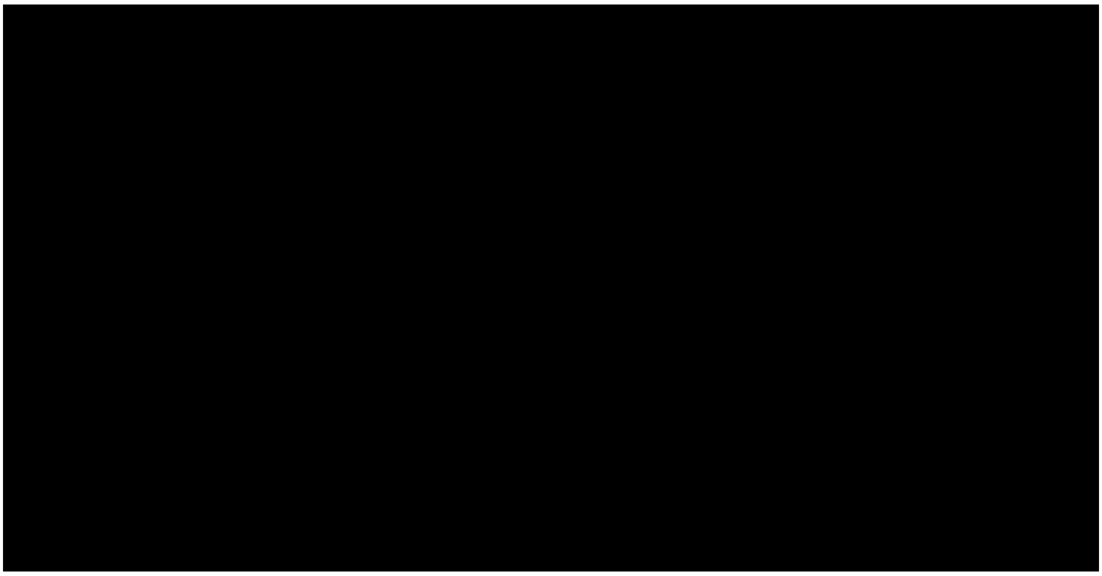

Figure 9: MZ1 lane highlighted in yellow along with the overflow lane.[2]

3.1 Merging Station

The merging lane is a piece of equipment that allows two conveyor lanes to come together as one while preventing cartons from colliding into one another. This is accomplished by having one of the two lanes stop if two cartons are going to collide. HyLife currently makes use of a merging lane between the overflow lane and the MZ1 lane. Figure 10 highlights the merging station currently in use on their cut line conveyor system.

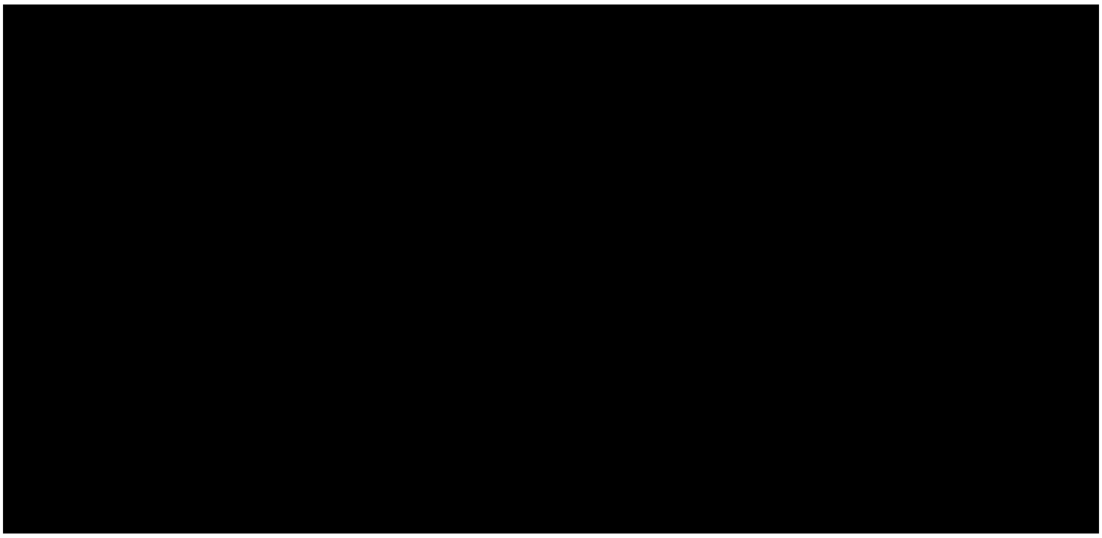

Figure 10: Highlighted in yellow is a merging station in the current layout.

Our design would implement two more of these merging stations to allow for smooth transitions between the overflow lane and the MZ2 and PZ1 lanes. The two new merging stations are shown in Figure 11 below.

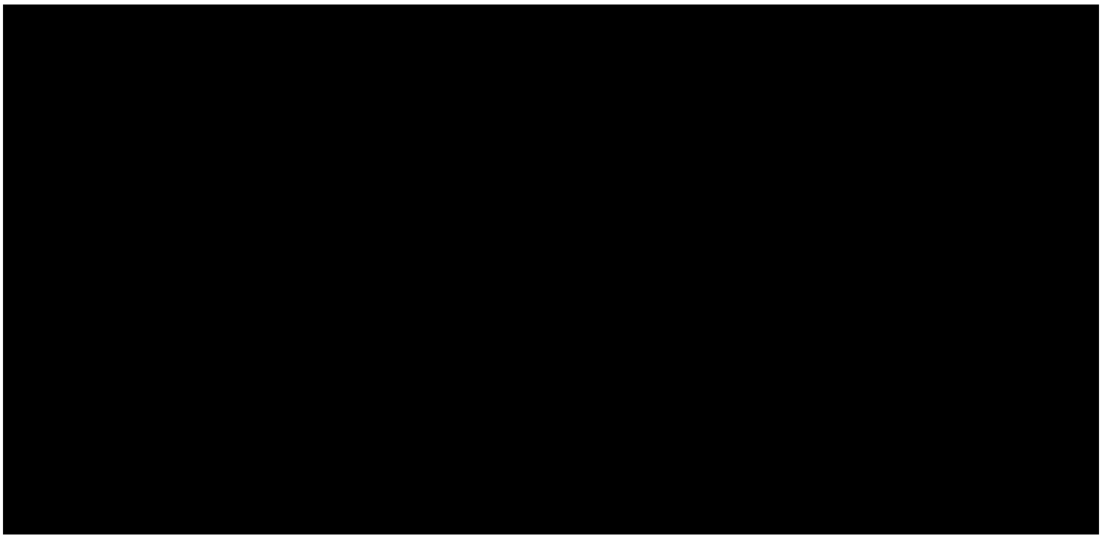

Figure 11: Highlighted in yellow is our proposal of the merging stations.

3.2 Linear Pneumatic Diverter

A Linear Pneumatic Diverter is a device that redirects cartons through the use of compressed gas that moves a retractable push bar. Shown below in Figure 12 is the location where the Linear Pneumatic Diverter is used.

[redacted]

Figure 12: Linear diverter location

These linear diverters change the the direction of an incoming carton by 90° via a retractable push bar as shown in Figure 13 below.

[redacted]

Figure 13: Linear pneumatic diverter schematic. [3]

This device works by retrieving data regarding product information that is acquired by the OCM machine right before the diverter. The diverter uses this data to determine whether or not to push the carton down the take-away conveyor.

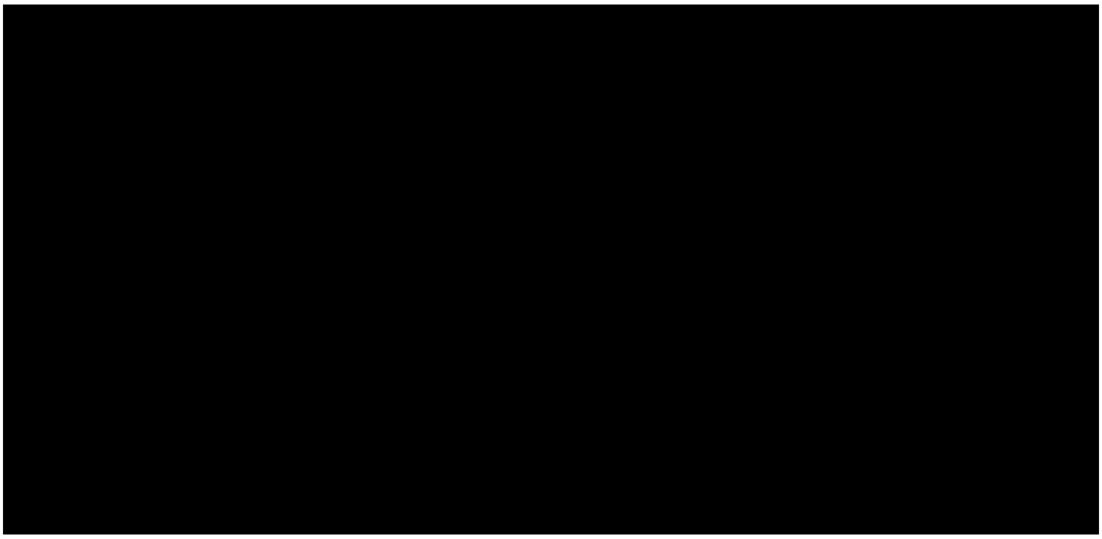

Figure 14: HYTROL HIGH SPEED PUSHER [4]

To accomplish this task the HYTROL HIGH SPEED PUSHER shown in Figure 14 was chosen. This is because it can push cartons up to 75lbs at a rate of up to 45 cartons/min. This greatly exceeds the weight and speed of incoming boxes. (See Appendix A for product specifications)

3.3 Angled Diverter

Another type of diverter is needed in the design to allow for a limited space transition from one lane to another. That is where the angled diverter is used for the overflow lane shown below in Figure 15.

Figure 15: Angled sorter. [5]

The linear diverters work well to move cartons from one lane to another, but the packages then lose their orientation. This is fine for areas where there is ample space to allow for the cartons to be rotated back to the original orientation however, when there is not enough room to rearrange the carton, a new solution is needed. That is where the pivoting belt sorter fits in, as seen in Figure 15 the cartons need to be able to leave the overflow lane at 45-degree angle to continue to the correct final line.

To accomplish this task the 796 SORT BELT PIVOTING BELT SORTER was chosen shown in Figure 16 below.

Figure 16: 796 SORT BELT DIVERTER with 45 degree rollers. [5]

This device works by using solenoid air controls to change the direction of the diverting wheels between neutral and 45 degrees. A carton flowing through this device would first cross over the staging diverter which adjusts the cartons to the right side of the conveyor, then the next set of diverters move the carton to the correct lane to continue its journey to be palleted.

Figure 17: 796 SORT BELT DIVERTER with product flow description.

This device solves the problem of carton orientation by turning the carton while it is being diverted over the rollers. For the proposed new layout of the cut line conveyor system the 796 SORT BELT PIVOTING BELT SORTER is a good fit as it meets all required conveyor line specifications highlighted in Table 1 below.

Specification	Required	Actual
Package Width	1'8"	1'8"
Conveyor Speed	1.64 fps	5 fps
Diverter Speed	25 per minute	75 per minute

Table 1: DIVERTER SPECIFICATIONS COMPARED TO ACTUAL PERFORMANCE

With the required specifications met to achieve the needed speeds and sizes of the conveyors belts and diverters, the 796 SORT BELT PIVOTING BELT SORTER was selected to be used for the angled sorting.

3.4 Cost

Below in Table 2 is the cost breakdown for the proposed design [4][5]

Component	Cost	Quantity
Linear Conveyor	$1500/ft	118
Linear Diverter	$1600	2
Angled Diverter	$4000	1
Merging Lane	$51 000	2
Total Cost		**$286 200**

Table 2: COST BREAKDOWN OF PROPOSED DESIGN

This cost assessment is based on price estimates for current mechanisms given by HyLife as well as quoted price estimates from vendors in the industry. The total cost of the design is $286,200 which is low than the given budget of $300,000. Therefore, the design satisfies the budget constraint.

3.5 Size

The size requirements for the project were given as the area highlighted in Figure 18 which equates to approximately 6800 square feet.

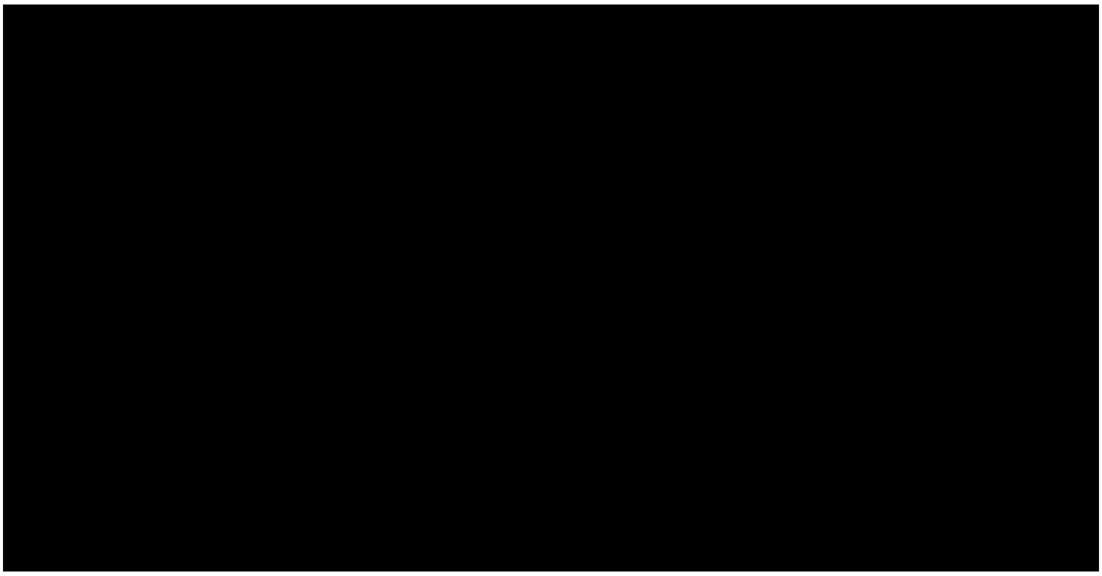

Figure 18: Design space highlighted in blue

Although the area is for the new design to be implemented, it is better to consider the space in terms of loss of packaging space. This packaging space is the area for forklifts to move around and lay down pallets for placing the product on. The lost pallet space was found by measuring the total pallet area and then measuring how much of that space was lost with the new design. Figure 19 shows the new design with the design space highlighted in blue.

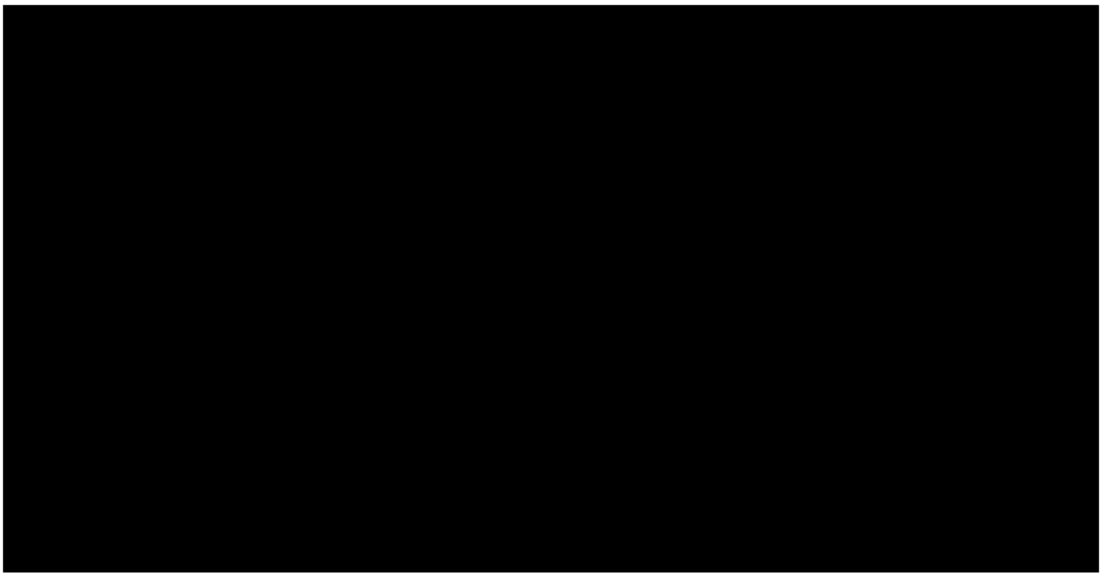

Figure 19: Design space highlighted in blue

The new design creates a packaging space loss of roughly 11% and fits well withing the required area as seen above in Figure 19. While this may seem like a substantial loss, the new design eliminates the need for manual transportation of products from one line to another, resulting in less foot traffic and better packing area flow. The lost space is also currently only used for storage pallets meaning the effective working area for the employees stays the same.

3.6 Efficiency

The main goal of the conveyor lane project is to improve the efficiency of the cut line by removing bottle necks experienced at the strapping and labeling machines.

The strapping and labeling machines can process an average of 20 cartons per minute [appendix C], this means at peak loads some lanes currently receive more than 20 cartons creating an overflow of cartons. The new conveyor lane layout tackles this issue by allowing up to 40 cartons per minute at peak load time for any given lane if no other lanes are overloaded. By doubling any given lanes carton capacity bottle necks are no longer an issue resolving the problem. However, when considering multiple conveyor lanes over flowing at the same time the over all capacity is 25 cartons per minute as the overflow lane now needs to pick up the slack for all four lanes. This is found by dividing 20 cartons per minute across each of the four lanes.

Regardless of multiple lanes are bottle necking at the same time 25 cartons per minute is more than enough to resolve current bottle necks that are experienced on the cut floor conveyor lanes.

3.7 Failure Mode and Effects Analysis

Introducing new systems into the current conveyor line setup up at Hylife comes with many risks. With health and safety and conveyor line efficiency being of the utmost importance, any change needs to ensure all needs and requirements are met without creating any new unforeseen problems. To make sure risks are minimized, an individual risk of failure analysis is completed for each piece of new equipment. The new equipment added includes:

- 2 linear pneumatic diverters
- 1 angled diverter
- Ground level conveyor line
- Raised conveyor line

With the new equipment, risks include:

- Employee safety
- Carton damage
- Stoppage in conveyor line
- Machine maintenance
- Equipment malfunction

With the risks of the new layout decided a risk matrix based on likelihood of occurrence and severity of risk was applied to each of the new pieces of equipment. Any piece of equipment that falls into the high or extreme risk category will be further looked at to ensure the system is safe to use.

Figure 20: Risk severity given its rank. [6]

The risk rating as seen in Figure 20 shows the combination of severity and likelihood to determine the risk level. Based on the table, a probability of 1 would mean the error may occur once a year and a probability of 5 would mean the failure may occur once a month. The severity depends on what the risk anything involving employee safety would be a 5 and package damage may vary depending on amount of damage. The risk level is calculated by multiplying the severity with the likelihood to get the final risk value.

Table 3: LINEAR PNEUMATIC DIVERTER RISK ANALYSIS

	Severity	**Likelihood**	**Rating**
Employee Safety	5	2	10
Carton Damage	4	2	8
Stoppage in Conveyor Line	3	1	3
Machine Maintenance	1	5	5
Equipment Malfunction	5	1	5

Table 4: ANGLED DIVERTER RISK ANALYSIS

	Severity	Likelihood	Rating
Employee Safety	5	1	5
Carton Damage	1	1	1
Stoppage in Conveyor Line	3	1	3
Machine Maintenance	1	5	5
Equipment Malfunction	5	1	5

Diverters are the two new pieces of equipment that are being added to the conveyor lane layout that are currently not in use anywhere on the cut line. Because of this, they carry the most risk in likelihood of a problem occurring. This is why the ratings are highest for these two products.

Table 5: MERGING LANE RISK ANALYSIS

	Severity	Likelihood	Rating
Employee Safety	5	1	5
Carton Damage	1	1	1
Stoppage in Conveyor Line	3	1	3
Machine Maintenance	1	5	5
Equipment Malfunction	1	1	1

Table 6: LINEAR CONVEYOR RISK ANALYSIS

	Severity	Likelihood	Rating
Employee Safety	5	1	5
Carton Damage	3	1	3
Stoppage in Conveyor Line	2	1	2
Machine Maintenance	1	3	3
Equipment Malfunction	4	1	4

Linear conveyor belts are used throughout the cut line at Hylife and are not likely to create any problems besides when scheduled maintenance needs to be done. As for severity, moving machines always create risk to people as loose clothing could potentially get caught. Equipment malfunctions would create stoppage in the conveyor line and both this is a huge concern as product needs to flow smoothly.

From the risk tables the only two items that need further investigation are the diverters for the risk of injury with the employees as well carton damage. These are high-risk items because any time new equipment is introduced with moving parts there is a chance that employees who have not seen or been properly trained around the new equipment could hurt themselves. The risk of injury can be reduced by ensuring only employees who know how to work safely with the equipment are allowed to interact with the new machines. In the case of the new diverter arms, no employees should ever be in the path of the diverter arm however it is still important that the staff understands the risks involved with the new equipment. As for carton damage, testing on cartons before implementing the device will allow for fine tuning so the pneumatic arm does not apply too much force. Therefore, it was decided that the risk of injury to the employees was low enough that they could be used for the design.

4 Conclusion

The proposed design is a retrofit modification to the current overflow conveyor line. The design consists of four modifications: Linear Pneumatic Diverters, Angled Diverter, Merge Lanes, and Linear Conveyor. These additions allow for the redistribution of product onto their respective conveyor lines during peak loading.

Currently, during peak loading, cartons gets redirected down the overflow line and thus, ending up at the wrong destination. With this new design, using sorting and merging techniques, the products are redirected to their desired end location. This satisfies the main need of the project where products need to arrive at the correct destination. The overall design costs a total of $286 200, this falls below the budgetary constraint of $300 000. The design offers the necessary spacing between strapping equipment in order to be maintained and operated. The additional conveyor lines use HyLife's standard machinery which is compliant with the carton sizing. Packaging area is minimally impeded on by the new proposed layout.

With the main objectives of the project being met by the potential implementation of this new design, it is believed that this is the most effective solution while conserving space, money, and complexity.

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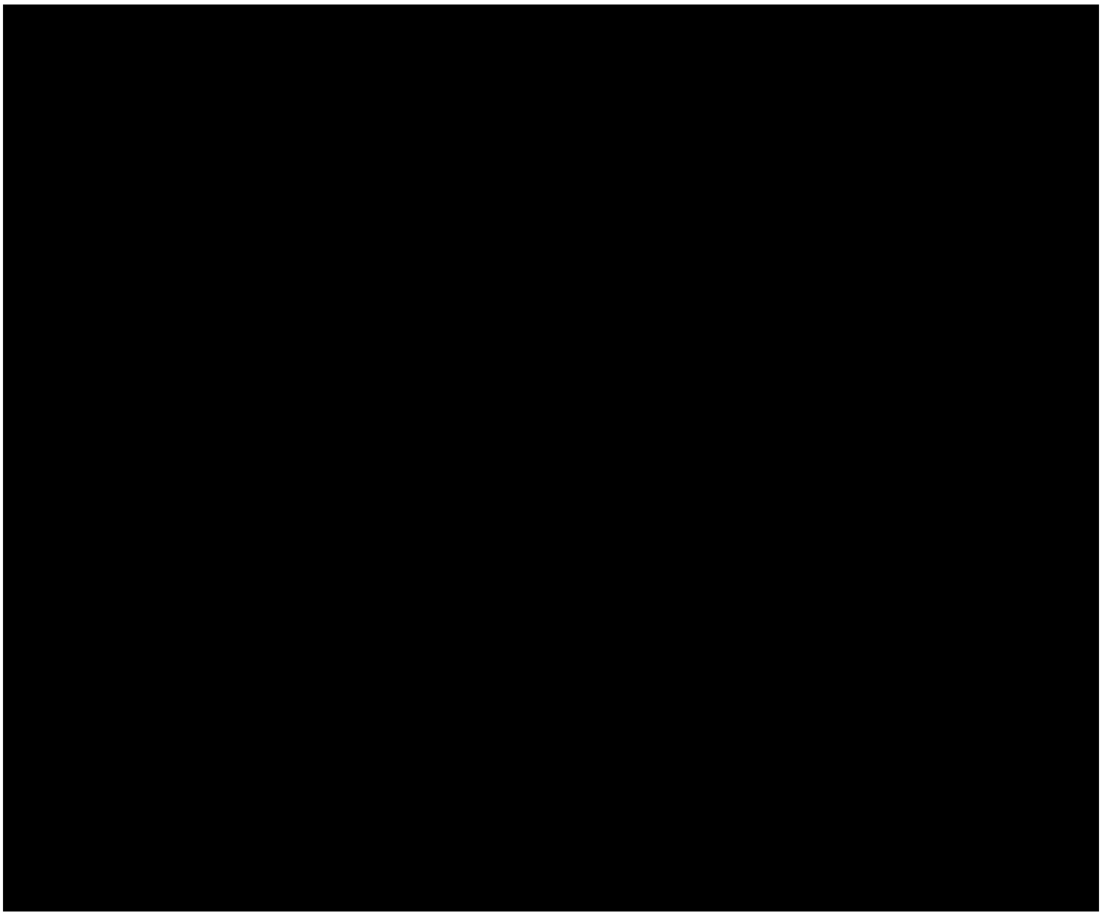
Appendix

A)



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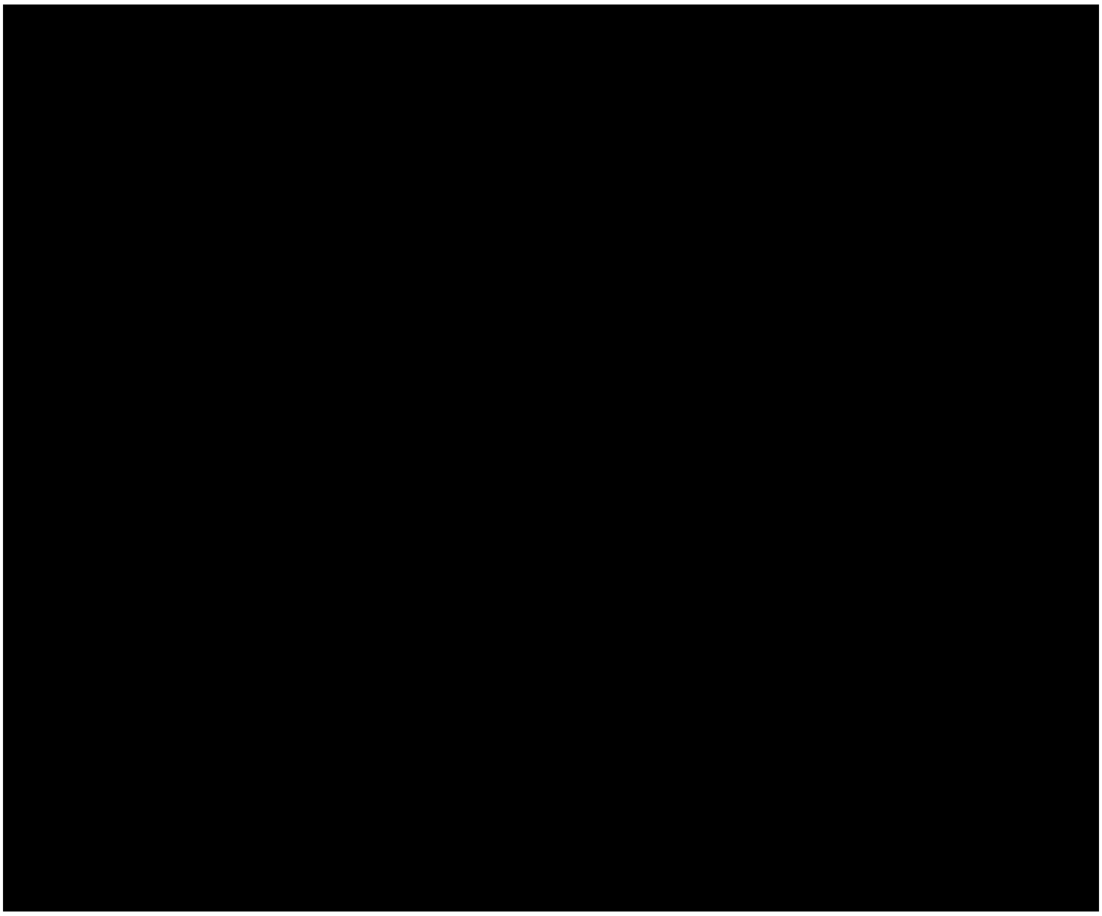

C)

OCM data showing number of cartons through each of the Lanes 4 current lanes

[redacted]