

Operators Manual for Pig Ear Sorting System



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Introduction

Currently Scott Pet Products' processing plant located in Tishomingo, OK is the final destination for 20% of the nations pig ears. The pig ears are shipped as a byproduct from pork harvesting facilities around the U.S. The ears are shipped frozen in ice blocks and then sent through a water bath on site in Tishomingo to thaw. Once the ears have been extracted from the ice they are then sent to cutting and trimming, where some of the ears are cut into halves while others are left whole. Ears then proceed to flavoring where they are allowed to soak up flavoring, and then they are then sent to the ovens for drying.

The ears are transported to packaging in a large square container, (or a Gaylord as the Scott Pet Product Staff calls them), approximately four feet on a side. Containers are placed in a device and lifted in such a way that the ears simply fall out of the containers into a chute where they are counted by hand and placed on a small conveyer. At the end of the conveyer, another person is holding a bag in order to catch the product. The bag is then handed to another person to be placed in the sealing machine. The number of half and whole ears counted for each bag is based on the specifications of the customer for which the ears are packaged.

The packaging line for this product currently consists of four large container dumpers, two conveyer belts, a sealing device, and seven employees. The purpose of this project is to minimize the amount of manpower necessary to operate this production line as well as maximize the production rate and efficiency of the packaging process.

Statement of Work

The focus of IBS with regards to this project will be the development of a separation device for the pig ears that will count and accurately meter the ears so they may be bagged. This device will not only require less people to operate than the current system, but will also have a higher capacity and be more accurate than the current system.

The development of this system will require IBS to formulate, refine, and test different ideas and concepts on how the separation and counting process can be accomplished. Once a concept or combination of concepts is agreed upon, the system will be constructed, tested and further modified for optimum performance. The final design will be a working model that can be implemented directly into the Scott Pet Products' processing line. To meet these requirements, the final system will have to be rugged, reliable, and easy to operate.

Along with the construction of the model IBS, will present to Scott Pet Products a progress report on the project on Dec. 4, 2003. IBS will also be responsible for delivering an operations manual, part sketches and diagrams, and any other pertinent information with the working model upon delivery. A final presentation will be made to Scott's Pet Products in May of 2004.

Requirements and Specifications

This system will be designed to singulate, count, and separate dried pig ears. The requirements are to produce at least 800 bags of 25 pig ears per bag of varying amounts

of whole and half pig ears per hour. The machine is required to be HACCP compliant. The machine should replace 4 of the current employees, and in the future will be able to accept an automatic bagger. The machine may not be taller than 12 feet due to lack of ceiling height. Due to foot and fork lift traffic, the machine can be no longer than 20 feet to prevent intrusion into the walking space. The machine will be able to use the current system for holding the Gaylord so that it can be filled with the current equipment. The machine must provide accurate counting for at least 99 bags out of 100, and have a minimal initial cost.

The design of a pig ear sorter has never been achieved in a manner that may be used in high production rates. The concepts that IBS have generated involve many different ideas on how to singulate, sort, and meter the non-flowing, non-uniform pig ears. The process for counting the ears will likely use multiple concepts integrated together to accomplish our goals. The first issue that IBS is concerned with is how the ears react when they are placed in the storage Gaylord and then allowed to slide down the black dumping chutes. There is little to no uniformity in the shape of the ears. Many times the ends and corners of the ears are curved. This allows for many of the ears to hook and intertwine together. The first step to packing the ears is getting the ears oriented in such a way that they may be distinguished from one another. Following separation the ears can easily be counted. Finally the pig ears need to be metered. They need to be allocated into equal amounts that can quickly be bagged. The system needs to be capable of accepting user input to specify the number of half and whole ears to be placed in each bag.

Research

Since this project is to build a one of a kind machine, IBS must be conscientious of patent infringement. After searching the United States Patent Office web site for singulation, singulation/conveyers, and singulation/air-jet, IBS determined there was limited information that would pertain to pig ear processing. The patents deal with actual machine fabrication. Since IBS plans to purchase different pieces of equipment from conveyers to photo arrays, the existing patents will not be infringed. Also, the singulation, counting, and separation of pig ears is not a large industry so very few of the companies that process pig ears will sponsor a project to do research that will be published in journals. IBS views beef jerky to be the closest product that would react to singulation and separation in a fashion similar to pig ears. However, there was no literature found dealing with the handling and packaging aspect of beef jerky. The food industry is extremely private on its layout of machines and processes. With this in mind, if IBS was to accidentally replicate the layout or design of another company's it would clearly be unintentional.

Design Concepts

There are, as mentioned before, three main tasks that this system will have to accomplish. They are: singulation, counting, and metering. The design concepts can be broken down into three groups; one concept dealing with each of the major tasks.

Singulation

The singulation of the pig ears is basically a way of making the counting process simple. This has been the main focus of IBS since we obtained to project. If the pig ears are conveyed by a counter with separation between each ear, then a basic electronic eye will easily count the pig ears.

The first concept that IBS generated to singulate the ears is using two conveyors in series. The first conveyor is set up to run at a speed much slower than the second conveyor. This speed difference provides a shearing effect when the ears reach the second conveyor. They are pulled away so fast that a separation forms between the ears, but they are not in any order. This concept will have to be one of the first processes after the ears are removed from the chutes of the lifting system. The conveyor belts will have to be made of material with enough frictional forces such that the ears will travel consistently and not slip.

The second concept builds on the two conveyor system, but instead of having a height difference there will be an “air curtain” between the conveyors. This air curtain, consists of a high velocity, high volume nozzles powered by 60 psi compressed air. There is a small gap between the fast conveyor and the slow conveyor, just enough to allow a strong blast of air from below to lift the ears and then allow them to fall down while still having forward momentum. The lifting of the ears allows separation to take place by not allowing the ears to be stacked one on another. This method requires constant pneumatic pressure.

The next separation concept comes from the general idea of an “air hockey table.” This idea involves the construction of a metal table with small orifices that allow air to

pass and then having a high air volume fan mounted on the underside in order to push air through the orifices. The table would be declined at an angle between the slow conveyor and the fast conveyor. It will fluidize the stream of ears off of the slow conveyor, and allow gravity to pull them down towards the high speed conveyor. The high speed conveyor would peel the ears off of the table two or three at a time, thus allowing the handling of the ears to be simplified. Once the ears come out of the chutes there will be a cleaned conveyor carrying the ears upward and then dumping them onto the air table and then to the second conveyor. Using a control system the number of ears on the table at any give time can be controlled by the size and speed of the conveyor that feeds it. This requires a high-speed fan which in turn will produce some noise, but could be significantly effective in separating the product.

Counting

The ears are not always counted and packaged by the same quantity. For example, there might be 20 whole ears and 5 halves in one package, but the next set of packages might have 16 wholes and 9 halves. The change in mixture is determined by the customer order being produced; however it is not known how often the mixture change occurs. The possibility of these situations requires the use of a programmer of some sort, which will be mentioned later, that allows the operator to select the quantity. The next few concepts are devised to count the ears and also to provide some sort of diverging of the sporadic placement of the ears from the separating techniques mentioned above.

The first idea IBS generated to control and count the ears is to use a lane system that would straddle the conveyor. The lanes would cause the ears to diverge first into two lanes and then to multiple other lanes. The idea is basic but effective in moving the ears

into two single file lanes from the random placement of the separator. The basic configuration consists of a V-shaped object in the middle of the conveyor that forces the ears to go on one side or the other creating two lines of ears. Once the ears have been formed into these two lanes there will be a swing arm that will use the friction of the belt and the forward movement to divert the ears into four lanes. The first line will split off and form two lanes, as will the second line. These four holding lanes will send ears to be bagged when so prompted by the operator. Once emptied the system begins to sort the ears once again. The lanes are 8" wide in order to accommodate the large ears and to prevent the ears from piling up. Shown below in Figure 1 is a prototype for the two lane part of the system.

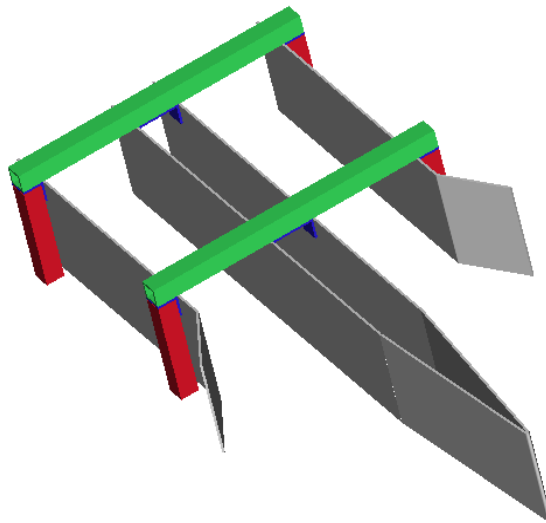


Figure 1: A computer aided sketch of the two lane separator that sets on top of the conveyors

The next concept for controlling the ears is much like the lane system, but instead of using conveyors to force the ears to diverge the driving force will be gravity. The idea is to use an inclined table with the lanes being permanently fixed to the table (Gravitron 3000). At the beginning the ears will be lifted via cleat conveyor and then dropped off at the top of the inclined table. The ears will slide down the table and the V-shaped

partitions will divide the ears much like the conveyor lanes. The number of lanes will start at two and then progress to four using a similar V-shaped partition. Using this system the need for conveyors is limited, and the cost is greatly reduced. The lanes will work in the same manner, but the control of the ears is dramatically reduced because they cannot be stopped when on the inclined table. This increases the chance for the ears to pile up thereby eliminating the usefulness of the separation process. A schematic of the table is shown below in Figure 2.

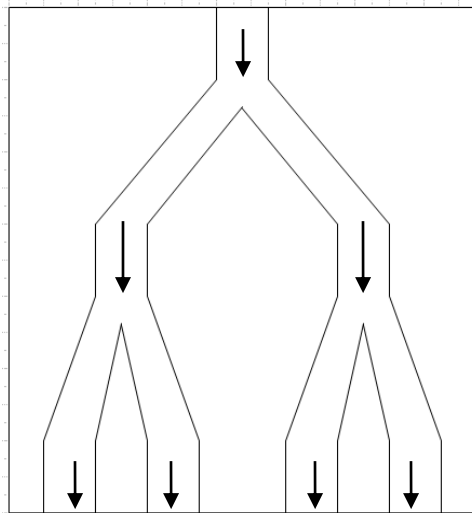


Figure 2: A Schematic view of the proposed gravity lane separator

The actual counting will be done by some sort of photo eye array; however the exact device to be used for this task has not yet been chosen. IBS currently has four basic electronic eyes that were part of the original prototype separator/counter that Scott's Pet Products provided. If these devices are not the specific hardware that will be implemented in the final design, then something very comparable to them will likely be used.

Metering

Currently it is difficult to choose what kinds of mechanisms will be used to meter pig ears after they have been separated and counted. This difficulty arises mainly from the dependence of this section on the rest of the system. Until a final separation and counting system has been decided on, this portion of the system will be very dynamic. Ideas for how the flow of the pig ears can be controlled in this last portion of the system are continually being generated.

Most of the current ideas that IBS has about metering the pig ears revolve around the use pneumatic arms and chutes. The chutes will be used to fill the bags with the pig ears after they have been counted out. Pneumatic arms can serve as a controlled way to divert the counted quantities of ears into the chutes or holding conveyors so they are ready to be sent to bags.

System Layout

While the final design will depend on the over all effectiveness of the system as it is further tested, IBS has a basic idea of how the pig ear counting system should be laid out. Currently plans are to place the pig ears into a large bin and use a cleated conveyor to move them into the system to be separated. The cleated conveyor will allow only a certain amount of pig ears to enter the system at a time, thereby making the singulation process much simpler. The ears will then be singulated by the use of elevated conveyors. The drop as well as the shearing effect of the second, faster moving conveyor has shown to be capable of separating the pig ears. The ears will then be moved into single file lines using the lane separators. At this point, with the ears singulated and in single file, the ears can easily be counted using an array of electronic eyes. With the ears counted they can

then be metered with pneumatic arms and doors. A picture of the proposed design can be seen in Figure 3. The ears will then be held in holding areas or chutes where they will be hand bagged. Two very similar systems will be developed; one system for both half and whole ears. The system for the half ears may not have to be as large as the system for the wholes since most customers require a lower volume of halves compared to wholes.

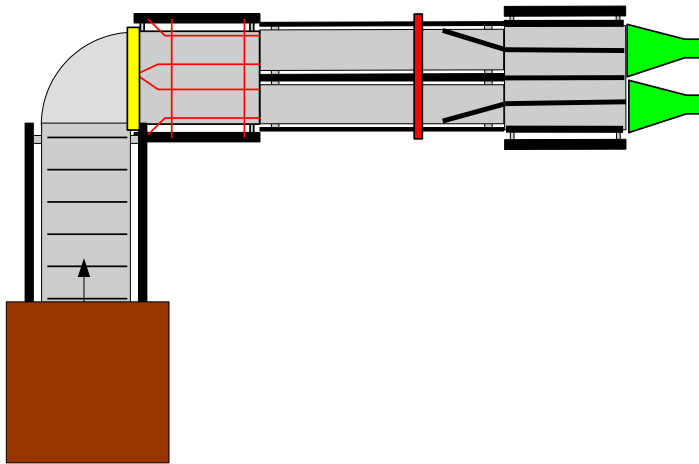


Figure 3: Initial layout proposal

This system will likely require two operators to continuously place bags underneath chutes or loading devices to receive the ears. However, this set up will eliminate the need for people to count out the ears. This lessens the amount of manpower required for production.

A PLC controller will be implemented to control the conveyor speeds, count the ears, provide a safety circuit and control any pneumatic arms or doors. A basic controller has already been selected for the cost estimate. This controller will have the ability to be upgraded in the event that an automatic bagger is to be installed.

A design change was proposed to eliminate the slide or curved conveyor. It was felt that with the slide the ears would tend to fall onto one side of the lane conveyor. This

would have only half the system under load while the other half is empty. The next design layout had the cleated conveyor place ears directly on to the lane conveyor. To add more separation an air blast is put at the exit of the cleated conveyor. To keep the ears from blowing off of the conveyor a shroud will be placed over the exit. The layout can be seen in Figure 4; after this modification the end of the system remains unchanged.

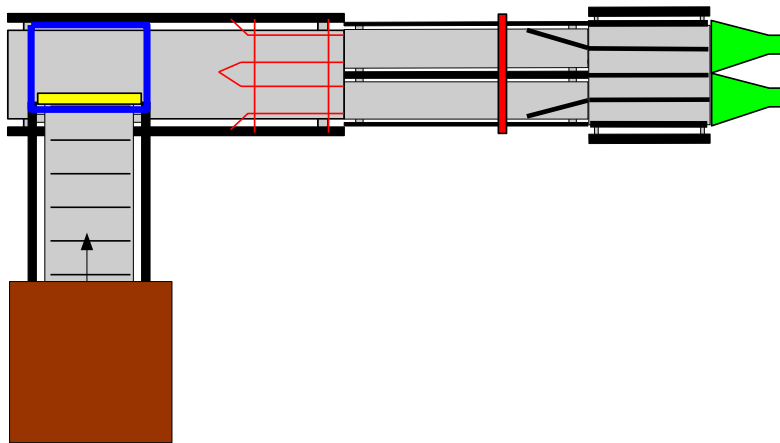


Figure 4: First revision of proposed design

The next design adds a transfer conveyor and eliminates the holding conveyor. The cleated conveyor will drop ears on a perpendicular transfer conveyor. The ears will be placed on the transfer conveyor in approximately, a single file fashion. The transfer conveyor will drop ears onto the perpendicular lane conveyor. Since the ears are mostly single file on the transfer conveyor, they will drop roughly one at a time onto the lane conveyor. This will allow a greater degree of separation than could have been achieved with a curved conveyor, and this solution will be considerably more cost effective than a curved conveyor. Also, eliminating the last conveyor from the design will make the system less expensive without effecting performance. The layout is shown in Figure 5.

With this setup, IBS feels that there will be enough separation between the ears to accurately count them with a basic photo eye sensor.

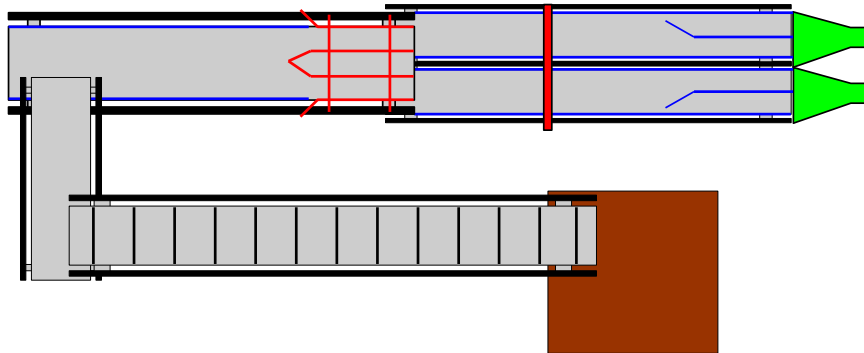


Figure 5: Elimination of holding conveyor and addition of transfer conveyor

After giving a demonstration to an executive at Scott's Pet Products he proposed using a vibratory table attached to a dumper to load the system. This addition severely eliminates the ability to control the inflow of product into the system. However, the vibratory table does an adequate job of separating the ears, and eliminates the need for a costly variable speed cleated conveyor. Figure 6 shows the final layout concept.

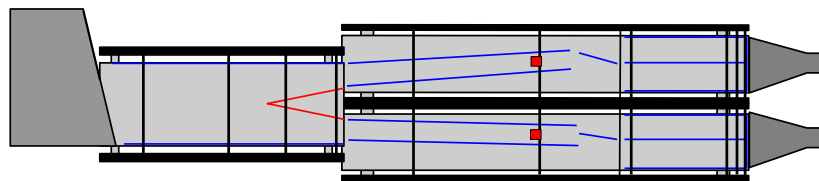


Figure 6: Final proposed design

The final revision to the proposed design will include the addition of a transfer conveyor that will be fed by the vibratory table; with the additional drop more separation can be obtained leading to the maximization of the system's efficiency.

Testing

In an attempt to define the average pig ear, IBS performed measurements on a sample of pig ears. Maximum diameter, minimum diameter, and mass were all measured for whole and halve pig ears. The sample of pig ears provided by Scott's Pet Products was taken from their top grade, retail production line. The results of these tests have determined minimum dimensions for some of the sorting equipment and designs for the separation and counting processes of the system. Results from these measurements are attached in *Appendix A*.

IBS conducted testing on the previously mentioned singulation concepts. To test these concepts, two conveyors in the Biosystems and Agricultural Engineering lab at Oklahoma State University were used. The first test conducted was on different speed conveyors. The ears were placed on a slow moving conveyor, feeding to a faster second conveyor. This provided some separation of the ears from one another. The lower the flow rates of ears and the higher the speed difference between the conveyors, the more effective this concept is at singulating the ears.

The second concept IBS tested was an elevation difference between two conveyors of different speeds. Dropping the ears from a slower conveyor onto a faster one, increases singulation efficiency. The falling impact causes the ears not catch and bind on one another while the fast moving conveyor pulls the ears away from each other. Figure 7 shows this concept being tested.



Figure 7: Different speed conveyors with an elevation difference

The third concept that was tested built on the two speed 24” conveyor system, but instead of having a height difference there was an “air curtain” between the conveyors (Figure 8). This air curtain, consisted of a high velocity, high volume nozzle powered by 60 psi compressed air. The small gap between the fast conveyor and the slow conveyor provided just enough room to allow a strong blast of air from below. This lifted the ears and allowed them to fall down while still having forward momentum. The lifting of the ears allowed separation to take place by not allowing the ears to be stacked one on another. During the testing of this concept, a single nozzle was fixed below the conveyors and aiming up and at a slight angle towards the fast conveyor. This method proved to have some success, but requires constant pneumatic pressure.

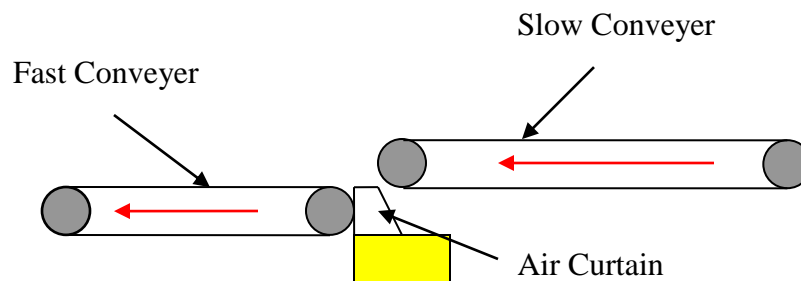


Figure 8: Air Curtain setup

The fourth test was to see how the ears reacted to being separated into lanes. By dividing the total flow, the amount of ears on a conveyer is decreased and easier to singulate. A lane system (Figure 1) was fabricated by IBS and was placed on the conveyer setup on the second conveyer. The second conveyer was the faster one in this test however no air-blast was used. The ears evenly divided themselves between the two lanes and continued down the conveyer. This test worked as expected and will most likely work into IBS's final design. Figures 9 and 10 show how the separator works.

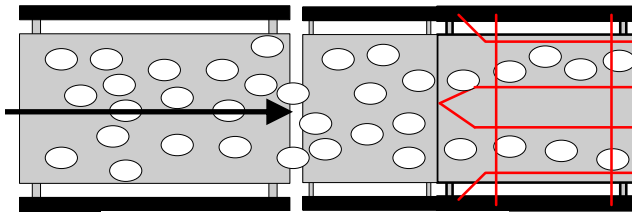


Figure 9: A representation of the Lane Separating Device



Figure 10: The actual Lane Separating Device

The final testing involved adding a trap door to the end of the lane separator. With this test the ability to stop the ears is examined and analyzed. To run the test a piece of metal is placed at the end of one lane and a group ears is sent down the lane. Once the ears hit the metal they piled up while the conveyer is still moved. The metal was held in place by a spring and after a good pile has accumulated the door is lifted and the ears whisk out of the lane. This test is done to show how we want the ears to react just before packaging. Figure 11 shows the trap door working.



Figure 11: Trap door on the Lane Separating Device

Testing of the new perpendicular oriented conveyors was one of the first tests conducted in the spring semester. Two conveyors were placed perpendicular to each other, and ears were passed from one conveyor to the next. As predicted, when the ears dropped on to the second conveyor, there was a large separation created. Essentially the ears went from zero velocity in the perpendicular direction to the velocity of the second belt in a fraction of a second. The test setup is shown in Figure 12. As shown in the results from the fall semester testing, an increase in velocity between belts is one of the most powerful separation tools that we have at our disposal.



Figure 12: Perpendicular conveyor test

The next test was to use the diverter arm that was constructed and a PLC that was acquired to test the ladder logic of the controller. Two photo eyes were taken from the old prototype and placed above the belt in front of the diverter arm. The program stated that once the eyes read the fifth input there would be a half second time delay then execute an output to ground the air manifold and reverse the airflow to divert the arm. With this setup another conveyor is needed to “accurately” simulate the system. So the ears were placed on the simulated transfer conveyor in a single file line. The test worked well provided there was plenty of separation between the ears. Figure 13 shows the diverter arm test setup.

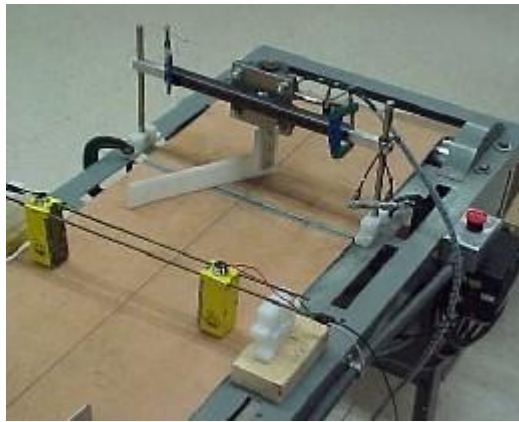


Figure 13: The diverter test setup

The next test had the same setup as the last one but the sensors were replaced with the distance sensor that will be used in the final design. This test was less successful than the previous test because the sensor is complex and getting the limits set correct so that they will see the ear and not the belt. Plus the spot the sensor sees is so small that the ears must be in perfect alignment to be read. To remedy this problem the far limit was set so that it would be reading the belt at all times and to trigger the sensor the near limit would be broken; a problem with this solution is that there is the possibility that if

someone were to stick something under the sensor at any height that it would send a reading to the controller and give a false reading.

The testing of the vibratory table proved to be the most arduous of all. There is no way to control how fast the ears come off of the table except to turn off some of the vibrating motors. The test setup had the table at the end of the lane conveyor; the table was loaded with approximately 100 ears and then turned on. The goal of this test is to see how well the table works at singulating the ears and making sure that they are not on top of one another. This test did not produce the types of results that were expected despite the best efforts the ears continued to stay on top of each other until the amount of ears left on the table was low. This test makes demonstrated the limiting factor in the overall design.

The final testing included an accuracy test of the system. A run of about 100 bags at 10 ears per bag was taken by just placing the ears on the lane conveyor; by doing this the variability of the vibratory table is eliminated. The ears were then counted to check the accuracy of the system. Unfortunately the test showed that the sensor is counting the front and back of the ears thus leading to a highly inaccurate count in the bags.

To investigate the problems with the sensing part of the system an oscilloscope was connected to the output of the sensor. With this setup ears were run under the sensor and the shape of the outputs observed. It was found that the ears would cause a 10-45ms false input before the main input of more than 100ms. This was causing the PLC to count the false input as an entire ear and increment the counter. To remedy this problem a filter program was added to the PLC and another screen added to the touch panel. In this screen an input minimum time is set; this will have the PLC disregard the 10-15ms inputs that the sensor sends.

To test the accuracy with the new filter the same test as before to gain some statistics of how accurate the sensor is. The filter was set at 55ms and then the test was run with 49 bags of 5 ears. The filter worked extremely well at eliminating the double counts on the ears. A problem did arise with the ears missing the sensor by being on the wrong side of the lane. This was solved by putting an extension on the end of the lane leading onto the counting conveyor. With this setup the 84% of the bags were correct while 4% were short. The 4% translates into 2 bags, and one of the short bags was due to the diverter arm timing.

Most of the testing conducted has shown promising results for the singulation of the pig ears. IBS will implement a combination of the elevated conveyors, lane separators, electronic eyes, and trap doors to singulate, count, and meter the pig ears.

Equipment

Diverter Arm

The first piece of equipment that was designed by IBS is the diverter arm. It consists of a paddle constructed of Ultra High Molecular Weight (UHMW) plastic. This plastic is commonly used in food processing plants as slides and walls because of its low friction with food. The paddle is attached to a rod that passes through two bearings. The bearings are on a plate that is welded to a piece of square tubing with a square bar in side. This bar will allow IBS to adjust the width of the diverter arm for different conveyor widths. The diverter arm is moved because of an air actuator that in one setting will have the air pressure on one side of the float and the other setting the air will reverse giving a two way power actuator. The actuator is connected to the rod in the top of the paddle.

Figure 14 shows the diverter arm.

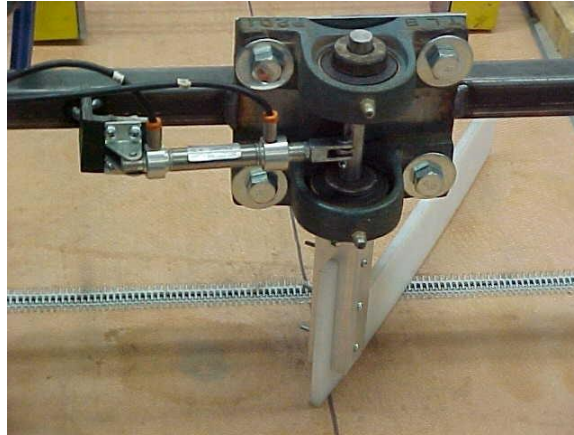


Figure 14: Diverter arm constriction

Lane System

The next piece of equipment that was designed by IBS is the lane trap door system. This consists of 4 lanes with the walls that are constructed from more UHMW plastic and 4 UHMW plastic doors. The lanes are 4 feet long and will be about 7 inches wide. The walls and trap door will be supported from ½” stainless steel rod that can be adjusted by cross blocks that will move up and down steel rod legs. The steel legs are placed in a block of UHMW plastic with a hole and a screw to secure the legs. Three rods will span the width of the two conveyors with a support in the middle. From the rod cross members above each wall there will be a connector that holds the wall in place. The doors will be attached to bearings that will provide a pivot point. To make the doors move and air cylinder will be placed so that it will be pushing in the top of the door to that the bottom will move and allow for the ears to be emptied. The bearings and the cylinders will all be held in place by more steel rod crossing both conveyors. Figure 15 shows the lane system design.

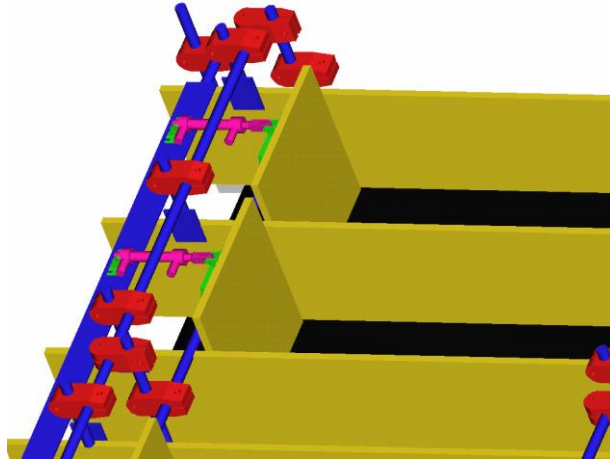


Figure 15: lane system drawing

Vibratory Table

Another piece of equipment that was used but not built by IBS is a vibratory table that will be used to load the system. The table is about 36 inches from ground to discharge. It is angled at the front with walls on each side to keep the ears on the table. It is run off 6 AC motors which magnetically move the semi floating bed that has rubber bushings attached to the bottom. The table is made of stainless steel. The table is 60 inches across so a wall across the front was built so that the discharge area is reduced to cover the conveyor. A 14'' opening is used because it will not overload the system but will give us the correct amount of ears that are singulated. The opening will be in the middle of the lane conveyor so that there is an even distribution of ears to be separated into both lanes.

Sensor

Counting the ears is a problem because of the irregular shape of the pig ears. For this reason a distance sensor (IDEC SA1D-LK4) will be used to count the ears. The distance sensor operates in the near infrared range and has lower and upper limit settings.

This sensor will be mounted above the conveyer looking down. As the ear passes underneath the sensor it will recognize the change in distances and send a signal to the PLC to count.

This sensor was chosen over the more traditional receiver emitter sensor to minimize counting errors. Sensors measuring horizontally across the belt may not read an ear that is abnormally flat or “double count” an ear that has a large curve with a valley that is below the sensor reading. Also, if a receiver emitter sensor setup were to be used to look down on to the ears, there would have to be a gap for the ears to pass across. This design would result in the addition of at least one more conveyer. This would greatly increase the cost of the design.

Unfortunately, as mentioned previously, this sensor also sends false counts to the PLC. However with the implementation of a filter in the PLC, this error has been minimized.

Another option for looking down on the belt is to measure contrast between the belt and the ear. The problem with this is the belt must be kept clean and since the ears are oily they will tend to leave a residue on the belt discoloring it and leading to inaccuracy counting.

Controller

The most integral piece of the system is the controller which takes all of the input and executes the ladder logic and performs operations as needed. The controller is a Siemens S7-200 controller starter pack with a touch screen. With the touch screen the operator will be able to input the number of ears that need to be counted before the diverter arm switches. This number can be anywhere from 5 to 25. The controller will

also open and close the trap doors at the end of the holding lanes. The doors will open 2 seconds after the diverter arm has moved and it will stay open for another 1½ seconds then close once that has occurred the lane is now ready to be loaded again.

Conveyors

The conveyors were purchased through Matrix Materials handling in Tulsa and they are Roach brand conveyors. They are fitted with DC motors with variable drives. The two ten foot long conveyors have one horsepower motors, and the six foot conveyor has a ½ Hp motor. The belt is a black PVC belt that is not food grade. The speeds of the conveyers in the system are all dependant on how fast the person bagging the ears can place a bag at the end of the lane, allow the bag to fill, give the bag to the sealer, and have another bag ready to fill. An estimate for this process is about 10 seconds. This limits the speed of the final speed to about 180 ft/min. The preceding conveyers will all be progressively slower. The complete specifications on all of the conveyors have been included with the Owners manual.

Final Product

Controller Logic

In *Appendix B* all of the programming and logic diagrams are shown.

Wiring Diagram

In *Appendix C* the diagrams for all of the control panel and other electrical sources is shown.

Project Schedule

The schedule for the project can be found in *Appendix D*. This will show how the days were spent and how long each task took.

Part Drawings

The drawings for all of the IBS designed parts are found in *Appendix E*.

Design Budget

Scott’s Pet Products supplied the majority of the money used in this project.

Table 1 shows the items that were purchased.

Table 1: Total Budget

Company	Description	Amount
Cope Plastics	UHMW Plastic	\$268.60
Fleck	Bearings	\$112.82
Allied	Electronics	\$1,334.08
Stillwater Steel	Stainless	\$48.40
Industrial Electronics	Electronics	\$1,689.33
Hughes	Screws	\$4.34
IBT	Cross Blocks	\$359.25
Hunzicker	Wiring components	\$332.63
Grainger	Misc.	\$72.71
Olinghouse Steel	Stainless	\$50.22
McMaster	Misc.	\$89.83
Trident	UHMW Plastic	\$199.00
Rockwell Automation	PLC Book	\$30.60
Hydroquip	pneumatics	\$31.35
	Total Credit	\$5,500.00
	Total Used	\$4,623.16
	Amount Left	\$876.84
Matrix	Conveyors	\$8,341.00
	Total Used	\$4,623.16
	Total Spent	\$12,964.16

Final Recommendations

Though the final product exceeded the expectations of many it was not as accurate as it could be. With the vibratory table being the height limiter two alternatives

can be made so that it will have better singulation. Figure 16 shows the layout that was tested but the vibratory table is placed perpendicular to the lane conveyor.

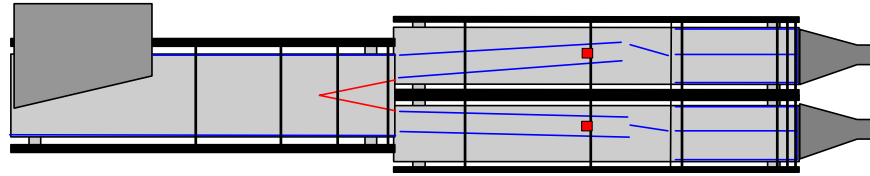


Figure 16: First recommendation to the final design

With this design the lane conveyor needs to be replaced with a longer conveyor so that the table can dump its whole width on the conveyor. The vibratory table will also have to be pulsed so that the ears dumped on the end of the conveyor clear the table opening before more ears come onto the table. Also a couple inch drop will need to be added to the counting conveyors to prevent the ears from being caught in the gap. This should not effect the bagging operation because the chutes are adjustable. This solution my work however it is still relying totally on the vibratory table to separate and not so much on the impact force. The next recommendation is to keep the cleated conveyor that was in the second to last layout concept. The second recommendation is shown in Figure 17.

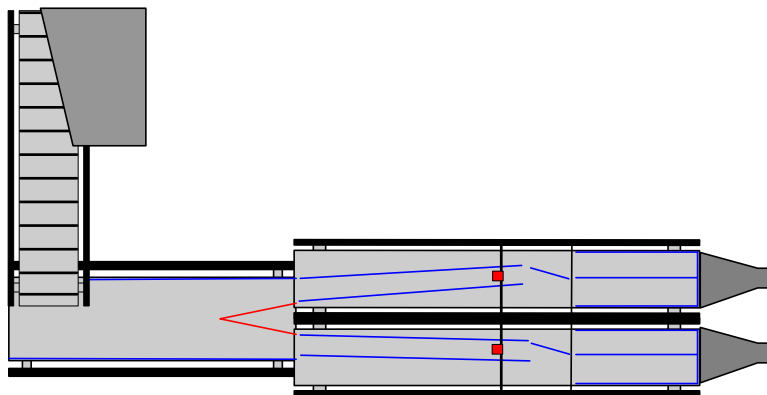


Figure 17: Second recommendation to the final design

This proposal will not only have the vibratory table to provide separation but the cleated conveyor will also have a drop to the lane conveyor. The table will also have to be

pulsed to prevent too many ears being on the cleated conveyor at once. The speed of the cleated conveyor is also variable and will allow for more height from the lane conveyor. This recommendation is the most promising of the two however cleated conveyors are more expensive than regular sliding bed conveyors. These additions will likely make the system perform at maximum speed with maximum accuracy.



Innovative Biological Solutions

Oklahoma State University

BAE 4022

April 29, 2004

Steven Fowler

Derek Storm

Travis Guy

Project Introduction



- Scott Pet Products
 - One of the nations leaders in the pet food and treat industry
 - Final destination of 20% of the nations pig ears
 - Would like to increase the production and efficiency of this product line
- IBS has been contacted to develop a system to sort, count, and meter pig ears



Project Introduction



- Pig ears
 - Favorite treat of many dogs
 - Thawed, baked, flavored
 - Some ears are cut in half
 - Counted, packaged, sealed, shipped



Project Introduction



➤ Packaging

- Ears sold by amount not weight
- Ears have to be counted
 - Currently counted by hand
- Ears stick together
 - Have to be separated to be counted



Customer Requirements



- Ears need to be sorted, counted, and metered
- 800 bags of 25 pieces per hour
- Economical
 - Minimize labor required
 - Maximize production capacity

Engineering Specifications



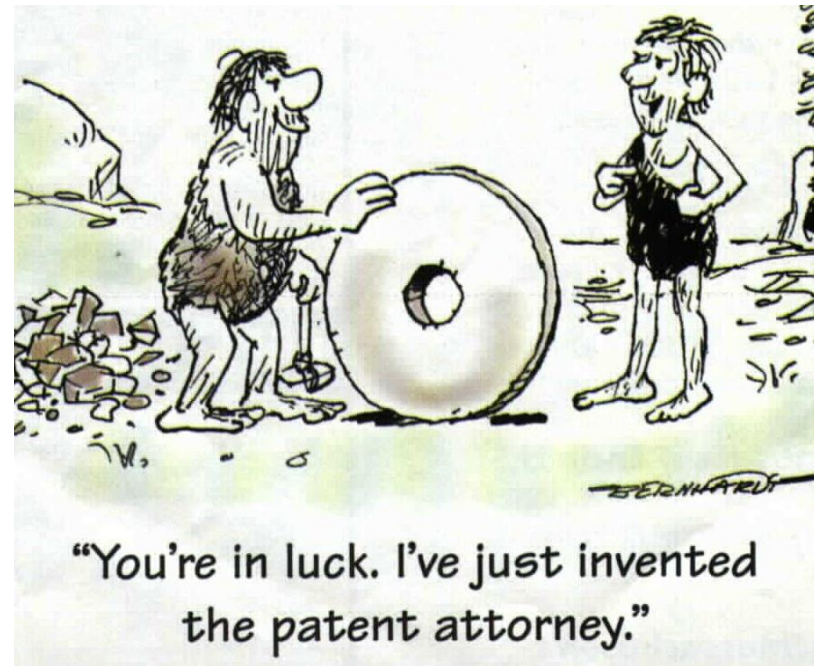
- Machine must not exceed 12 feet in height and no longer than 20 feet
- Machine needs to be accurate



Patent Research



- United States Patent Office search
 - Results applied to construction of equipment.
 - Process patents were not found
- We plan on buying different pieces and applying them towards our system



Process Research



- No research has been done on pig ear singulation, sorting, or metering
- The closest product that would react and have similar irregularities to pig ears is beef jerky
- All of the information needed to complete the project will come from our testing

Breaking Down The Problem *IBS*

- This problem can be broken down into three main objectives
 - Singulation and Separation
 - Counting
 - Metering



Design Approach



- Concept Generation
- Testing of concepts and ideas
- Selection of equipment

Separation Concepts



- “Air hockey” table
 - Fluidized bed
- Different speed conveyors
- Elevated conveyors
- Air curtain



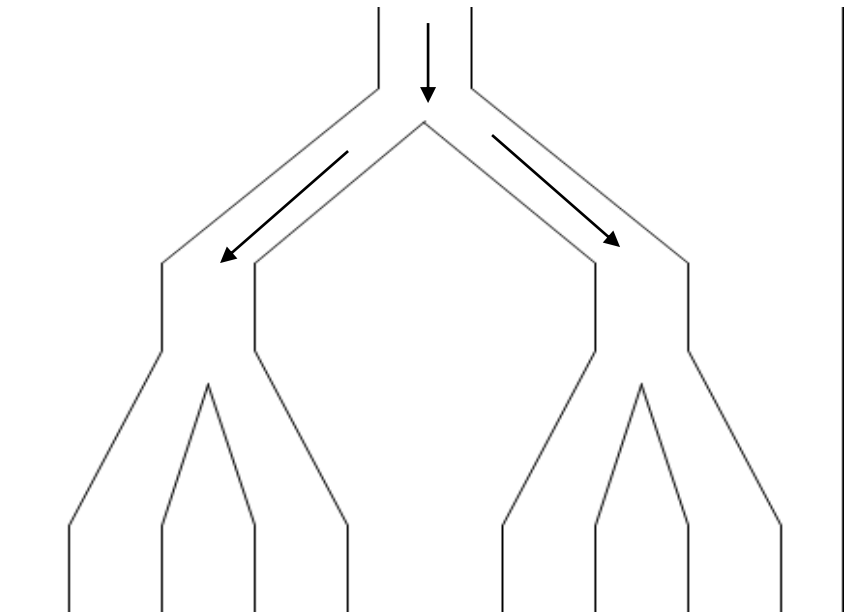
Counting Concepts



- Lane separator
 - two diverging lanes
- Electronic eye



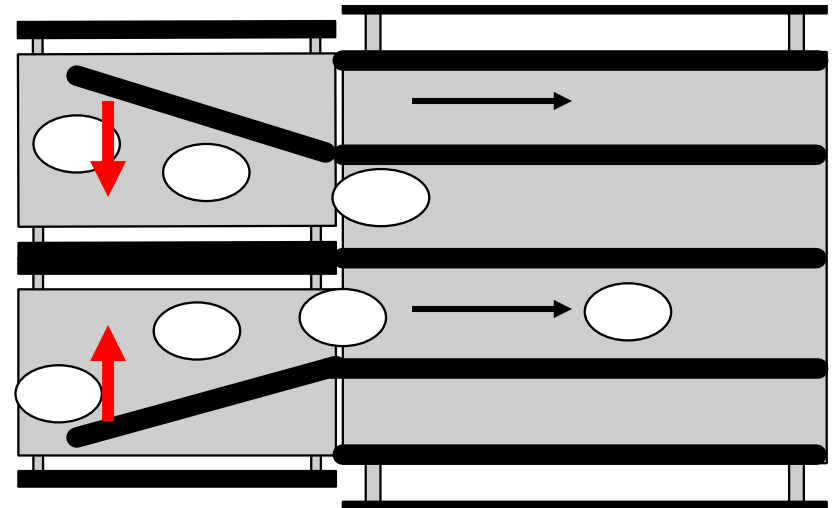
- Gravity separator
 - limited flow control



Metering Concepts



- Using a pneumatic diverter arm to divert two lanes of ears into four lanes
- Have a trap door to stop flow of ears, allowing the conveyor to continue to run



Ear Dimension Testing



- These ears were taken from retail bags.
- This data allows us to have a lane width for our design.

	Whole Ears (n=40)			Half Ears (n=10)		
	Weight (oz)	Length (in)	Width (in)	Weight (oz)	Length (in)	Width (in)
Max	2.09	7.50	5.00	1.20	7.00	4.50
Average	1.56	5.86	4.17	.90	5.09	3.80
Standard Deviation	0.32	0.91	0.61	.20	1.00	0.40

Conveyer Speed Test

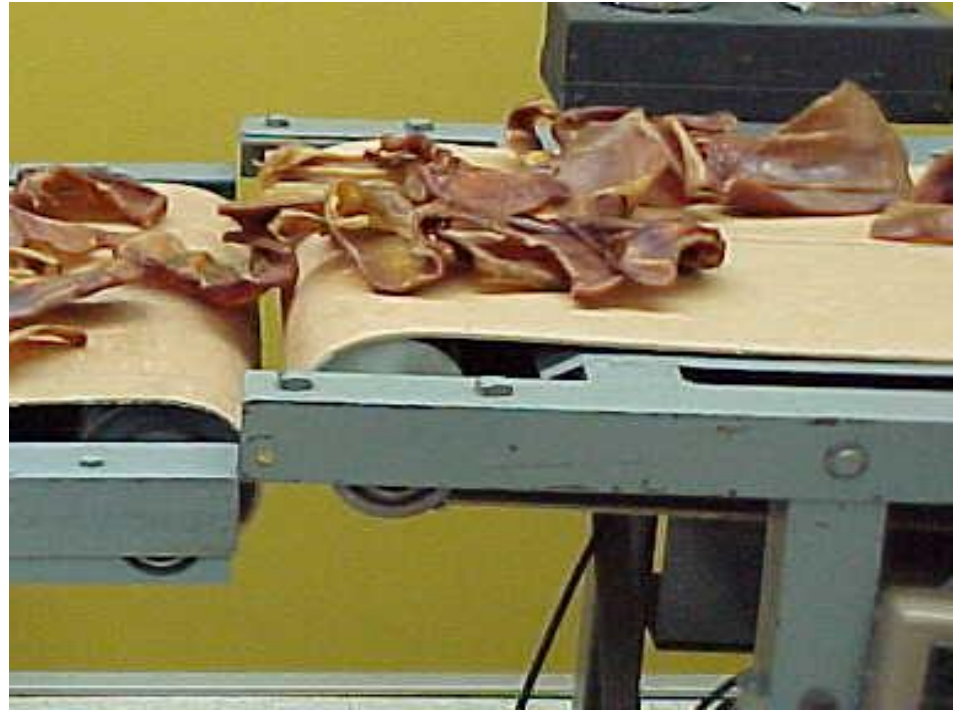


- Test is set up with two conveyers in series, with the first conveyer set at 3.3 ft/s and the second conveyer set at 6.6 ft/s
- Shearing force from the faster conveyer separates the ears
- The lower the mass flow rate and higher speed difference, allows for greater separation

Elevation Test



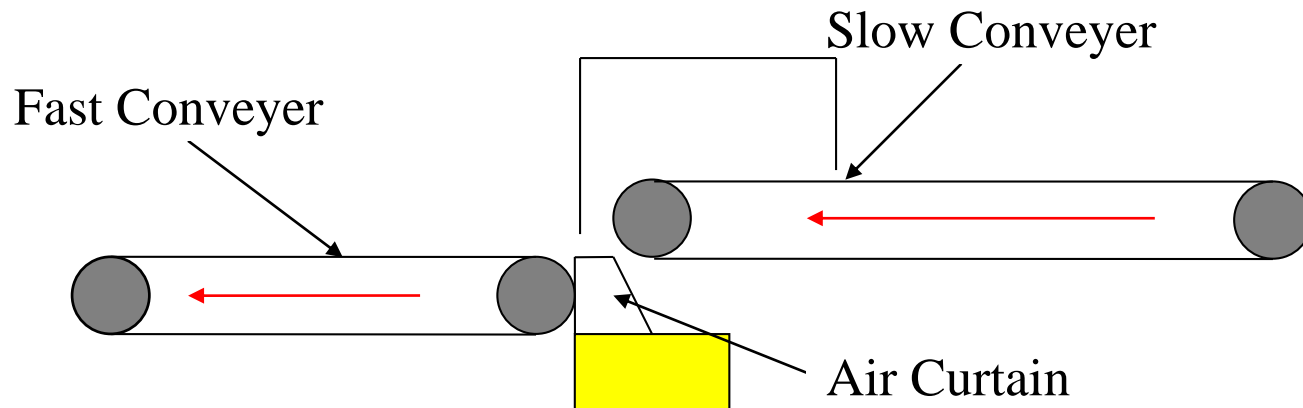
- Setup same as previous test except slower conveyer is elevated
- The height change creates an impact force to separate ears.



Air Curtain Test



- Setup the same as elevated test but at junction of conveyers a high velocity, high volume air nozzle was placed
- Limited results and drain on air compressor



Lane Test

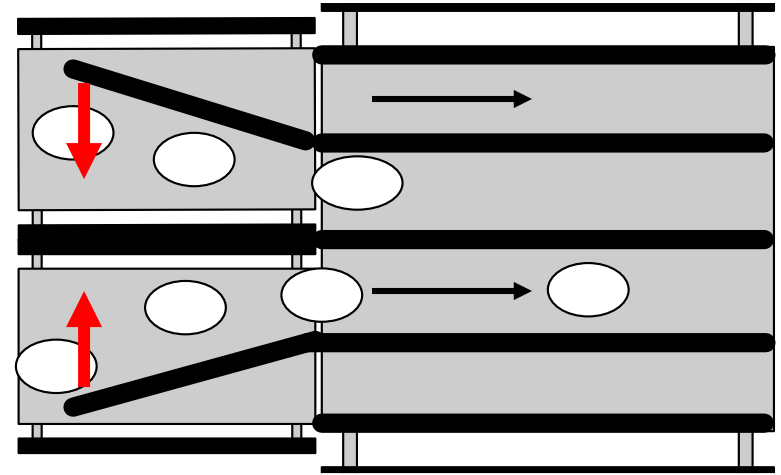


- Split the flow of ears
- Less ears for each sensor to count
- Easier singulation

Diverter Arm Test



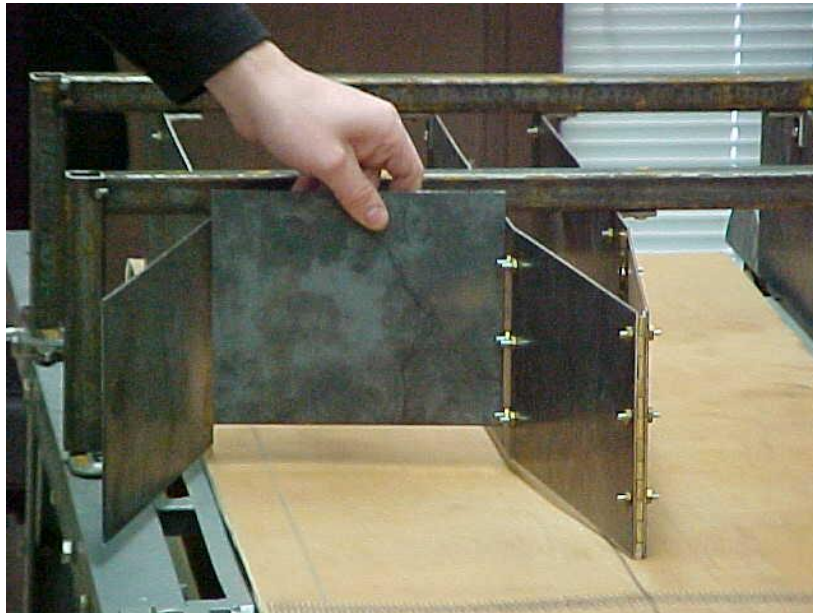
- Testing if ears could be forced into a certain lane
- At high belt speeds the ears would go into the desired place



Trap Door Test



- This test is to determine the feasibility of holding counted ears in a lane until the operator is ready



Perpendicular Conveyor Test



- Ears were dropped onto a conveyor running in a perpendicular direction
- With the change in direction separation occurs



Cleated Conveyor Simulation

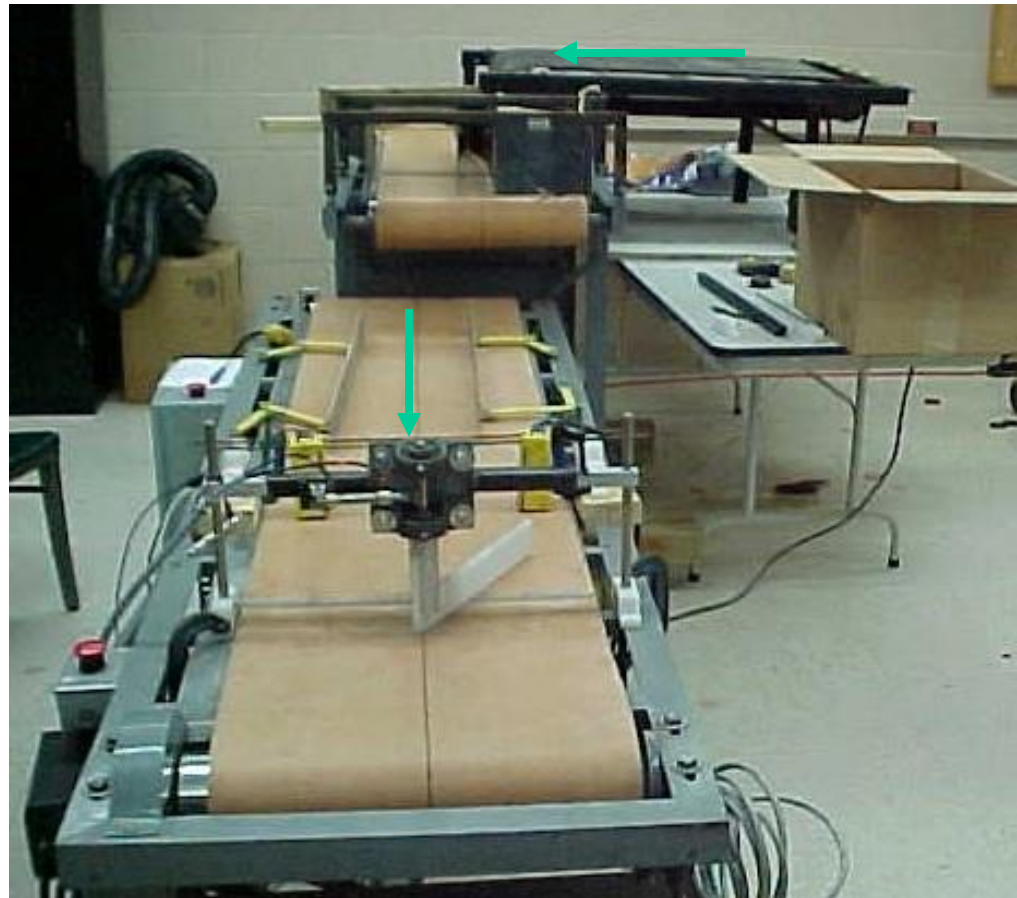


- Another conveyor added to simulate cleated conveyor
- Pulses translated into a continuous flow

Diverter Arm Test



- Implemented a prototype of the diverter arm
- Tested prototype for moving ears into correct lanes
- Photo eyes used to count ears and trigger diverter arm



Lane System Test



- Lanes will be needed to direct the ears underneath a sensor
- If the lanes slow the ears too much they will not have the needed separation to count
- The ears slid along the walls as predicted
 - As long as the lanes do not move the ears drastically

Initial Design Proposal

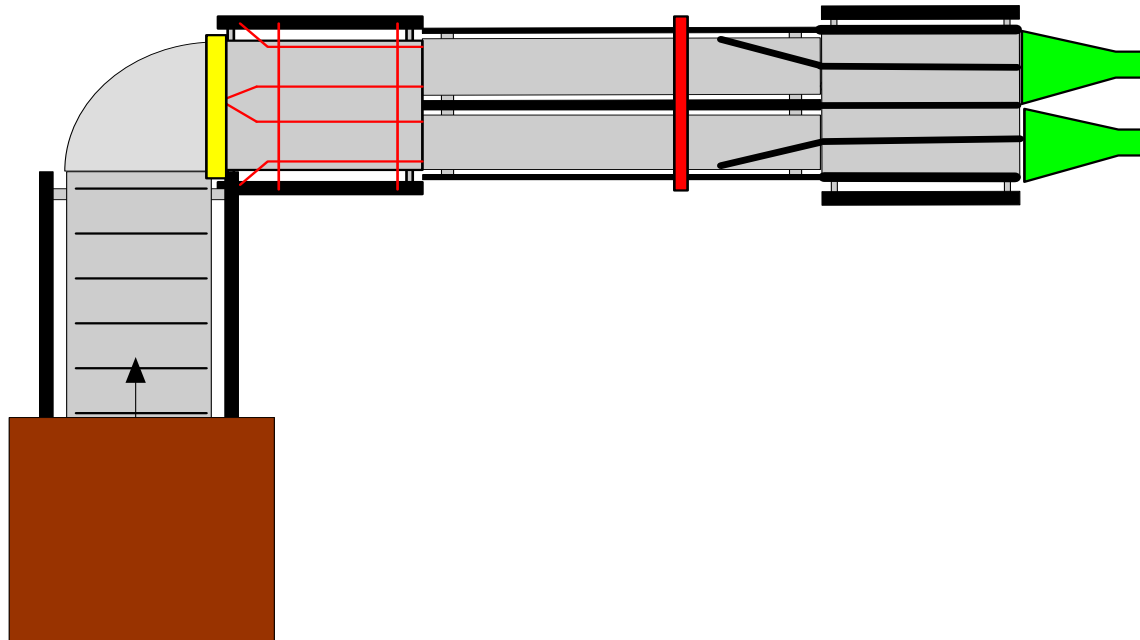


- Design will include elevated conveyer separation and lane separation
- A culated conveyer will load the system and be the limiting factor on bags per hour
- To unload the machine 2 operators will hold bags under chutes
- The use of a programmable controller

Layout Concepts



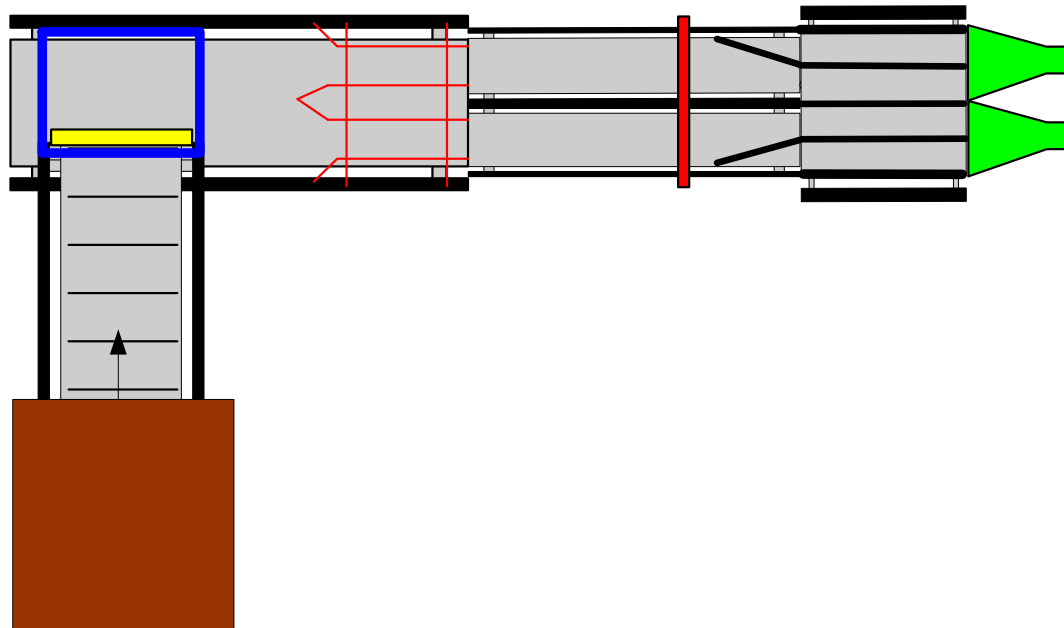
- Initial layout has cleated conveyor to elevate ears
- Ears slide down to laner conveyor
- Once in lanes metering counting and holding can occur



Layout Concepts



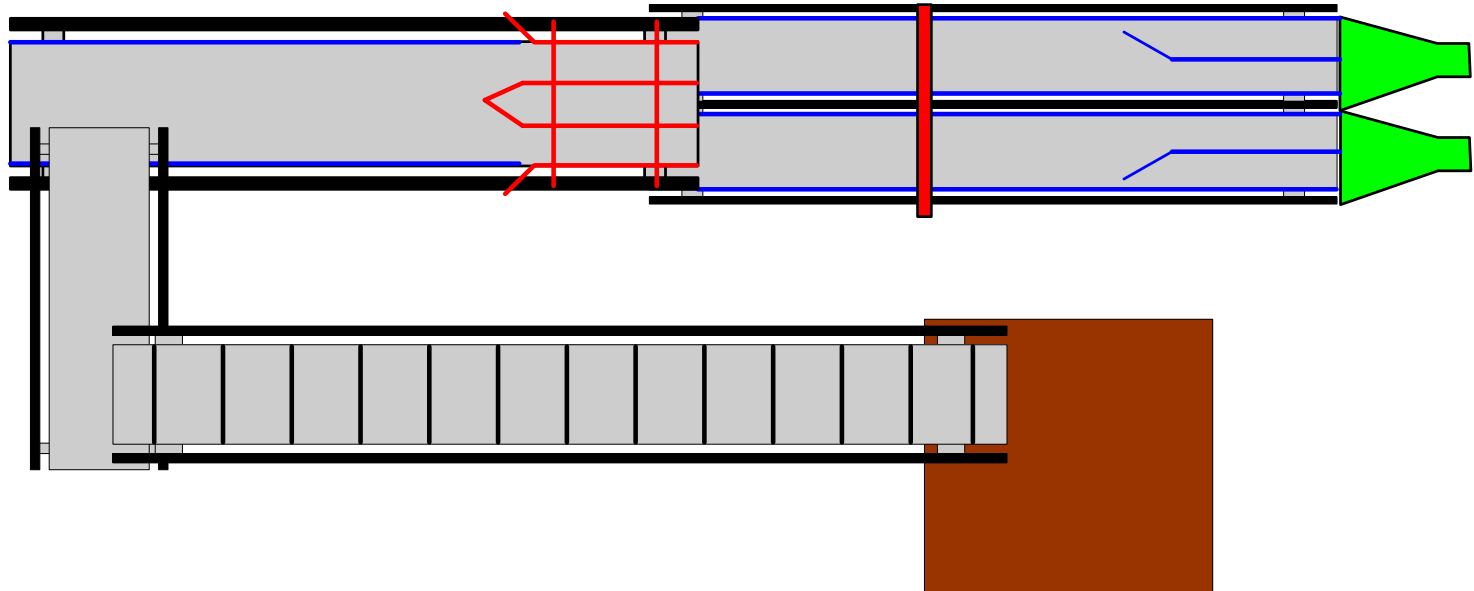
- Use the cleated conveyor to place ears directly onto laner conveyor perpendicularly
- This setup gives another point of separation with the drop



Layout Concepts



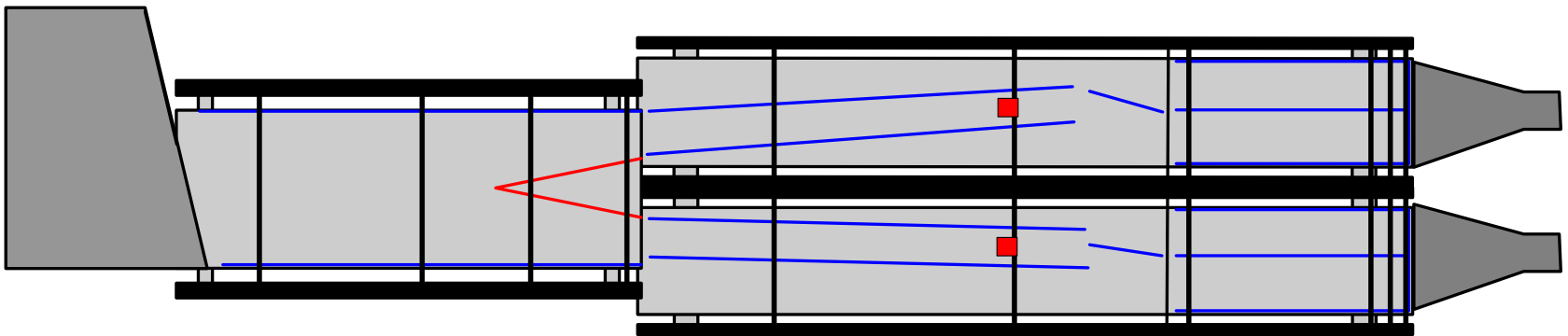
- Add another conveyor that receives ears from the cleated conveyor and then will feed the laner conveyor



Layout Concepts



- Remove cleated and transfer conveyor to make way for a vibratory table that will feed directly onto the laner conveyor
- The vibratory table was already in Scott's facility so it was of no additional cost



More Testing



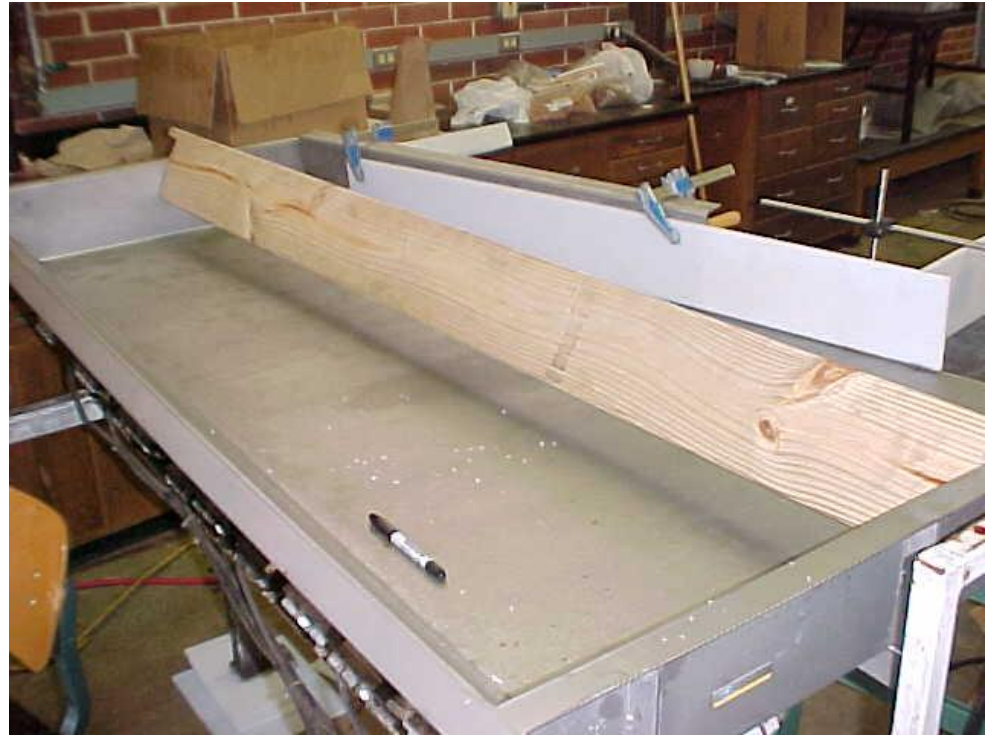
- The change in design called for testing of new additions to the system
- This also required some additional idea generation
 - Back to the drawing board



Vibratory Table Test



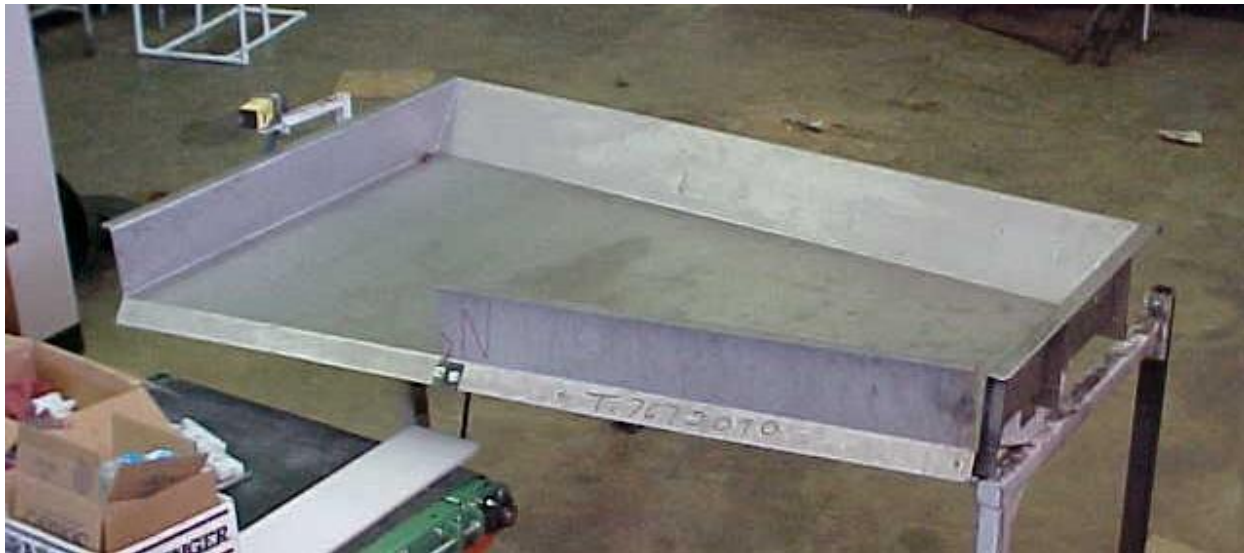
- Implemented different restrictions to better load the system
- The ears that go under the wood are in one layer



Vibratory Table Test



- The table is the most critical point in the new design
- The table did not work as expected
- It cannot be over loaded and expected to perform properly



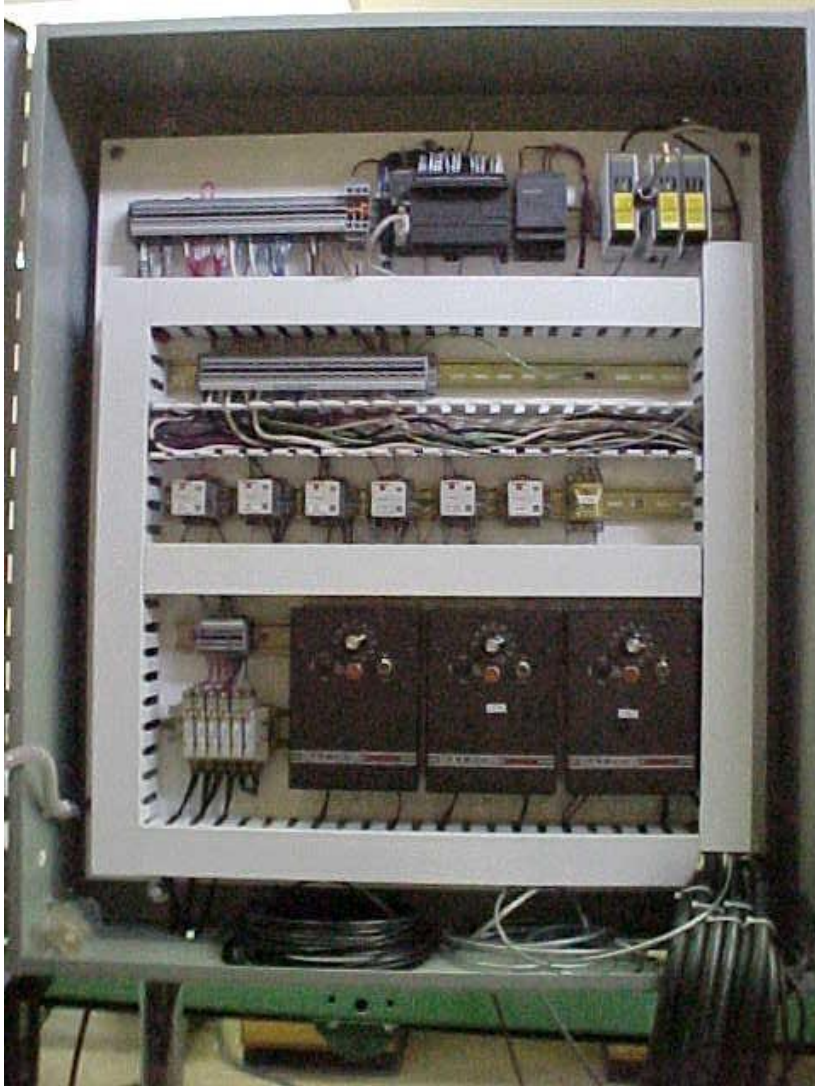
Final Testing



- 49 sets of 5 ears per package
- Complete system assembled only a short time
 - Still some fine tuning to do

	Correct Packages	Over packages	Short Packages
number	41	6	2
percentage	84%	12%	4%

Control Panel Layout



- Components
 - 30 Amp fused disconnect
 - PLC
 - Relays
 - Variable speed DC drives
 - Touchscreen

Electrical Description



- 120V single phase power.
 - Variable speed drive for the 1/2 hp motor
 - PLC
 - 24v DC power supply
 - E-Stop circuit
 - Vibratory table
- 240V single phase power.
 - Variable speed drive for 1 hp motors

Pneumatics



- Compressed air main form of ear diverting
- The system is set to run at 95 psi
 - The air enters a directional control valve where it pressurizes one side of the air actuator
 - Once the valve is energized the direction of the pressurized air is reversed
- Actuators
 - 1/2 inch Bore 1 inch Stroke
 - Small volume for quicker response

Equipment



- IDEC Distance Sensor
- Adjustable limits
 - Far limit set below the conveyor belt.
 - Near limit set just above the belt surface.
- Anything sensed above the near (an ear) limit sends an output



Equipment



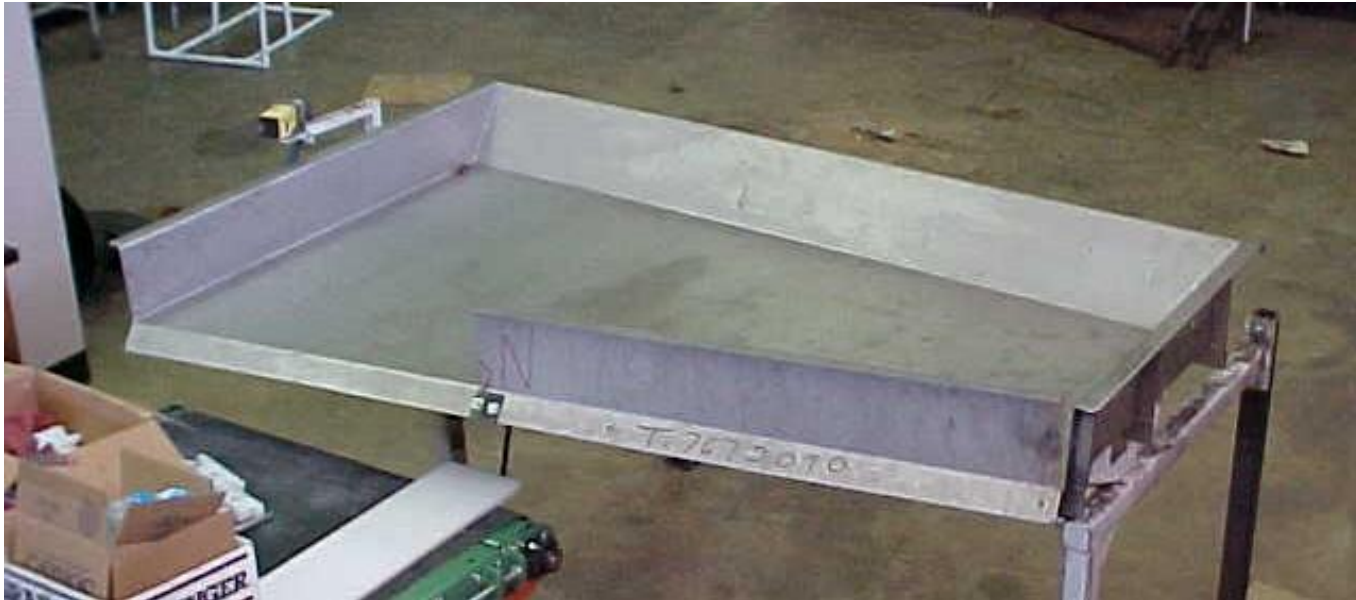
- Diverter arm
 - Ultra High Molecular Weight plastic (UHMW)
 - Air actuated
 - Pivots on two pillow block bearings
- Used to move ears into correct holding lanes



Equipment



- Vibratory Table
 - Six 120v AC motors provide mechanical vibrations of table
- Will load the ears onto the laneing conveyor
- The Gaylords will dump into table by means of hydraulic dumper



Equipment



- **Conveyors**
 - Roach model 350 SB slider beds
 - Standard black PVC belt with wire lacing
 - Variable drive DC motors



Equipment

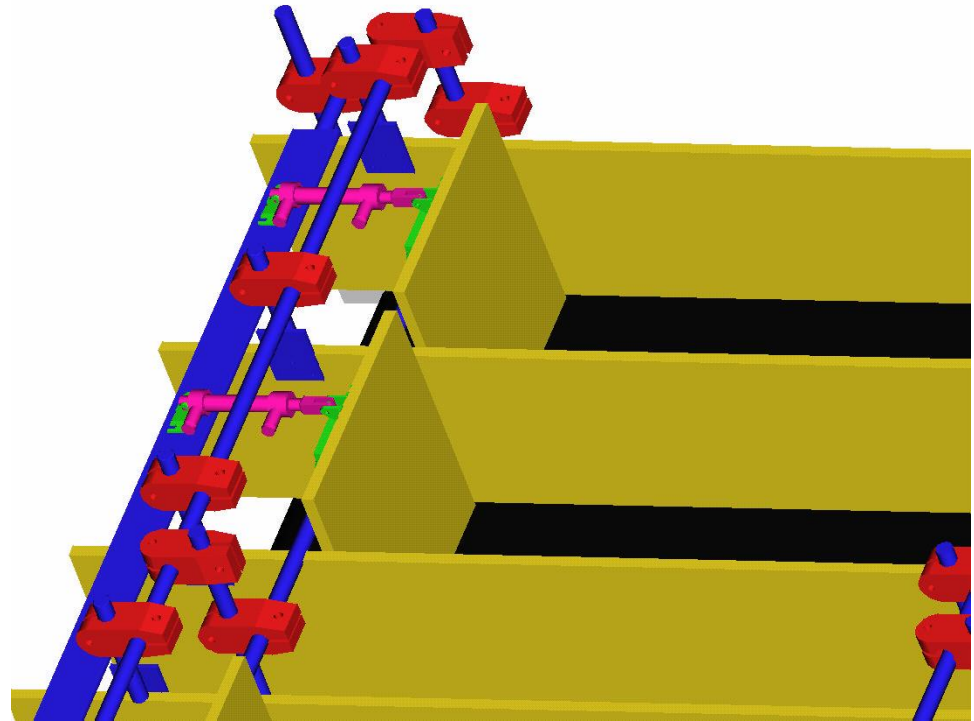


➤ Lane System

- All of the walls and doors are made of UHMW plastic
- Doors are actuated by pneumatics cylinders
- Pivot on two needle bearings

➤ Holding Lanes

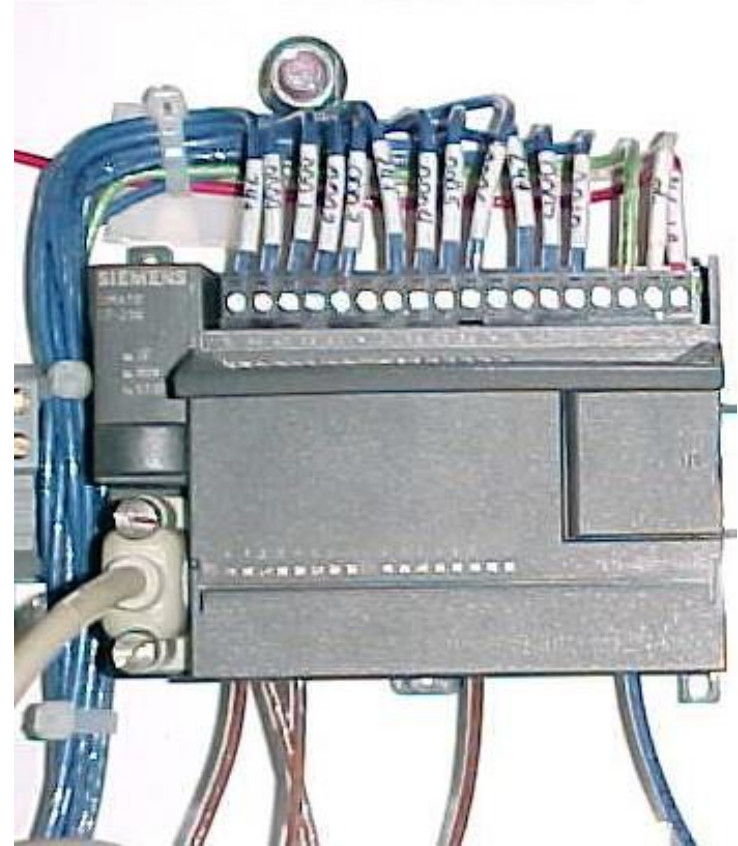
- Hold counted ears to be bagged



Equipment



- PLC
 - Siemens S7-224
 - Controls the motion of the ears in the system
- Touchscreen
 - Simatic TP170A
 - This is where all of the setpoints are entered
 - Performs statistical analysis



Final Proposal



- Implementation of an additional conveyor
 - Perpendicular to laneing conveyor
 - Use of vibratory table to feed this conveyor
 - Will provide the impact separation that is required

Recognitions



- Scott Pet Products
 - Randy Steinmetz
 - Joe Laskowski
- OSU Extension
 - Doug Enns
- BAE Faculty and Staff
- BAE Lab Personnel
 - Wayne Kiner
- Matrix Material Handling
 - Jerry Malach
- Industrial Electronic Supply
 - Travis Pettyjon

Thank You



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- [http://biosystems.okstate.edu/SeniorDesign/
2003/PetFoodSorter/index.html](http://biosystems.okstate.edu/SeniorDesign/2003/PetFoodSorter/index.html)

A collage of biological images serves as the background for the text. It includes close-up shots of green plant leaves, a sunflower head, and a lizard's head. The images are arranged in a grid-like pattern with some overlapping.

Innovative Biological Solutions

IBS solves your biological puzzles

Steven Fowler
Derek Storm
Travis Guy
BAE 4022
April 29, 2004

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Introduction

Currently Scott Pet Products' processing plant located in Tishomingo, OK is the final destination for 20% of the nation's pig ears. The pig ears are shipped as a byproduct from pork harvesting facilities around the U.S. The ears are shipped frozen in ice blocks and then sent through a water bath on site in Tishomingo to thaw. Once the ears have been extracted from the ice they are then sent to cutting and trimming, where some of the ears are cut into halves while others are left whole. Ears then proceed to flavoring where they are allowed to soak up flavoring, and then they are then sent to the ovens for drying.

The ears are transported to packaging in a large square container, (or a Gaylord as the Scott Pet Product Staff calls them), approximately four feet on a side. Containers are placed in a device and lifted in such a way that the ears simply fall out of the containers into a chute where they are counted by hand and placed on a small conveyor. At the end of the conveyor, another person is holding a bag in order to catch the product. The bag is then handed to another person to be placed in the sealing machine. The number of half and whole ears counted for each bag is based on the specifications of the customer for which the ears are packaged.

The packaging line for this product currently consists of four large container dumpers, two conveyor belts, a sealing device, and seven employees. The purpose of this project is to minimize the amount of manpower necessary to operate this production line as well as maximize the production rate and efficiency of the packaging process.

Statement of Work

The focus of IBS with regards to this project will be the development of a separation device for the pig ears that will count and accurately meter the ears so they may be bagged. This device will not only require less people to operate than the current system, but will also have a higher capacity and be more accurate than the current system.

The development of this system will require IBS to formulate, refine, and test different ideas and concepts on how the separation and counting process can be accomplished. Once a concept or combination of concepts is agreed upon, the system will be constructed, tested and further modified for optimum performance. The final design will be a working model that can be implemented directly into the Scott Pet Products' processing line. To meet these requirements, the final system will have to be rugged, reliable, and easy to operate.

Along with the construction of the model IBS, will present to Scott Pet Products a progress report on the project on Dec. 4, 2003. IBS will also be responsible for delivering an operations manual, part sketches and diagrams, and any other pertinent information with the working model upon delivery. A final presentation will be made to Scott's Pet Products in May of 2004.

Requirements and Specifications

This system will be designed to singulate, count, and separate dried pig ears. The requirements are to produce at least 800 bags of 25 pig ears per bag of varying amounts of whole and half pig ears per hour. The machine is required to be HACCP compliant. The machine should replace 4 of the current employees, and in the future will be able to accept an automatic bagger. The machine may not be taller than 12 feet due to lack of ceiling height. Due to foot and fork lift traffic, the machine can be no longer than 20 feet to prevent intrusion into the walking space. The machine will be able to use the current system for holding the Gaylord so that it can be filled with the current equipment. The machine must provide accurate counting for at least 99 bags out of 100, and have a minimal initial cost.

The design of a pig ear sorter has never been achieved in a manner that may be used in high production rates. The concepts that IBS have generated involve many different ideas on how to singulate, sort, and meter the non-flowing, non-uniform pig ears. The process for counting the ears will likely use multiple concepts integrated together to accomplish our goals. The first issue that IBS is concerned with is how the ears react when they are placed in the storage Gaylord and then allowed to slide down the black dumping chutes. There is little to no uniformity in the shape of the ears. Many times the ends and corners of the ears are curved. This allows for many of the ears to hook and intertwine together. The first step to packing the ears is getting the ears oriented in such a way that they may be distinguished from one another. Following separation the ears can easily be counted. Finally the pig ears need to be metered. They

need to be allocated into equal amounts that can quickly be bagged. The system needs to be capable of accepting user input to specify the number of half and whole ears to be placed in each bag.

Research

Since this project is to build a one of a kind machine, IBS must be conscientious of patent infringement. After searching the United States Patent Office web site for singulation, singulation/conveyers, and singulation/air-jet, IBS determined there was limited information that would pertain to pig ear processing. The patents deal with actual machine fabrication. Since IBS plans to purchase different pieces of equipment from conveyers to photo arrays, the existing patents will not be infringed. Also, the singulation, counting, and separation of pig ears is not a large industry so very few of the companies that process pig ears will sponsor a project to do research that will be published in journals. IBS views beef jerky to be the closest product that would react to singulation and separation in a fashion similar to pig ears. However, there was no literature found dealing with the handling and packaging aspect of beef jerky. The food industry is extremely private on its layout of machines and processes. With this in mind, if IBS was to accidentally replicate the layout or design of another company's it would clearly be unintentional.

Design Concepts

There are, as mentioned before, three main tasks that this system will have to accomplish. They are: singulation, counting, and metering. The design concepts can be

broken down into three groups; one concept dealing with each of the major tasks.

Singulation

The singulation of the pig ears is basically a way of making the counting process simple. This has been the main focus of IBS since we obtained to project. If the pig ears are conveyed by a counter with separation between each ear, then a basic electronic eye will easily count the pig ears.

The first concept that IBS generated to singulate the ears is using two conveyors in series. The first conveyor is set up to run at a speed much slower than the second conveyor. This speed difference provides a shearing effect when the ears reach the second conveyor. They are pulled away so fast that a separation forms between the ears, but they are not in any order. This concept will have to be one of the first processes after the ears are removed from the chutes of the lifting system. The conveyor belts will have to be made of material with enough frictional forces such that the ears will travel consistently and not slip.

The second concept builds on the two conveyor system, but instead of having a height difference there will be an “air curtain” between the conveyors. This air curtain, consists of a high velocity, high volume nozzles powered by 60 psi compressed air. There is a small gap between the fast conveyor and the slow conveyor, just enough to allow a strong blast of air from below to lift the ears and then allow them to fall down while still having forward momentum. The lifting of the ears allows separation to take place by not allowing the ears to be stacked one on another. This method requires constant pneumatic pressure.

The next separation concept comes from the general idea of an “air hockey table.” This idea involves the construction of a metal table with small orifices that allow air to pass and then having a high air volume fan mounted on the underside in order to push air through the orifices. The table would be declined at an angle between the slow conveyor and the fast conveyor. It will fluidize the stream of ears off of the slow conveyor, and allow gravity to pull them down towards the high speed conveyor. The high speed conveyor would peel the ears off of the table two or three at a time, thus allowing the handling of the ears to be simplified. Once the ears come out of the chutes there will be a canted conveyor carrying the ears upward and then dumping them onto the air table and then to the second conveyor. Using a control system the number of ears on the table at any give time can be controlled by the size and speed of the conveyor that feeds it. This requires a high-speed fan which in turn will produce some noise, but could be significantly effective in separating the product.

Counting

The ears are not always counted and packaged by the same quantity. For example, there might be 20 whole ears and 5 halves in one package, but the next set of packages might have 16 wholes and 9 halves. The change in mixture is determined by the customer order being produced; however it is not known how often the mixture change occurs. The possibility of these situations requires the use of a programmer of some sort, which will be mentioned later, that allows the operator to select the quantity. The next few concepts are devised to count the ears and also to provide some sort of diverging of the sporadic placement of the ears from the separating techniques mentioned above.

The first idea IBS generated to control and count the ears is to use a lane system that would straddle the conveyor. The lanes would cause the ears to diverge first into two lanes and then to multiple other lanes. The idea is basic but effective in moving the ears into two single file lanes from the random placement of the separator. The basic configuration consists of a V-shaped object in the middle of the conveyor that forces the ears to go on one side or the other creating two lines of ears. Once the ears have been formed into these two lanes there will be a swing arm that will use the friction of the belt and the forward movement to divert the ears into four lanes. The first line will split off and form two lanes, as will the second line. These four holding lanes will send ears to be bagged when so prompted by the operator. In the event Once emptied the system begins to sort the ears once again. The lanes are 8" wide in order to accommodate the large ears and to prevent the ears from piling up. Shown below in Figure 1 is a prototype for the two lane part of the system.

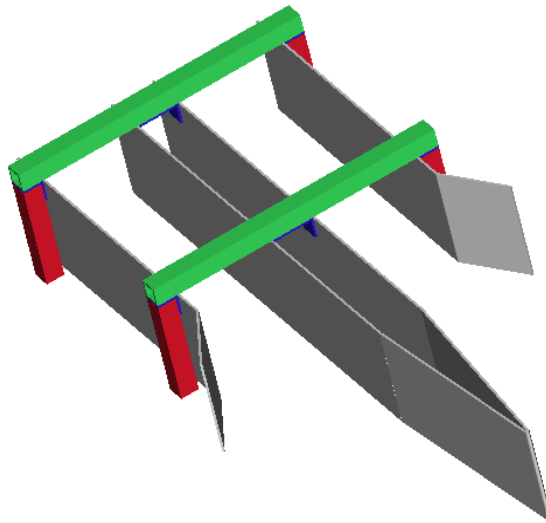


Figure 1: A computer aided sketch of the two lane separator that sets on top of the conveyors

The next concept for controlling the ears is much like the lane system, but instead of using conveyors to force the ears to diverge the driving force will be gravity. The idea is to use an inclined table with the lanes being permanently fixed to the table (Gravitron 3000). At the beginning the ears will be lifted via cleat conveyor and then dropped off at the top of the inclined table. The ears will slide down the table and the V-shaped partitions will divide the ears much like the conveyor lanes. The number of lanes will start at two and then progress to four using a similar V-shaped partition. Using this system the need for conveyors is limited, and the cost is greatly reduced. The lanes will work in the same manner, but the control of the ears is dramatically reduced because they cannot be stopped when on the inclined table. This increases the chance for the ears to pile up thereby eliminating the usefulness of the separation process. A schematic of the table is shown below in Figure 2.

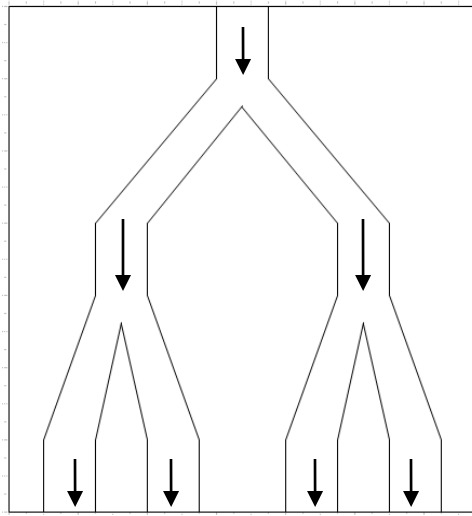


Figure 2: A Schematic view of the proposed gravity lane separator

The actual counting will be done by some sort of photo eye array; however the exact device to be used for this task has not yet been chosen. IBS currently has four basic

electronic eyes that were part of the original prototype separator/counter that Scott's Pet Products provided. If these devices are not the specific hardware that will be implemented in the final design, then something very comparable to them will likely be used.

Metering

Currently it is difficult to choose what kinds of mechanisms will be used to meter pig ears after they have been separated and counted. This difficulty arises mainly from the dependence of this section on the rest of the system. Until a final separation and counting system has been decided on, this portion of the system will be very dynamic. Ideas for how the flow of the pig ears can be controlled in this last portion of the system are continually being generated.

Most of the current ideas that IBS has about metering the pig ears revolve around the use pneumatic arms and chutes. The chutes will be used to fill the bags with the pig ears after they have been counted out. Pneumatic arms can serve as a controlled way to divert the counted quantities of ears into the chutes or holding conveyors so they are ready to be sent to bags.

Testing

IBS has currently concentrated most of its work on the generation of ideas of how the separation and counting of pig ears can be accomplished. Thus, testing for the project has been limited. Also, results for the singulation tests are often more qualitative than quantitative. Many times the results of testing one idea versus another are often a

comparison of how effective one mechanism is compared the others that have been tested.

One test that IBS performed, that did provide quantitative results, was the average measurements of a sample of pig ears. Maximum diameter, minimum diameter, and mass were all measured for whole and halve pig ears. The sample of pig ears provided by Scott's Pet Products was taken from their top grade, retail production line. The results of these tests have determined minimum dimensions for some of the sorting equipment and designs for the separation and counting processes of the system. Results from these measurements are attached in appendix A.

IBS conducted testing on the previously mentioned singulation concepts. To test these concepts, two conveyors in the Biosystems and Agricultural Engineering lab at Oklahoma State University were used. The first test conducted was on different speed conveyors. The ears were placed on a slow moving conveyor, feeding to a faster second conveyor. This provided some separation of the ears from one another. The lower the flow rates of ears and the higher the speed difference between the conveyors, the more effective this concept is at singulating the ears.

The second concept IBS tested was an elevation difference between two conveyors of different speeds. Dropping the ears from a slower conveyor onto a faster one, increases singulation efficiency. The falling impact causes the ears not catch and bind on one another while the fast moving conveyor pulls the ears away from each other. Figure 3 shows this concept being tested.

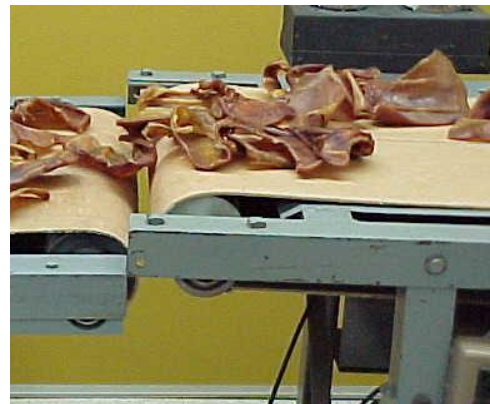


Figure 3: Different speed conveyors with an elevation difference

The third concept that was tested built on the two speed 24” conveyor system, but instead of having a height difference there was an “air curtain” between the conveyors. This air curtain, consisted of a high velocity, high volume nozzle powered by 60 psi compressed air. The small gap between the fast conveyor and the slow conveyor provided just enough room to allow a strong blast of air from below. This lifted the ears and allowed them to fall down while still having forward momentum. The lifting of the ears allowed separation to take place by not allowing the ears to be stacked one on another. During the testing of this concept, a single nozzle was fixed below the conveyors and aiming up and at a slight angle towards the fast conveyor. This method proved to have some success, but requires constant pneumatic pressure.

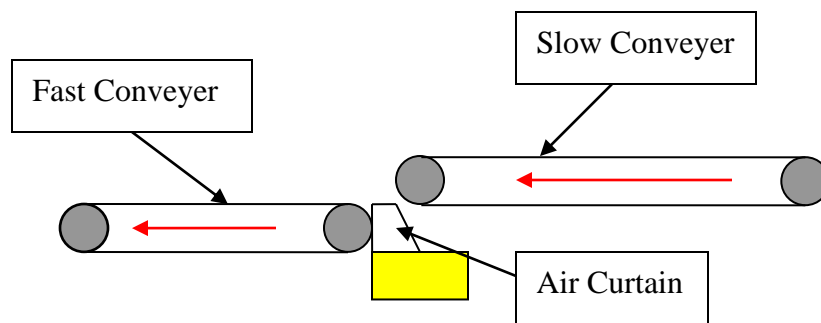


Figure 4: Air Curtain setup

The fourth test was to see how the ears reacted to being separated into lanes. By dividing the total flow, the amount of ears on a conveyor is decreased and easier to singulate. A lane system (Figure 1) was fabricated by IBS and was placed on the conveyor setup on the second conveyor. The second conveyor was the faster one in this test however no air-blast was used. The ears evenly divided themselves between the two lanes and continued down the conveyor. This test worked as expected and will most likely work into IBS’s final design. Figures 5 and 6 show how the separator works.

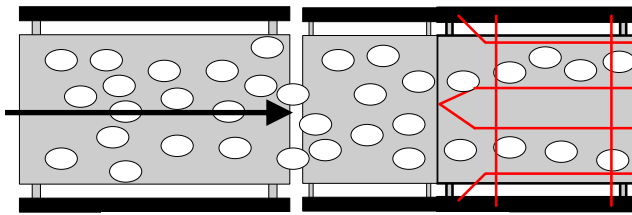


Figure 5: A representation of the Lane Separating Device



Figure 6: The actual Lane Separating Device

The final testing involved adding a trap door to the end of the lane separator. With this test the ability to stop the ears is examined and analyzed. To run the test a piece of metal is placed at the end of one lane and a group ears is sent down the lane. Once the ears hit the metal they piled up while the conveyer is still moved. The metal was held in place by a spring and after a good pile has accumulated the door is lifted and the ears whisk out of the lane. This test is done to show how we want the ears to react just before packaging. Figure 7 shows the trap door working.



Figure 7: Trap door on the Lane Separating Device

Most of the testing conducted has shown promising results for the singulation of the pig ears. IBS will implement a combination of the elevated conveyors, lane separators, electronic eyes, and trap doors to singulate, count, and meter the pig ears.

Project Future

Proposed Design

While the final design will depend on the over all effectiveness of the system as it is further tested, IBS has a basic idea of how the pig ear counting system should be laid out. Currently plans are to dump the pig ears into a large bin and use a cleated conveyor to scoop them out and into the system to be separated. The cleated conveyor will allow only a certain amount of pig ears to enter the system at a time, thereby making the singulation process much simpler. The ears will then be singulated by the use of elevated conveyors. The drop as well as the shearing effect of the second, faster moving conveyor has shown to be capable of separating the pig ears. The ears will then be moved into single file lines using the lane separators. At this point, with the ears singulated and in single file, the ears can easily be counted using an array of electronic eyes. With the ears counted they can then be metered with pneumatic arms and doors. The ears will then be held in holding areas or chutes where they will be hand bagged. Two very similar systems will be developed; one system for both half and whole ears. The system for the half ears may not have to be as large as the system for the wholes since most customers require a lower volume of halves compared to wholes.

This system will likely require two operators to continuously place bags underneath chutes or loading devices to receive the ears. However, this set up will

eliminate the need for people to count out the ears. This lessens the amount of manpower on the production line by three to four.

A PLC controller will be implemented to control the conveyor speeds, count the ears, provide a safety circuit and control any pneumatic arms or doors. A basic controller has already been selected for the cost estimate. This controller will have the ability to be upgraded in the event that an automatic bagger is to be installed.

Design Budget

Table 1 lists the prices of the components as determined from the manufacturer. The conveyors listed below include the motors, belts, and structural support. The Micrologix controller is built by Allen Bradley and might have to be upgraded to a larger platform to meet the final design needs. The controller will have to be mounted in an enclosure for safety and protection, which will be a NEMA rated electrical box. The motor starters are rated for 230 volt ½ hp motors, needed to start stop the conveyors, also priced from Allen Bradley. There will be some parts for the chutes fabricated from sheet metal in the BAE Lab. The size of sheet metal will vary and the quantity is unknown as of right now. The miscellaneous and unforeseen cost includes all of the wiring, electronic eyes and pneumatic parts required.

Device	Price	Quantity	Total
Motors (1/2 hp 230 volt) vs AB	\$350	2	\$700
Starter 240 volt thru wiring AB	\$275	14	\$3,850
Micrologix 1200 AB	\$750	1	\$750
Enclosure Hoffmann	\$750	2	\$1,500
Cleated conveyor (24"wide X 8')	\$2,000	2	\$4,000
Flat conveyors (24"wide x 6')	\$1,600	2	\$3,200
Flat conveyors (16"wide x 6')	\$1,400	4	\$5,600
Flat conveyor (30"wide x 6')	\$1,600	2	\$3,200
Sheet metal fabrication	\$2,000	1	\$2,000
Misc and Unforeseen costs	\$5,000	1	\$5,000
Total for two systems			\$29,800

Table 1: Estimation of Project Budget

Project Schedule

A Gantt chart for the next semester is attached as appendix B. This shows the timeline of how IBS plans to build the system and some time to allow for testing. All timelines are rough estimates.

Final Comments

The next 4 months will include a complete building and testing period for the proposed pig ear counting system. A conceptual layout sketch of the system is shown below in figure 8. While this solution is becoming complicated, it is well within reach. IBS's proposed system, when completed, will accurately do the job of three to four workers. IBS looks forward to the upcoming assembly of the finished system.

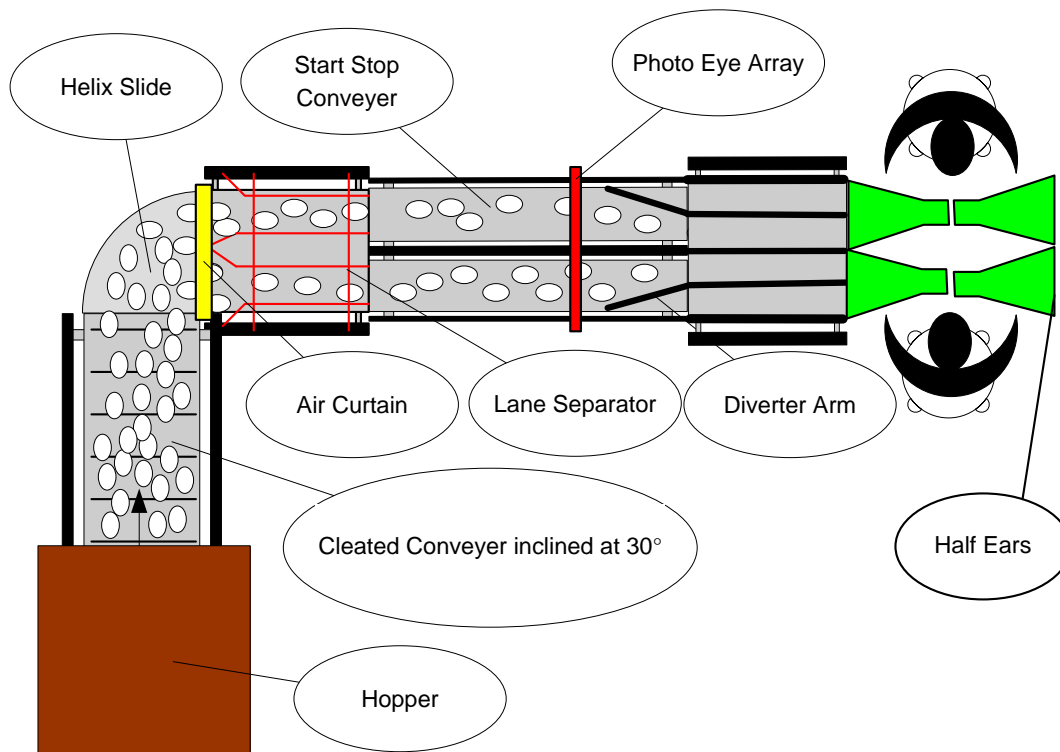


Figure 8: Rough sketch of how the sorting system will be laid out



Innovative Biological Solutions

Oklahoma State University

BAE 4012

Dec. 4, 2003

Steven Fowler

Derek Storm

Travis Guy



Project Introduction

- Scott Pet Products
 - One of the nations leaders in the pet food and treat industry
 - Final destination of 20% of the nations pig ears
 - Would like to increase the production and efficiency of this product line
- IBS has been contacted to develop a system to sort, count, and meter pig ears



Project Introduction

■ Pig ears

- Favorite treat of many dogs
- Thawed, baked, flavored
 - Some ears are cut in half
- Counted, packaged, sealed, shipped



Project Introduction

■ Packaging

- Ears sold by amount not weight
- Ears have to be counted
 - Currently counted by hand
- Ears stick together
 - Have to be separated to be counted





Customer Requirements

- Ears need to be sorted, counted, and metered
- 800 bags of 25 pieces per hour
- Economical
 - Minimize labor required
 - Maximize production capacity
- HACCP compliant

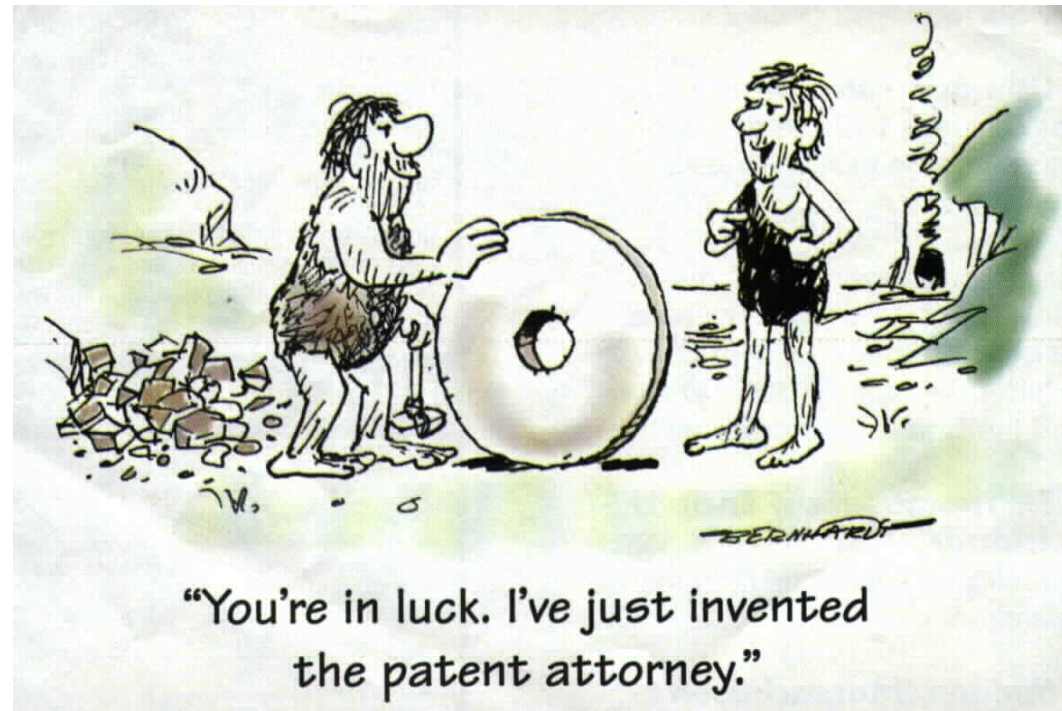
Engineering Specifications

- Machine must not exceed 12 feet in height and no longer than 20 feet.
- The machine must have the correct number of both size ears in 99 out of 100 bags.



Patent Research

- United States Patent Office search
 - Results that came up applied to construction of individual pieces of equipment.
 - Processes patents were not found
- We plan on buying different pieces and applying them towards our system.





Process Research

- No research has been done on pig ear singulation, sorting, or metering.
- The closest product that would react and have similar irregularities to pig ears is beef jerky.
- All of the information needed to complete the project will come from our testing.

Breaking Down The Problem

- This problem can be broken down into three main objectives
 - Singulation and Separation
 - Counting
 - Metering



Separation Concepts

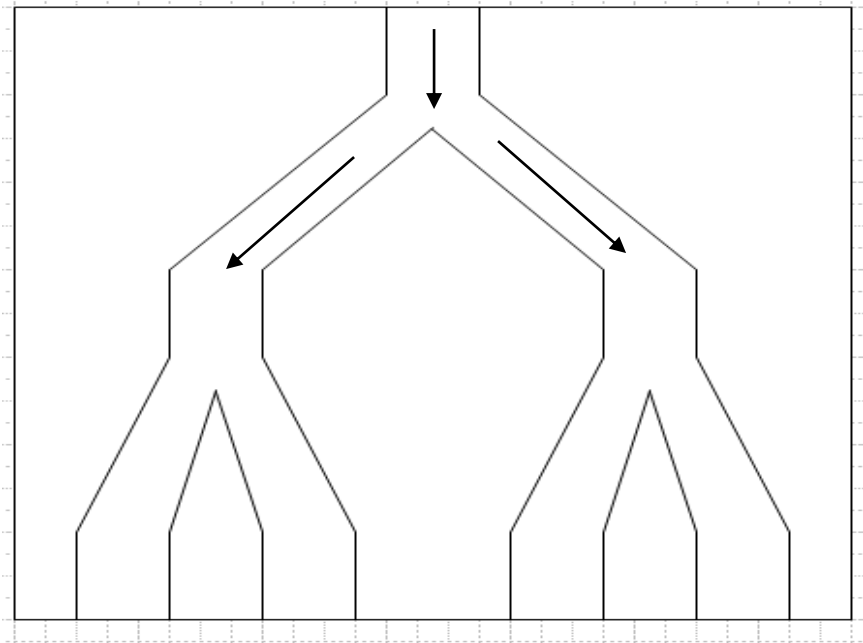
- Different Speed Conveyors
- Elevated conveyors
- Air Curtain
- “Air Hockey Table”
 - Fluidized Bed



Counting Concepts

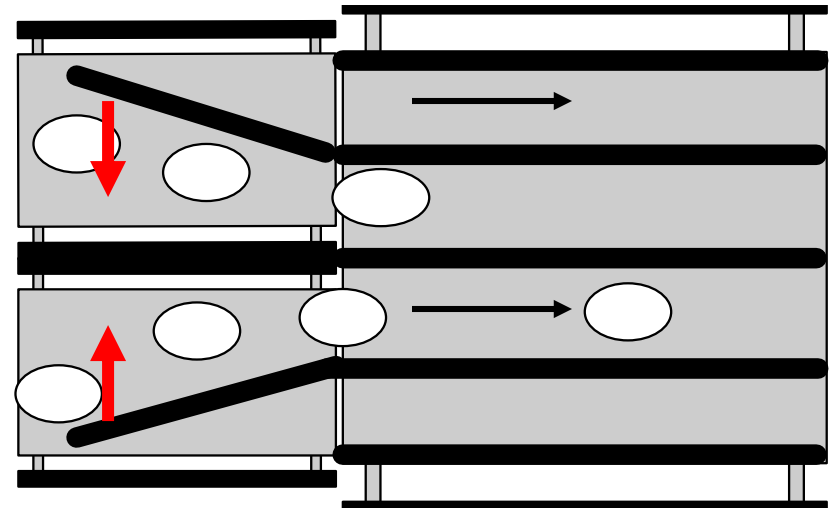
- Lane separator
 - two diverging lanes
- Electronic eye

- Gravity separator
 - limited flow control



Metering Concepts

- Using a pneumatic diverter arm to divert two lanes of ears into four lanes
- Have a trap door to stop flow of ears, allowing the conveyor to continue to run





Ear Dimension Testing

- These ears were taken from retail bags.
- This data allows us to have a lane width for our design.

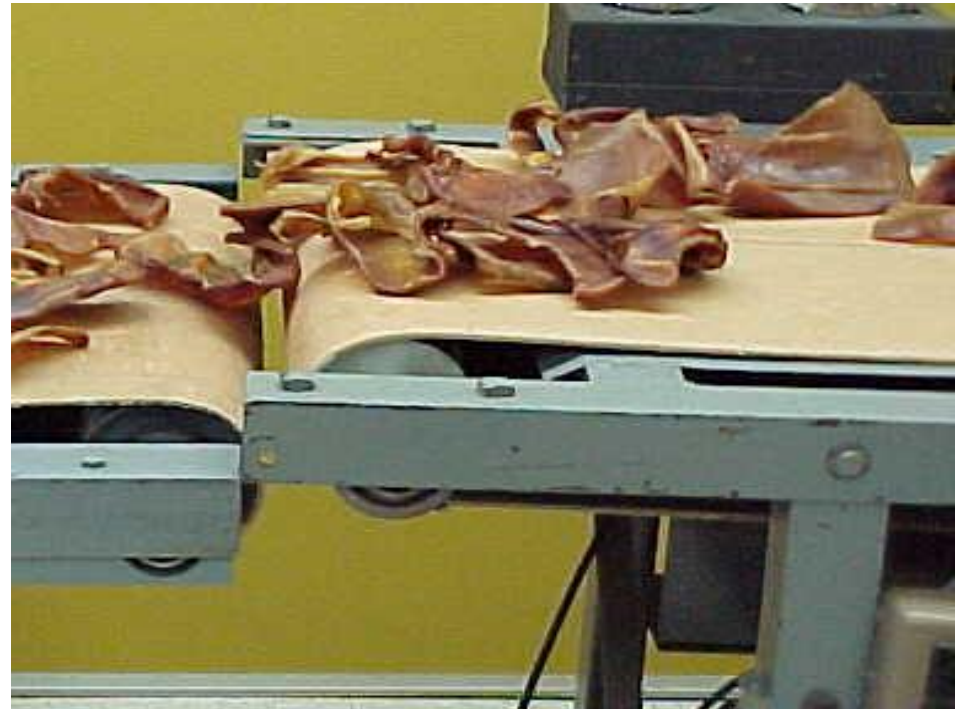
	Whole Ears (n=40)			Half Ears (n=10)		
	Weight (oz)	Length (in)	Width (in)	Weight (oz)	Length (in)	Width (in)
Max	2.09	7.50	5.00	1.20	7.00	4.50
Average	1.56	5.86	4.17	.90	5.09	3.80
Standard Deviation	0.32	0.91	0.61	.20	1.00	0.40

Conveyer Speed Test

- Test is set up with two conveyers in series, with the first conveyer set at (slowest speed) and the second conveyer set at 6.6 ft/s.
- Shearing force from the faster conveyer singulates the ears.
- The lower the mass flow rate and higher speed difference, allows for greater singulation.

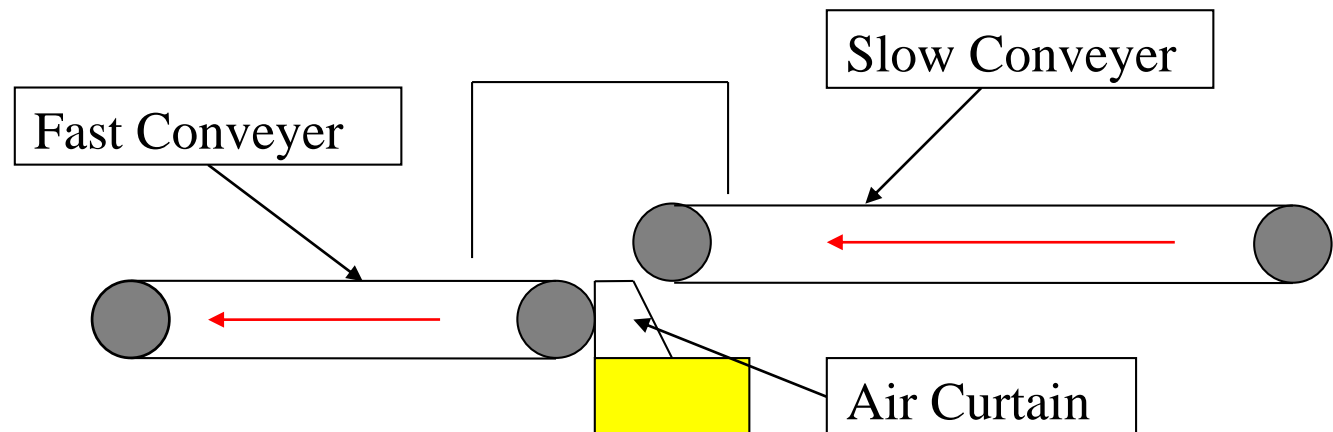
Elevation Test

- Setup same as previous test except slower conveyer is elevated.
- Provided greater singulation than even conveyers.
- The height change allows for more force to be applied to ear mass.



Air Curtain Test

- Setup the same as elevated test but at junction of conveyers a high velocity, high volume air nozzle was placed.
- The pressure delivered to the nozzle is 60 psi.



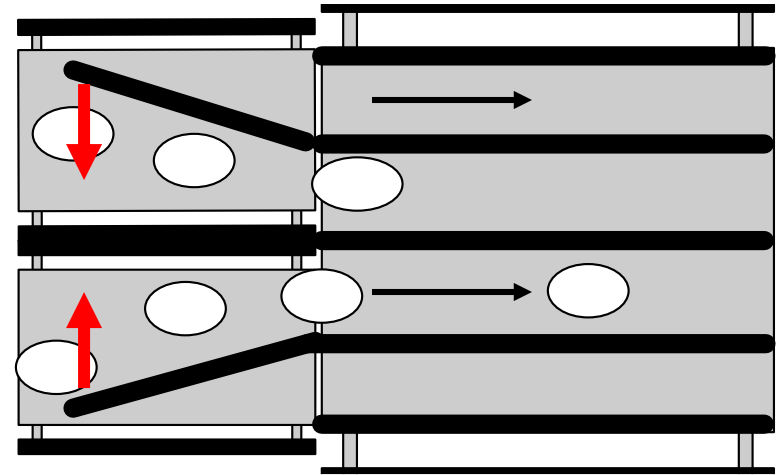
Lane Test



- After the ears are singulated they need to be placed into lanes.
- The lane system is placed over the second conveyer after the air curtain

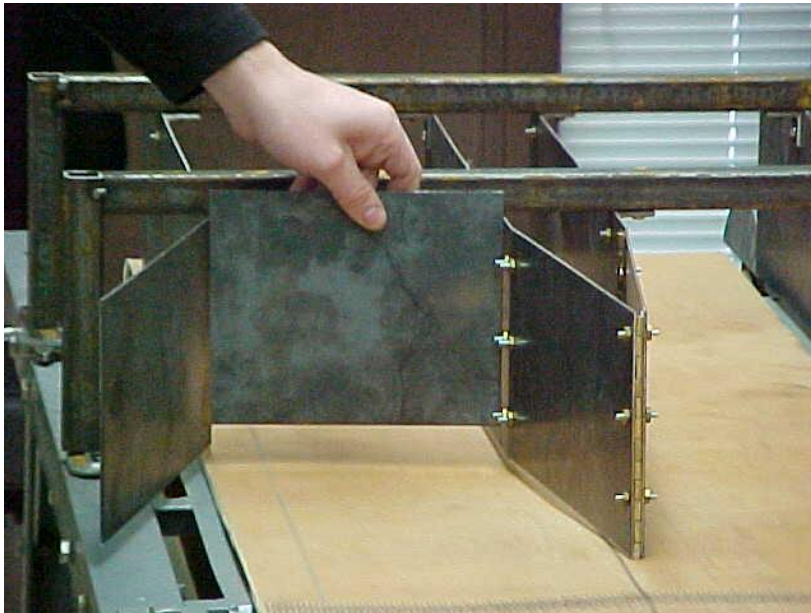
Diverging Arm Test

- The arm was held over the high speed conveyer to guide the ears to separate lanes.
- The first conveyors are slower than the large single conveyer.
- If the four lanes ever fill up with ears the feeding conveyers will stop.



Trap Door Test

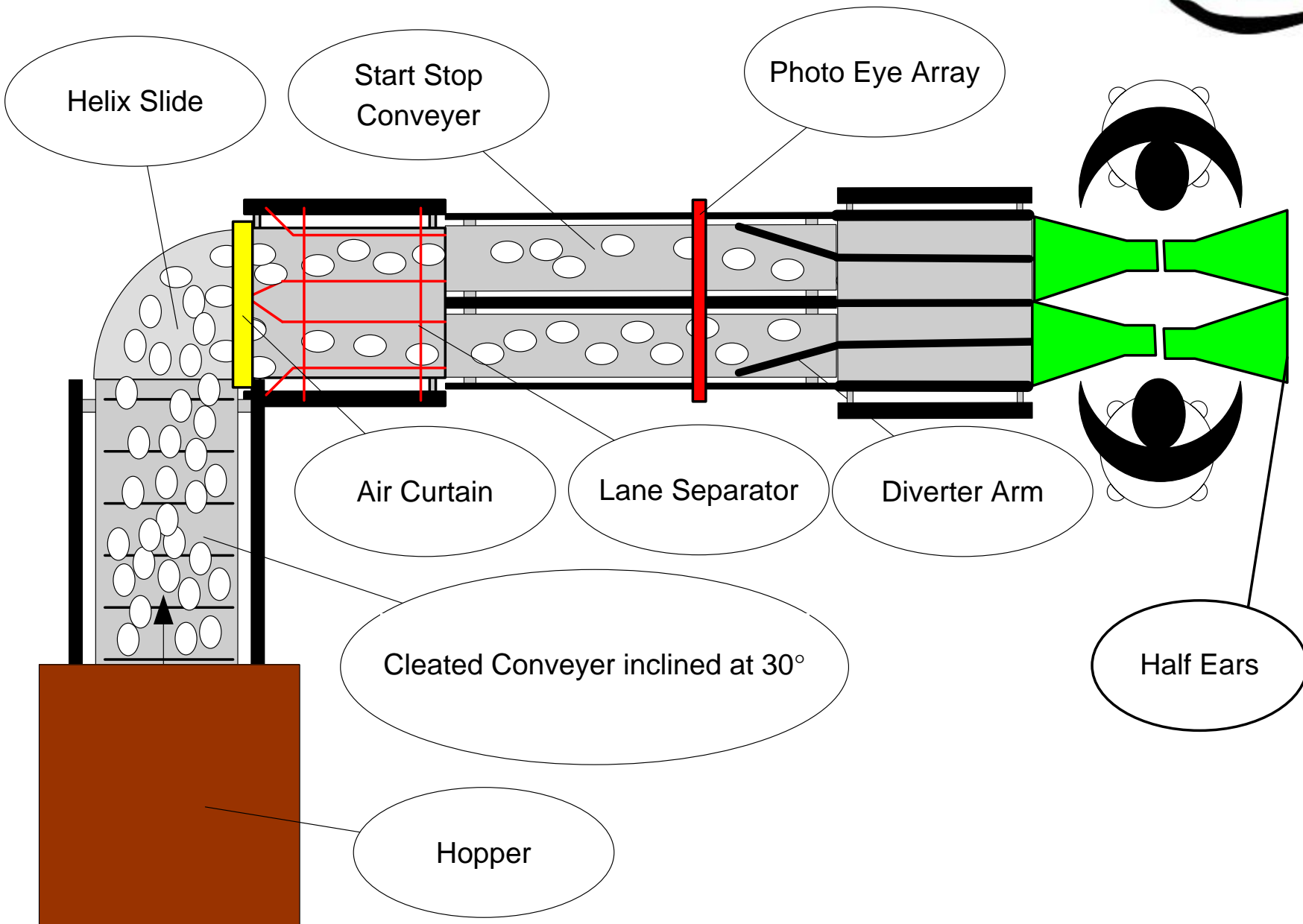
- This test is to determine the feasibility of holding counted ears in a lane until the operator calls for them.





Proposed Design

- Design will include elevated conveyer separation, air curtain, and lane separation.
- A cleated conveyer will load the system and be the limiting factor on bags per hour.
- To unload the machine 2 operators will hold bags under chutes.



Helix Slide

Start Stop
Conveyer

Photo Eye Array

Air Curtain

Lane Separator

Diverter Arm

Cleated Conveyer inclined at 30°

Half Ears

Hopper

Recognitions

- Scott Pet Products
 - Mark Osteen
 - Mike Zimmerman
- OSU Extension
 - Doug Enns
- BAE Faculty and Staff
- BAE Lab Personnel
 - Wayne Kiner

THANK YOU



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