AMPC

FINAL REPORT

Automation of Primal Cut Bagging

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1.0 EXECUTIVE SUMMARY

Red meat processors primarily utilise manual skilled labour for bagging of primal cuts after processing. This requires significant labour costs from staff trained to identify cuts, place them in appropriately sized bags and seal them. Automation, where utilised effectively, should be able to reduce production costs and improve quality. Where limited automation does exist, it still relies on manual checking or intervention to operate reliably. A fully automated design is necessary to overcome these issues and reduce productions costs.

This report details the various tasks required for a fully automated bagging system, including challenges and interconnections between tasks. These tasks include; identification and inspection, transportation of cuts, additional items placed on top of cuts, bagging of primal cuts, labelling of primal cuts and vacuum sealing of primal cut. Currently available automated bagging technologies that might be used for the task of automatic bagging of primal cuts were assessed. Additionally, available technologies that might be used as building blocks in the creation of a system for automated primal cut bagging from the ground up were also assessed.

From the examined technologies, a concept design for an automated primal cut bagging system was developed. This design was focused on providing minimal manual operation. It is presented as a generic design and is expected to need to be customised to suit an individual meat processor, as well as to optimise the overall efficiency of the automation. This project has set the framework required for an automated bagging system. The system has the ability to integrate within an operating meat processor and communicate with additional automation systems downstream.

It is recommended that further work be undertaken to developing a suitable prototype for the robotic spatula tool design for automatic handling of naked primals, prototyping for the additional items placed inside the bag systems, and optimise the bagging robot design and layout for picking and positioning of the pre-formed bags. Once integration of all the technologies has been achieved, the system could be further developed to handle quality control checks and automated grading and sorting.

2.0 INTRODUCTION

Meat processing plants suffer significant labour costs and OH&S risks associated with the manual bagging of meat cuts after processing. While some automation has been utilised in meat processors in the past, after discussions with processors the general opinion was that the current level of automation was not complete, not reliable and in some cases not economically feasible. Most existing automation still relies on manual positioning of primal cuts or operator intervention to maintain suitable quality and consistent operation of the bagging systems in place.

This project aims to examine the most effective way of bagging and labelling naked primal cuts, through research and development into automation technologies that could be directly applied to bagging tasks and identify available technologies that might be applied and used as building blocks for the development of an automated bagging system. Finally a concept design for a fully automated primal cut bagging system was developed and discussed, with recommendations for future development.

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3.0 PROJECT OBJECTIVES

Objectives for the Automation of Primal Cut Bagging project are outlined below:

- Determine existing available technologies that might be deployed in automating the task of placing naked primal cuts into vacuum sealed bags if available.
- Determine other available technologies that might be used as building blocks in the creation of a system for automating primal cut bagging from the ground up.
- Determine a suitable design for an automated naked primal cut bagging system based on assessed technologies.

4.0 METHODOLOGY

4.1 Challenges for Automated Bagging

The range of primal cuts requiring bagging were examined and the various complexities that involved with an automated bagging system were identified.

4.1.1 Variation in shape

There is a large variation in the size and shape of different primal cuts, from large clod or chunk roll, to long tenderloins and small cube rolls. This variation in product requires a similar variation in handling equipment, whether it be conveyors and chutes or robotic grippers and fingers. Either similar sized products are grouped together to be processed by appropriately sized equipment or the processing equipment needs to be designed with sufficient flexibility to handle the varying range of primal cuts.

4.1.2 Amorphous nature of red meat

Red meat is not completely solid or ridged and prior to bagging naked primal cuts have an amorphous nature that can complicate automated bagging. The way the meat is positioned, transported and handled will affect the way the meat rests inside the bagging material. This could affect the size of the bag or amount of film used to bag primal cuts, as some primals typically are rolled up into a smaller package. Some primal cuts need to be positioned or wrapped a particular way for presentation of the meat or to minimise potential losses in quality of the product during storage and transport.

4.1.3 Presence of bone with hard or sharp edges

Bone-in primal cuts need to be positioned and bagged specifically to try and prevent puncture of the bag on the edges of the bone. Typically, bone-in primal cuts are handled and packaged with the fat side down to minimise the potential of damage to the bag during packing and transport. However, some bone-in primal cuts are packaged with padding or other protection material placed inside the bag over top of the bone. This would require an additional step in an automated system or a separate task that involved placing the additional material on the meat prior to bagging.

4.1.4 Transporting and positioning meat for bagging

Automated bagging systems will typically require product singulation prior to bagging to ensure only one product is packaged per bag. Excess product handling of primal cuts increasing the risk of contamination from bacteria and the potential for loss of quality of the product from weep or purge or colour deterioration. As such accumulation and singulation of the product needs to be designed carefully in an automated system. Singulation of the product should occur as close to the automated system as possible. Ideally no accumulation of product ahead of the automated system is best, but ultimately some accumulation is going to be necessary to maintain a consistent cycle time.

4.1.5 Variation in bagging material or bag labelling

Due to the size variation of each primal cut, different bag sizes must be used if an automated system was to use pre-formed bags. Some primal cuts need to be packaged in specific bags with identifying labelling pre-printed on them. Other primal cuts may only have printed labels applied after bagging or only on to the box/carton after packaging. Some export regions require a label inside the bag of primal cuts. All these different methods of labelling the bagged primal cuts requires some level of flexibility in an automated bagging system. Different sized bags, if using pre-formed bags, may require different sized tooling to handle the bags. Pre-printed bags will require manual or automatic changeover of the bagging material at different stages of production. Attaching labels pre or post bagging will require additional tasks in a completely automated system.

4.2 Bagging Requirements and Available Technologies

Currently available automated bagging technologies that might be used for the task of automated bagging of primal cuts were assessed. Additionally, available technologies that might be used as building blocks in the creation of a system for automated primal cut bagging from the ground up were also assessed.

4.2.1 Identification and Inspection

The first task for an automated bagging system is to identify the type of cut. This allows the correct packaging, label and any additional items placed inside the bag to be applied to the particular primal cut. Additionally, this task could include positioning or presentation of the primals where required for specific cuts and depending on the method of bagging. The primary requirements for this task are:

- Identification of primal cut
- Quality control inspection of primal cut, where applicable
- Tracking primal cut position and orientation, where applicable
- Determining position for placement of bone guard etc, where applicable
- Determining appropriate size bag or bagging material, where applicable

Currently there does not exist a complete solution to handle the full scope of this first task. Manual identification is required due to the enormous variability of primal cuts, in size, shape, colour, and weight. There is no single metric or detectable property to effectively distinguish individual primal cuts reliably. As such, more sophisticated sensing systems are required, combining multiple properties and algorithms to automate the identification process.

Automated quality control inspection has the potential to improve product quality and over time optimise yield in the boning process. Systems developed in other industrials typically utilise machine vision for inspection of products, identifying defects or quality control issues and verifying dimensional or other specifications are met. The challenge in migrating similar machine vision systems into the meat industry continues to be the variability and range of the primal cuts product. Although it can be done, in theory at least, the shear amount of design and development required for such a system generally outweighs the return on investment.

Tracking, determining positions and measuring dimensions for bag sizing can all be achieved with a variety of sensors. The most applicable would typically depend on space and environment requirements of specific meat processors, unless a single system could be developed that was capable of being customised to suit individual processors. Machine vision would be a prominent solution across all points. However, specific points such as measuring dimensions for appropriate bag sizing could be achieved with certain laser measurement or scanner systems.

There are some meat processors that have sophisticated tracking systems capable of tracking the identity of a primal cut from deboning all the way through bagging to packaging. These types of systems, where already available, could be used to identify the primal cuts as part of automated bagging. However, the requirement for a plant wide tracking system as part of automated bagging will reduce the overall cost benefits of such as system for processors that do not already have such a system installed.

A previous research project completed in 2017 for AMPC, project 2017-1064, does offer a possible vision based system capable of identifying naked primal cuts. [1][2] It combines dimensional, weight and colour tolerances, to identify each primal cut, and can be installed directly over existing conveyors. In theory, the same vision system could be modified and used for the rest of the points provided the consistent position of the primal cut can be assured after identification.

4.2.2 Transportation of Cuts

Transportation of the primal cuts is one of the most important tasks for potentially any automated system. The accuracy of determining/tracking the position while maintaining a consistent/controlled orientation of the primal cut is essential to the reliability of the entire automated system. Additionally, the method of transportation must not have a negative effect on the quality of the primal cut. The primary requirements for this task are:

- Movement of primal cuts from one place to another
- Singulate primal cuts
- Provide accumulation of primal cuts, where applicable
- Reorientation of primal cut and maintaining orientation

There is currently no specific automated system for this exact task, as the task is quite broad and very dependent on the method of automation of the other tasks. The current solution in most processors is a combination of conveyors and gravity chutes. Any other physical movement of the primal cuts is achieved manually by human operators. Increased handling of the primal cut, long delays in processing or inappropriate methods of conveyance, can increase the risk of contamination, result in excess weep or purge and ultimately reduce the product shelf life.

Any automated bagging system is going to require individual products to be separated from others at the point when they are physically bagged. Any overlapping product will inevitably cause failure of the system or attempt to combine more than one product into a single bag. From a production standpoint this will require accumulation of the product somewhere upstream from the actual bagging task. This is to accommodate the varying speed at which primal cuts are fed into the system and prevent it from causing a bottleneck in the overall production. Automating the accumulation of primal cuts will require either a large space where the cuts can remain separated or the cuts are lumped together and will have to be separated again prior to bagging.

Separation after accumulation can be achieved through strategic use of conveyors or some selective picking and placing automation. Picking and placing individual primal cuts from a lump accumulation of several cuts presents numerous challenges and an existing solution is not currently present. Separation through the use of conveyors and similarly accumulation through the use of conveyors is an existing technology that has proven effective in other industries. However, conveyors used for these purposes require a significant amount of space, which is a definite disadvantage in meat processors where space is very limited.

Reorientation and maintaining an orientation for consecutive automated tasks can be quite challenging. The way this is achieved in other industries is through omnidirectional style conveyors, narrow belt conveyors, sliding shoe sorter conveyors and right angle pushing mechanisms. Some of these conveyor orientation mechanisms are relatively gentle and designed for varying size, shape and weight of product, which would suit the variability and requirements of primal cuts. However, hygiene standards and cleaning of these types of conveyors will be quite challenging. They are not designed for wet food handling, and the numerous crevices and small recesses in most of the of roller mechanisms present quite a challenge to redesign such a system for a harsher wash-down environment.

Besides simple conveyors and conveyor based sorting systems, industrial robotics could be utilised for transporting and orienting primal cuts provided they have a suitable gripper mechanism. This approach mimics the current manual process more so than basic conveyor mechanisms. Instead of a worker picking up and manipulating a primal cut, a robotic arm would pick and manipulate the primal cut as required before placing it down on another conveyor or even potentially in a pre-formed bag. The challenge with this approach is the design of a robotic gripper and end of arm tooling which has the dexterity and strength to handle the primal cuts without damaging the meat.

Advances in artificial muscles and human-hand like grippers are continuing to develop, but are still relatively limited in industry due to their limited payload capacity and relatively high cost. The dexterity of these grippers simulates that of human hands, making them well suited to automated handling of primal cuts. If the load capacity could be increased while still maintaining gentle enough actuation to prevent damage to the cut this would be a viable alternative to exclusively conveyor based translation and orientation operations.

Another potential gripper is the Japanese designed SWITL, which loosely translates to "scooped-up transfer machine". [3] The SWITL is capable of picking up and moving Sol-Gel materials while preserving their shape. It works somewhat like a robotic spatula with a belt wrapped around a plate. As the plate extends or retracts, the belt moves to scoop up or place down the object. It is designed to handle delicate products such as pastries, sliced meat and liquid filled bags, all of which require their shape to be maintained during pickup and transport. [4] This technology has the potential to be able to automate handling of the naked primal cuts for picking, placing, reorientation and transportation.

4.2.3 Additional Items Placed on Top of Cuts

Some primal cuts have additional items placed inside the bag such as a printed label or a bone guard. The primary requirements for this task are:

- Identify type of cut and what items need to be included inside the bag
- Identify where the additional items need to be placed
- Pick the items from input fixture and place where required on meat or inside bag as required

Additionally, the location of the primal cut needs to be tracked, whether stationary or moving, after identifying where the items need to be placed, unless a capable vision system was integrated into the mechanism doing the final placing.

Assuming the identification of the primal cut has already been achieved in an earlier stage, the first point becomes a simple programmed input signal into this task. If the earlier identification step included vision capture and processing of the primal cut, then the second point could also be a programmed input into this task. How easily that information can be reused depends on the method of transportation and whether the position and orientation of the primal cut is reliably maintained.

Following identification, the next challenge is to determine exactly where the item needs to be placed. If the identification of the primal cut did not include sufficient vision to identify where the items need to be placed, then this task would require a separate vision system capable of identifying that position. This is particularly necessary for accurate placement of the bone guard, which in theory could be identified with other sensors. However, a machine vision system would be the most suitable in terms of accuracy, efficiency and cost. Furthermore, a machine vision system should allow for tracking of the primal cut if/or as required, and can be positioned on the end of an articulated robot arm which could be utilised for picking and placing.

The final point can be achieved with mechanical actuators or a small industrial robot with an appropriate gripper to handle the required items. With an appropriate design two or three linear actuators could achieve picking and placing anywhere over the primal cut in a specified area, whether stationary or in motion on a conveyor. This method could be more cost efficient depending on the situation, however given the amount of design required compared to the flexibility provided with an industrial robot the decision may ultimately depend on the other factors of this task as well as consecutive tasks.

4.2.4 Bagging of Primal Cuts

The process of placing the primal cut into a bag, or forming a bag around the cut, is a task that does have currently available automated technologies. When trying to research technologies that could be used as building blocks for a new automated design, the primary requirements are:

- Identify type of cut and length, width, height dimensions to select which bagging material or pre-formed bag to use, where applicable
- Move the primal cut into position to be bagged
- Open and pickup pre-formed bag, where applicable
- Place primal cut into bag, or form bag around primal cut

Additionally, the location of the primal cut may need to be tracked, whether stationary or moving, after it is moved into position to be bagged. Alternatively, the first point could be rearranged to be after the second point which would require a sensor system at the final position of the primal cut to be bagged instead of tracking the location up to that point. However, as with previous tasks, this first step could be taken as a simple programmed input from the earlier stage of primal cut identification.

The process of placing the primal cut into a bag, or forming a bag around the cut, is a task that does have currently available automated technologies. There have been two existing automated bagging systems identified and have been used successfully in meat processors. The first system utilises a flow wrapper to form a bag around the cut of meat, while the second system uses pre-formed bags and a robot to automatically open and position the bag for meat to be transferred in to the bag via a conveyor. [5][6]

The flow wrapper is a bagging technology that has been utilised very effectively in a wide range of industries. It can accommodate for the varying size of the primal cuts by automatically forming the bag around the cut, whether it is a large or small primal. The disadvantage of the flow wrapper is the amount of variation that can be handled in the actual packaging material. Where some plants may use a variety of pre-printed plastic for packaging of specific cuts or for certain export markets, using a flow wrapper to automate the bagging process would require changing the stock material repeatedly, unless space allowed for multiple flow wrapper machines.

Utilising pre-formed bags, the second system allows for greater flexibility in the packaging material when compared to the flow wrapper. However, only a fixed number of pre-formed bags can be used by a single system. Depending on the specific packaging requirements of a particular meat processor, a single robot bagging system may not be able to handle the full range of primal cuts. Multiple robot systems may be required to handle the size range of the primals that are produced.

After discussions with meat processors utilising both of these existing automation technologies, the general opinion was negative. Both the flow wrapper and the bagging robot required more bagging material which was an additional operation cost. The additional material also resulted in additional contaminated waste that had to be disposed of. Both systems had limited material or bag sizing flexibility, which meant not all products could be bagged with one system. The existing robotic bagging systems still require a human operator to correctly position each primal cut on the conveyor to ensure reliability of the system.

All of these issues make the existing automated solutions unfavourable or not economical for most processors. New or improved design for the task of bagging primal cuts is required to increase reliability, optimise the operational costs and reduce additional wastes generated by the existing systems. Furthermore, complete automation of all tasks should allow further reductions in manual labour and space requirements due to integration of safety and guarding across the whole system.

The task of moving the primal cut into position depends on the bagging process being used. If a flow wrapper, or similar mechanism for bagging, is used where the bag essentially is formed over the primal cut, rather than pre formed, then some form of conveying system would be used to transverse through the bagging, sealing and cutting process.

With pre formed bags, there is generally two options, either the primal cut is placed or moved into the bag, or the bag is put over top while the primal cut remains stationary. For the first option, a conveyor or chute could be used to translate the primal cut into the stationary pre-formed and pre-opened bag. The bag would need to be held open by some mechanical means, which could be a purpose designed actuators or a robotic arm.

For the second option, the bag needs to be held open and moved over top of the primal cut. This most likely will require the bag to not only be held mechanically but also move along a linear axis, typically. Again this could be achieved with actuators or, perhaps more likely, by a robotic arm. Alternatively, a combination of both options is possible, where both the bag and the primal cut are moving together. This may be advantageous for increased cycle time, but at this early development stage adds complexity.

4.2.5 Labelling Primal Cuts

After bagging some primal cuts need to be externally labelled. This task is similar to section 4.2.3 above, in that some but not all cuts have a printed label applied onto the packaging and that it is a fairly standard automation task. The primary requirements for this task are:

- Identify type of cut and what label needs to be applied to the bag
- Print the label and apply to the primal cut as required

Additionally, the location of the primal cut needs to be tracked, whether stationary or moving, to allow the label to be applied. Alternatively, a vision system integrated into the mechanism doing the final placing could be used. Identification of the primal cut can be passed from a previous task or be determined with sensors, as discussed in section 4.2.3 above.

A robot would be the best choice for automating this task if the location of the label varied with each primal cut and had to be relatively accurate. A robot could be used to apply a printed label anywhere onto the cut. It will require a vision system or a similar system that can provide the location data for the label to be applied. However, where exact positioning of the label isn't a concern, an automated label machine could potentially be integrated in a way that can accommodate the variation in sizes of the primal cuts.

4.2.6 Vacuum Sealing of Primal Cuts

The final task of vacuum sealing the primal cut has the highest level of automation within existing systems. The majority of meat processors already have automated or at least semi-automated vacuum sealing systems. These systems would require integration with the previous tasks to avoid the need for an operator to manually position or align the primal cuts with the seal bar in order to get a high quality vacuum seal. The primary requirements for this task are:

- Position the bagged primal cut along the sealing bar
- Enclose the primal cut and evacuate the air by applying a vacuum
- Seal the vacuumed bag
- Remove vacuum sealed primal cut

As automated vacuum sealing machines are already prevalent in meat processors and industry, there isn't much else in terms of available technologies to compete or augment existing systems. The majority of the design instead is directed at transportation and positioning of the primal cuts, as discussed in section 4.2.2 above, to eliminate the need for manual positioning or intervention.

5.0 PROJECT OUTCOMES

The fully automated primal cut bagging design presented here makes the following assumptions:

- Primal cuts are already singulated ahead of the vision identification section. This could be achieved with slow conveyor transferring onto the faster vision conveyor. There are other methods that could be utilised, but this section is not included in this design for the sake of simplicity.
- The design allows for minimal accumulation of primal cuts. Longer conveyor runs could be used to allow for some product accumulation. There are other methods that could be utilised, but is not included for the sake of simplicity. The design would need to be modified and customised to each individual meat processor’s throughput requirements and space availability.
- Primal cuts enter the automated system in the correct up-down orientation, i.e. none of the primal cuts must be flipped or turn upside down. It is expected that the only reorientation necessary is that the primal cuts be rotated clockwise or counter-clockwise. Furthermore, it is expected that any additional items, such as bone guards, will be placed on the top/side surface of the primal cut.

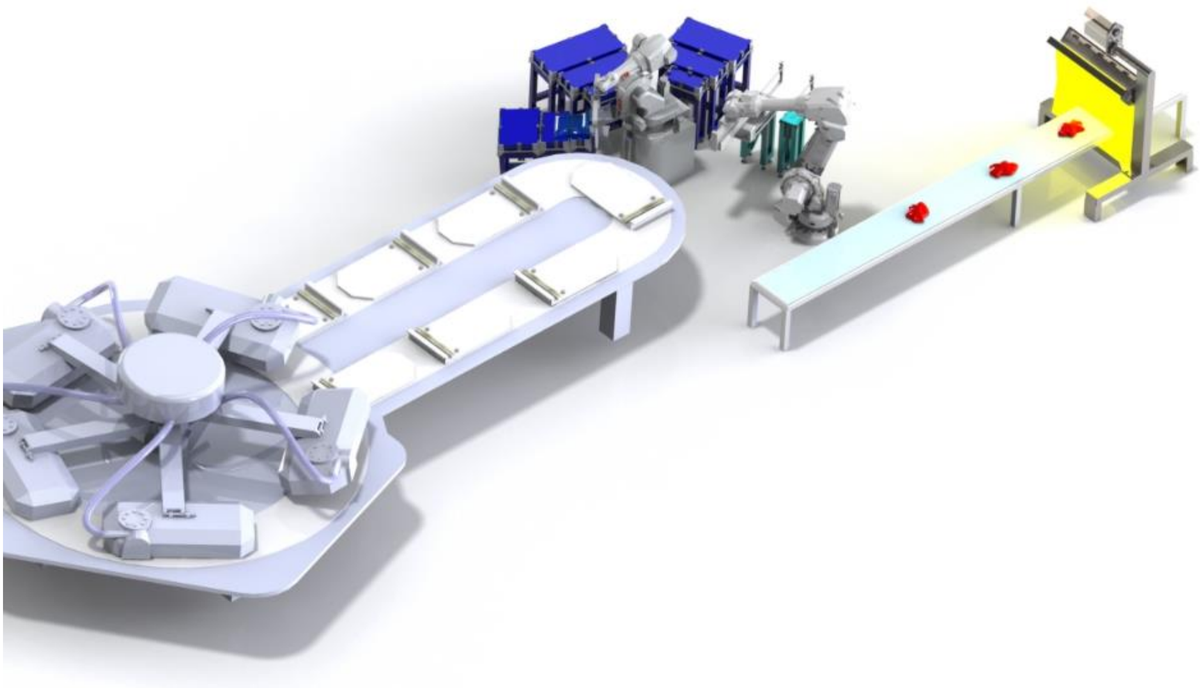

Figure 1: Overhead view of complete automated bagging system.

5.1.1 Identification and Inspection

The first step for the automated bagging system is to identify the type of cut, which allows the correct packaging, label and any additional items placed inside the bag to be applied to the particular primal cut. A stereo line scan camera with LED lighting bars is integrated with a typical belt style conveyor to capture colour images and generate a 3D point cloud of each primal cut. The image data is processed to identify the type of primal cut and track relevant positions of the cut for later tasks.

Figure 2: Stereo Line Scan Camera and LED lights for the Identification of the primal cuts.

5.1.2 Transportation of Cuts

Transportation of the primal cuts through the automated bagging system and between the various tasks will be achieved with standard conveyors and a specially designed robotic spatula type gripper. It is expected that this will allow for alignment and placement of the primal cut into a pre-formed bag with greater precision than current robotic bagging technologies.

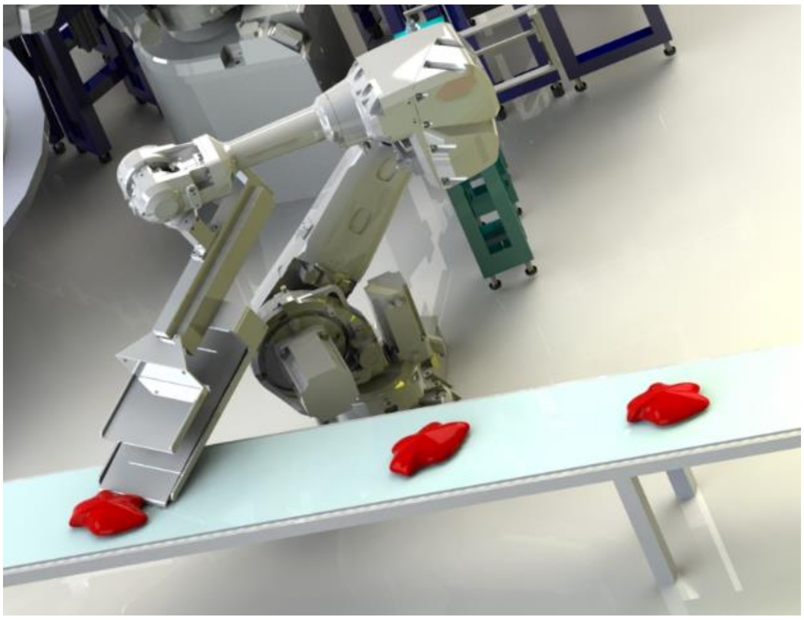

Figure 3: Robot with spatula type gripper known as SWITL

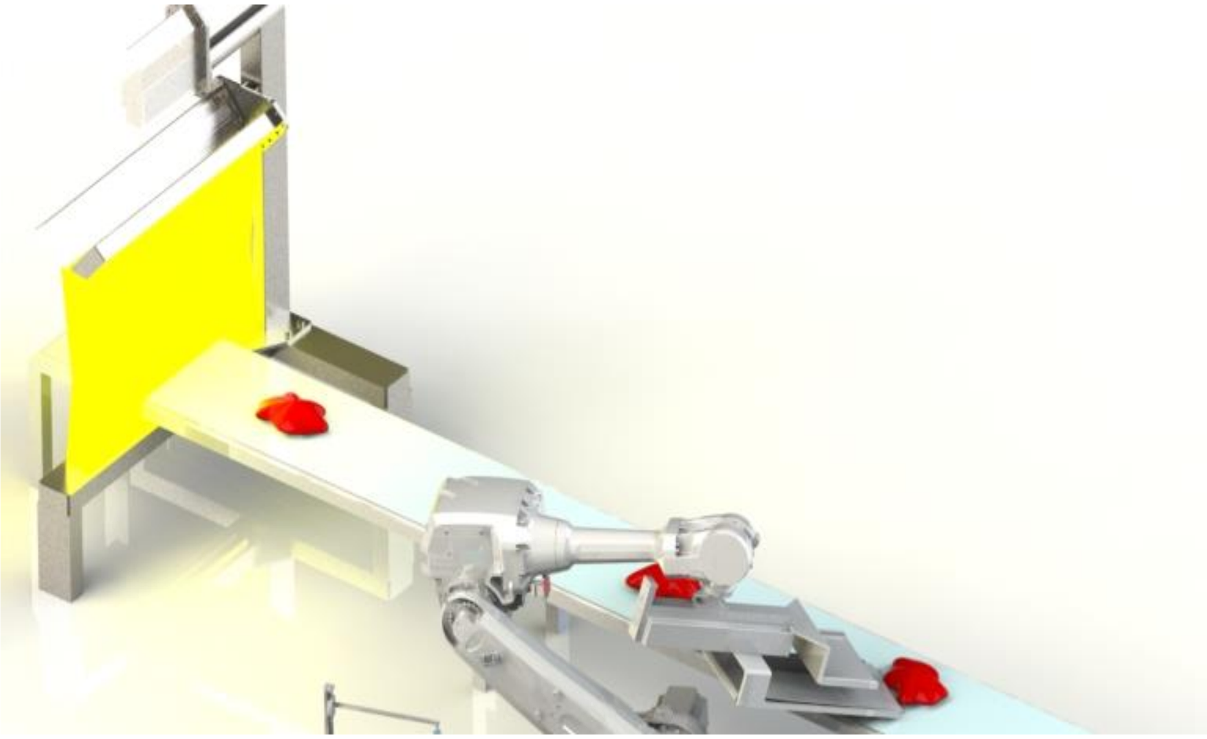

Figure 4: Robotic picking of primal cuts after vision identification.

5.1.3 Additional Items Placed on Top of Cuts

After identification, any additional items placed inside the bag will be determined and their placement coordinates passed to the robot. Once the primal cut is picked it will be positioned under a work station where the additional items will be positioned on top of the cut.

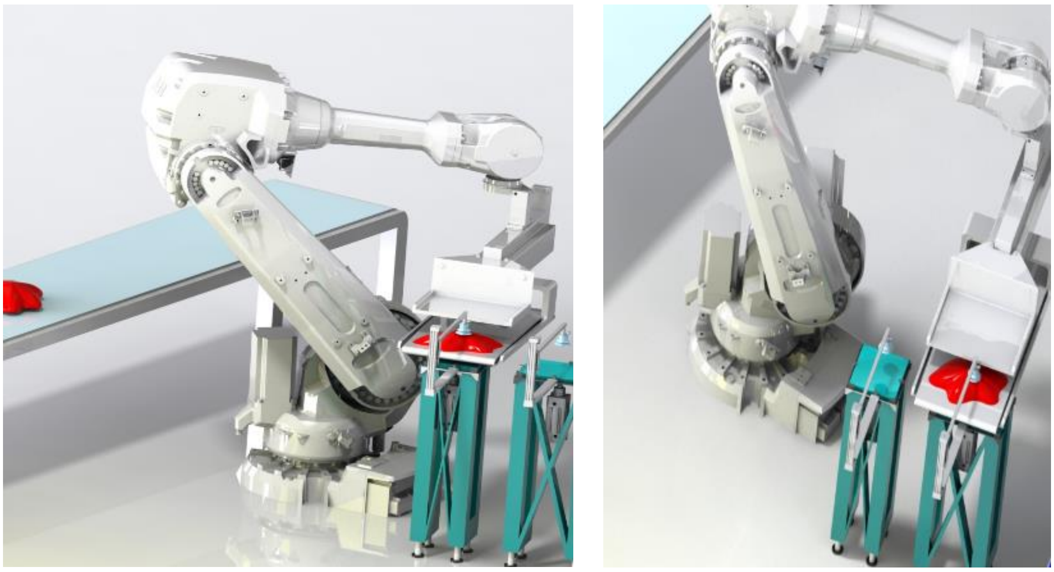

Figure 5: Robot positioning primal cut for placement of bone guard, etc.

5.1.4 Bagging of Primal Cuts

The bagging robot has been designed with 9 different sized pre-formed bag magazine bins. The magazine bins were based on the nominal sizing of the pre formed bags sold by Cryovac®, Sealed Air®. [7] A blast of compressed air inflates the top bag before the custom robot gripper grasps the open bag. The robot then positions the bag for an external label to be applied if required, before positioning the bag above the carousel of the vacuum sealing machine. Finally, the robot handling the primal cut positions the cut inside the bag, where it is released onto the vacuum sealing machine.

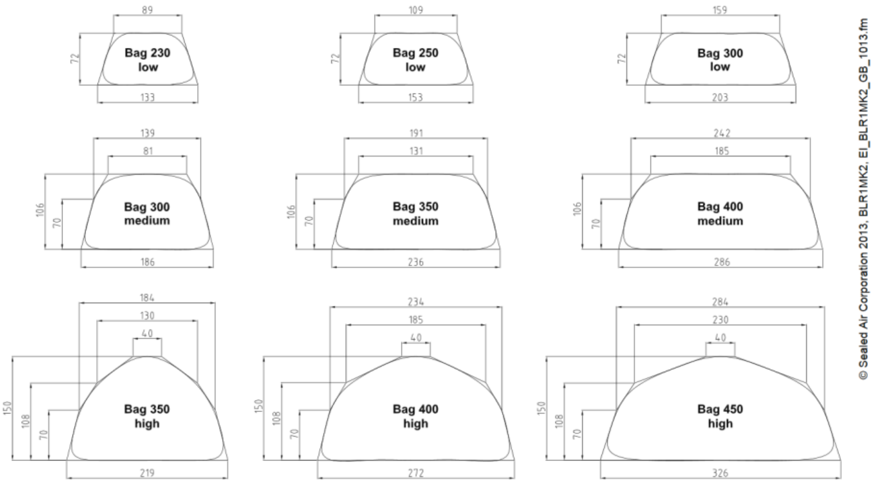

Figure 6: Illustration of the 9 bags with nominal sizing that the concept design was based on.

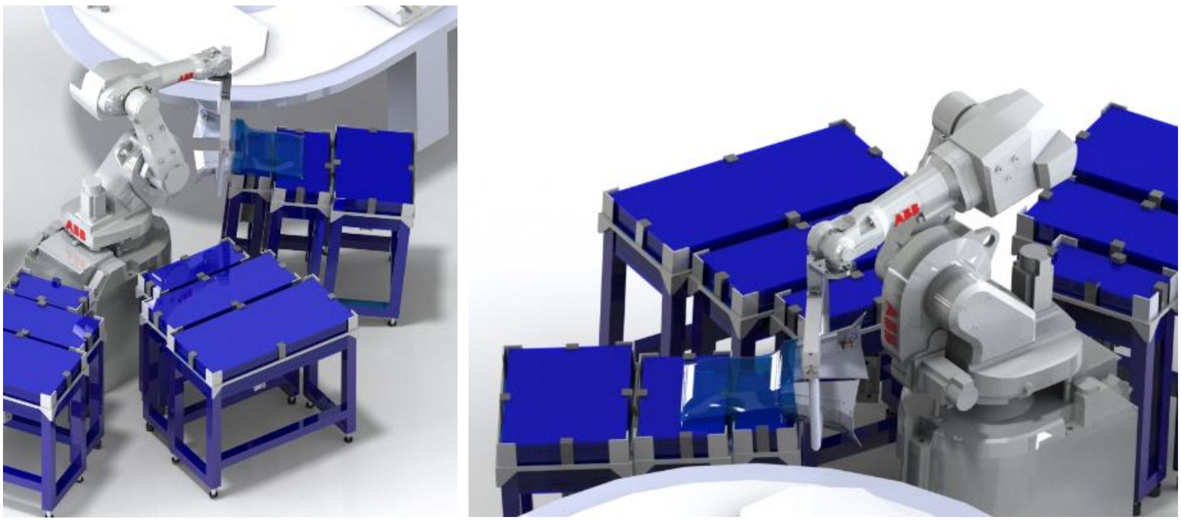

Figure 7: Bagging robot opening and picking pre-formed bags.

5.1.5 Labelling Primal Cuts

External labelling of the bags is similar to section 5.1.3 above. The bagging robot will position the bag to be labelled, as required, by the particular primal cut. In theory the label could be affixed to the outside of the bag or placed inside the bag.

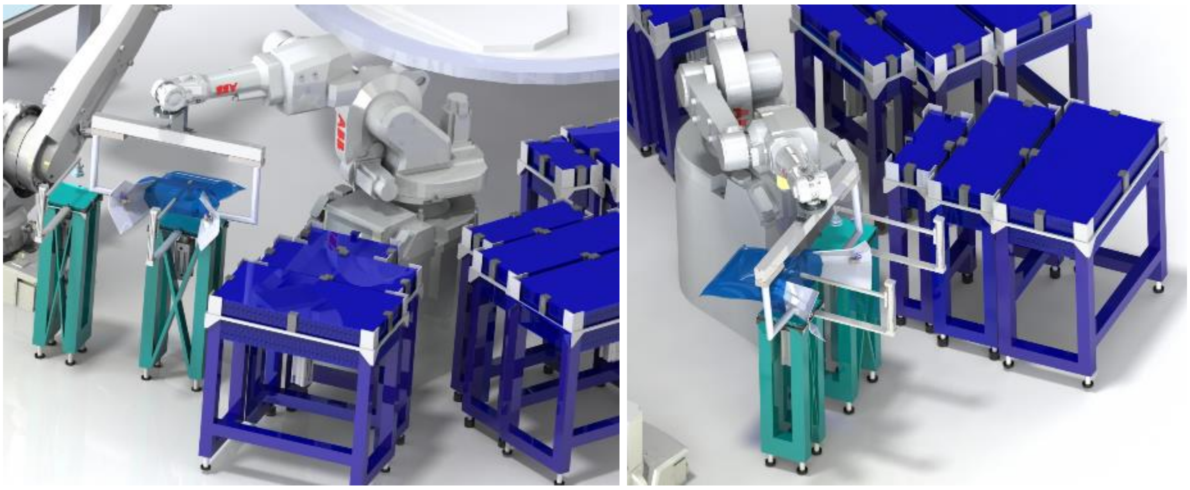

Figure 8: Robot positioning bag for labelling.

5.1.6 Vacuum Sealing of Primal Cuts

The majority of meat processors already have automated or at least semi-automated vacuum sealing systems. However, the majority still require manual operators to accurately position the unsealed bags onto the sealing bar of the carousel. The automated bagging system is designed around the actual placement of the primal cut into the pre-formed bag occurring on or above the vacuum machine carousel. This allows accurate positioning of the unsealed bag over the sealing bar by the robot and proper positioning of the particular primal cut inside the bag and on the moving platen.

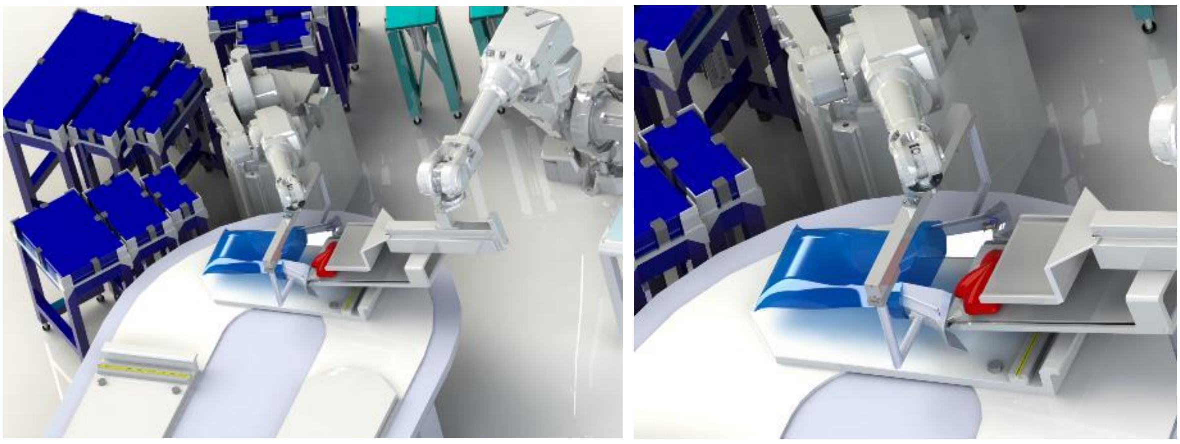

Figure 9: Robotic bagging of primal cut over top of the vacuum sealing machine.

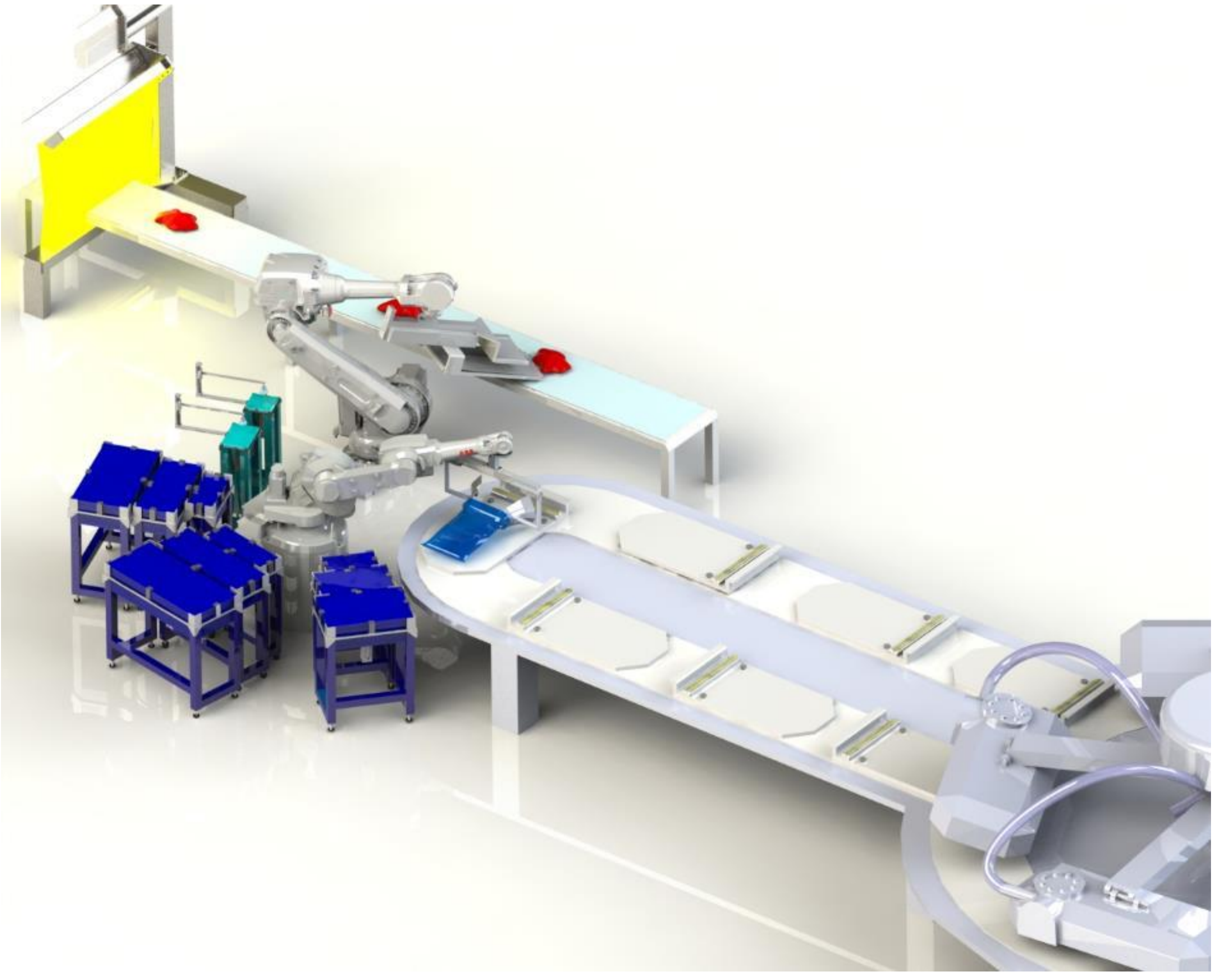

Figure 10: Overview of bagging area and vacuum sealing machine.

6.0 DISCUSSION

The final concept design of an automated primal cut bagging system presented here utilised three existing technologies that were identified within meat processors: The more or less standard conveyor systems was used to transport the primal cuts, an industrial robotic arm was used to pick and position pre-formed bags from a series of bag magazines, and a carousel type vacuum sealing machine to evacuate the oxygen and seal the bagged primal cut.

These existing technologies were selected as are already present in some processor facilities and there was no alternative technologies with significant advantages identified. The one alternative worth mentioning is the flow wrapper. Use of pre-formed bags was preferred due to the increased flexibility between bagging sizes and pre-printed materials. Furthermore it is assumed that the use of a flow wrapper machine would have physically taken up more space than the bagging robot presented in the design.

The remaining tasks in the automated design were based on current technologies that were identified as potential building blocks. The actual performance of these technologies included in the design is not yet known, they have not been utilised in equivalent production environments as yet. Nevertheless, with a few basic assumptions, their integration into the fully automated primal cut bagging system can be approximated.

To simplify the design, several assumptions were made for the specific requirements of the automation system. These were done to save space and time as the complexity added by not making the assumptions is generally physical and not technical. Singulation and accumulation will be necessary in an operating automated bagging system. But they must be customised to the design in each specific case. The addition of long conveyors for accumulation or staggering conveyors for singulation is a well understood design and so it was chosen not to be explicitly shown in the concept design.

Furthermore, in the ideal automated bagging system, the accumulation and singulation would both take place upstream from the identification and tracking system. This would be the most efficient design, assuming each step can meet the minimum required cycle time, and that the primal cut can consistently be tracked through the whole automated bagging system.

The design assumption requiring the correct up-down orientation was added to simplify the design requirements for manipulating the primal cut. The prototype design for the robotic spatula is yet to be tested on red meat products. In theory, once the primal cut has been picked from a moving conveyor, it should be able to be flipped any angle up to 180 degrees. However, this would require considerable research and development, prototyping and experimentation. And it is beyond the scope of this project.

In principal, this assumption would require the operators who perform the boning, or are otherwise the last to handle the primal cuts before bagging, to ensure that the cut is placed on a conveyor with the correct side facing upwards. Worst case scenario, an operator has to be stationed at the start of the automated bagging system to ensure the primal cuts are in the correct up-down orientation for the system. Once the concept design of the robotic spatula tool has been prototyped and tested, it would be feasible to further develop a design capable of this method of reorientation of the primal cut.

This concept design is focused on increased levels of automation and reliability and not specifically production throughput, cycle time or overall efficiency of the design. Further development is required in prototyping each design task, which will lead to optimisation of the overall design and improve the efficiency and reliability. Additionally, bottleneck areas of the design can be duplicated or adapted as necessary to increase overall production capacity.

Two robots could be utilised to pick from the conveyor, add any additional items and place the cut into a bag. This would not be simultaneously, but with each robot picking alternate cuts from the conveyor and using the other stations in sequence. A robotic arm could be used instead of the dedicated work stations for placement of additional items. This may only be advantageous when there is a range of different items and not just at total of two or three. Similarly a robot could be added specifically for applying labels, depending on space and desired throughput. As some larger plants already have multiple boning lines, multiple automated bagging cells may be necessary for maximum production rates.

7.0 CONCLUSIONS/RECOMMENDATIONS

Overall a suitable design for an automated primal cut bagging system was developed based on the current methods and assessed technologies. This design was focused on providing minimal manual operation. It is presented as a generic design and is expected to need to be customised to suit an individual meat processor, as well as to optimise the overall efficiency of the automation. This project has set the framework required for an automated bagging system. The system has the ability to integrate within an operating meat processor and communicate with additional automation systems downstream.

7.1 Suggested Next Step Points of Action

- Expand the scope of the naked primal vision identification system and automated picking and packing vision system for the additional requirements of automated bagging identified
- Recommended that a prototype of the robotic spatula design be tested with naked primal cuts to develop a method of automatic handling of naked primal cuts
- Prototype test cell of the bagging robot presented in this concept design, optimising the picking, positioning and opening of bags, as well as maximising the range of sizes available.
- Design, manufacture and test of prototype machine to position additional items, such as the bone guard and moisture absorbent pads, on top of the primal cuts
- Develop complete integrated automated bagging system into an existing meat processing facility with required automation safety components
- Increase the scope of the present design for automated bagging to handle additional reorientation of the primal cuts
- Further develop the automated bagging system to include quality control and assurance checks and/or automated grading and sorting

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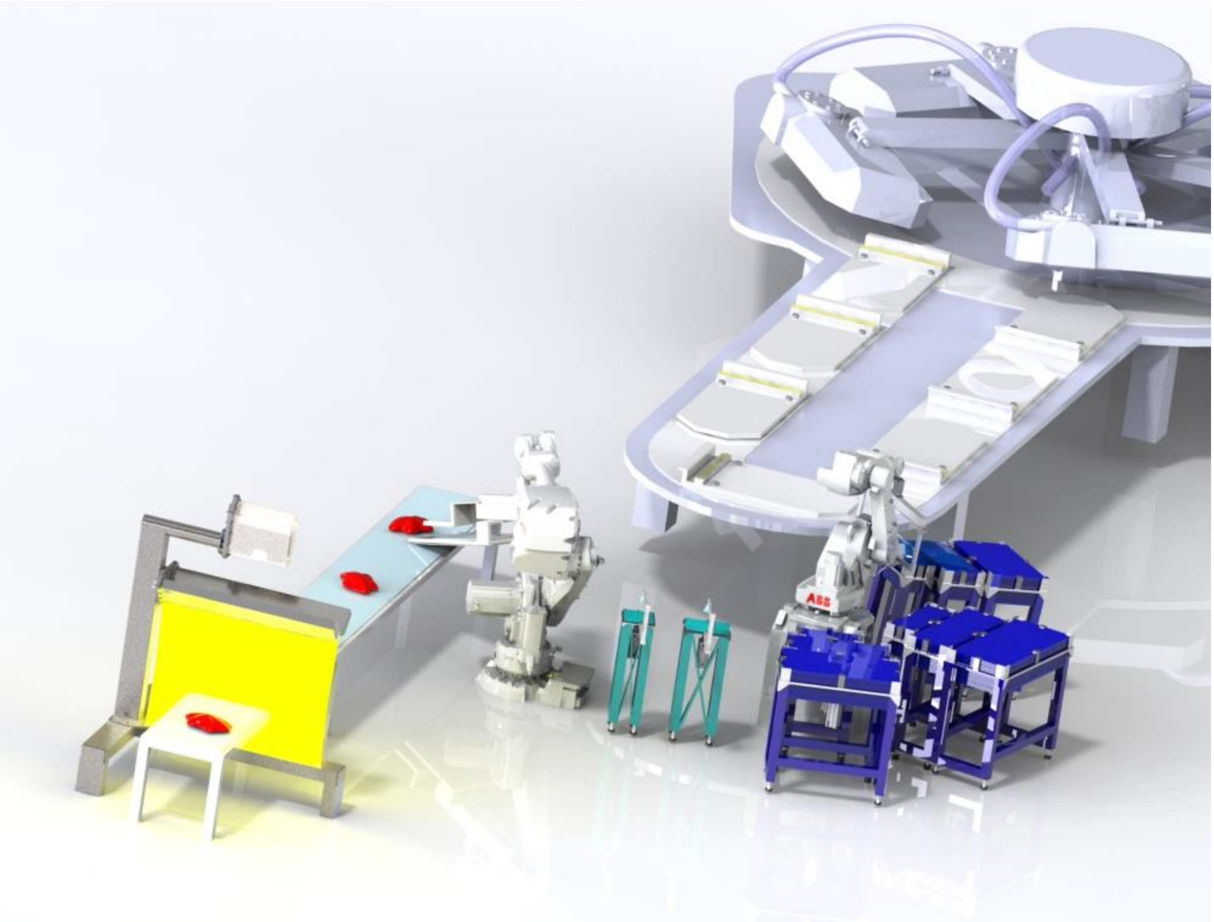
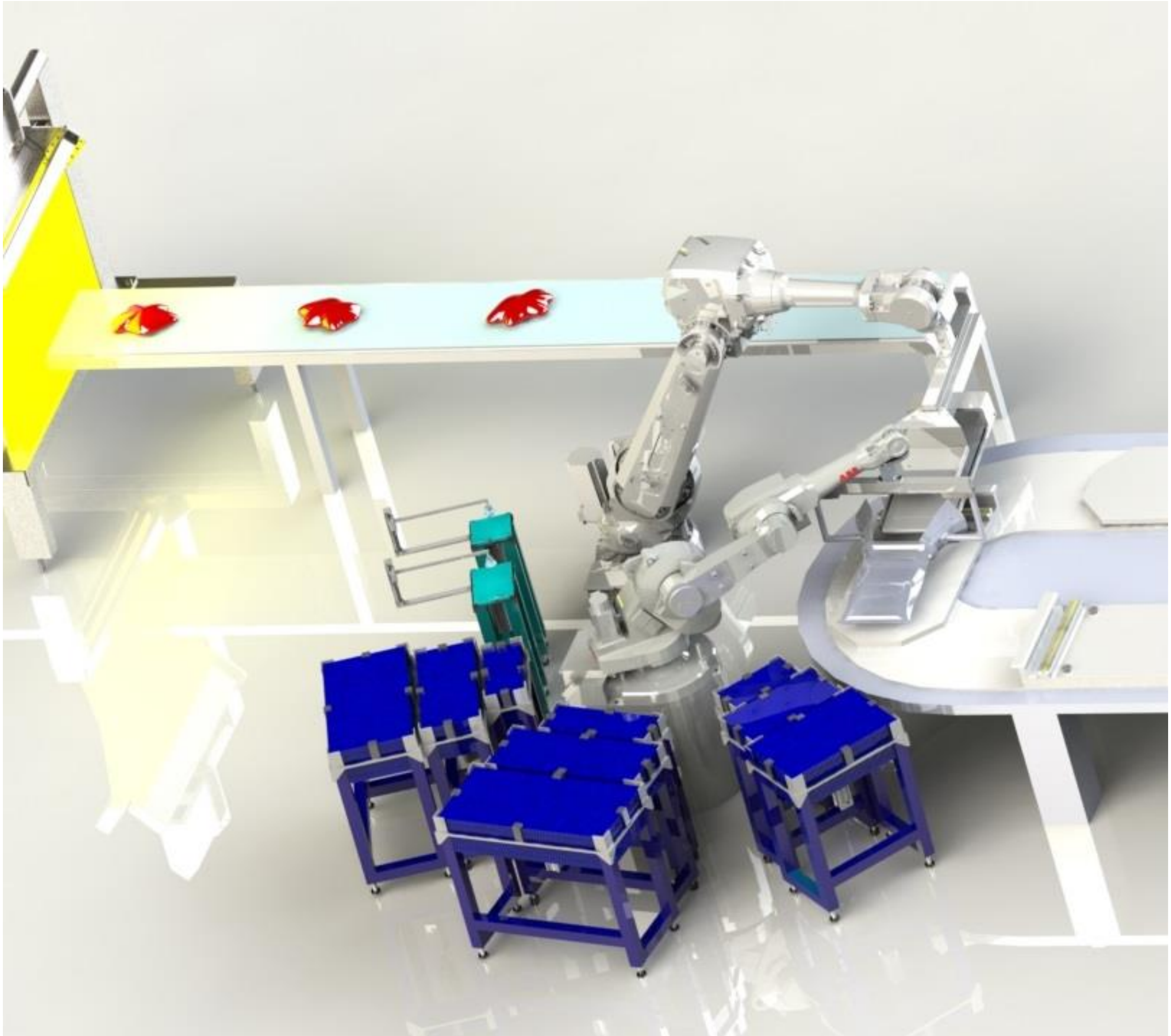
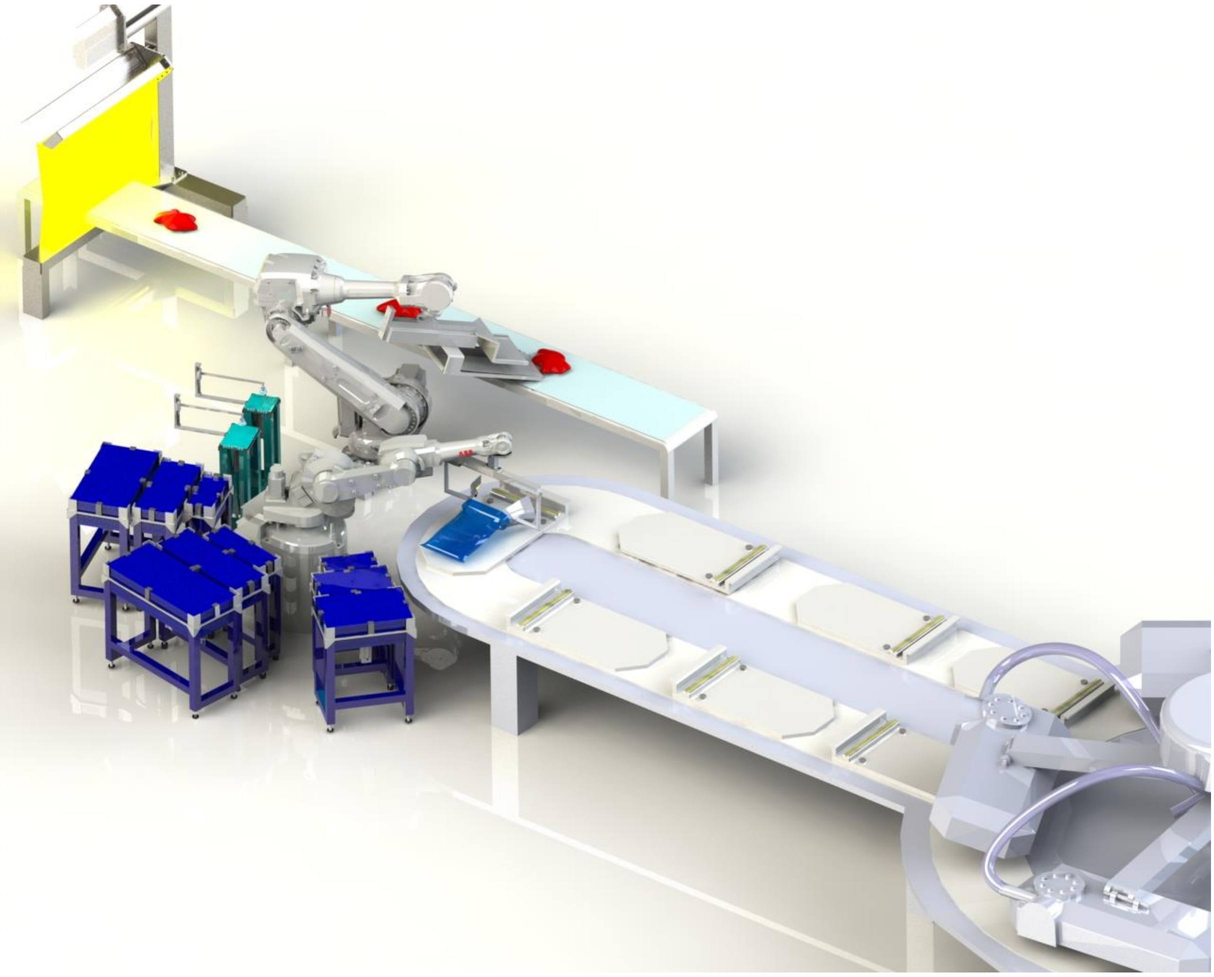
9.0 APPENDICES

9.1 Full Sized Concept Design Images







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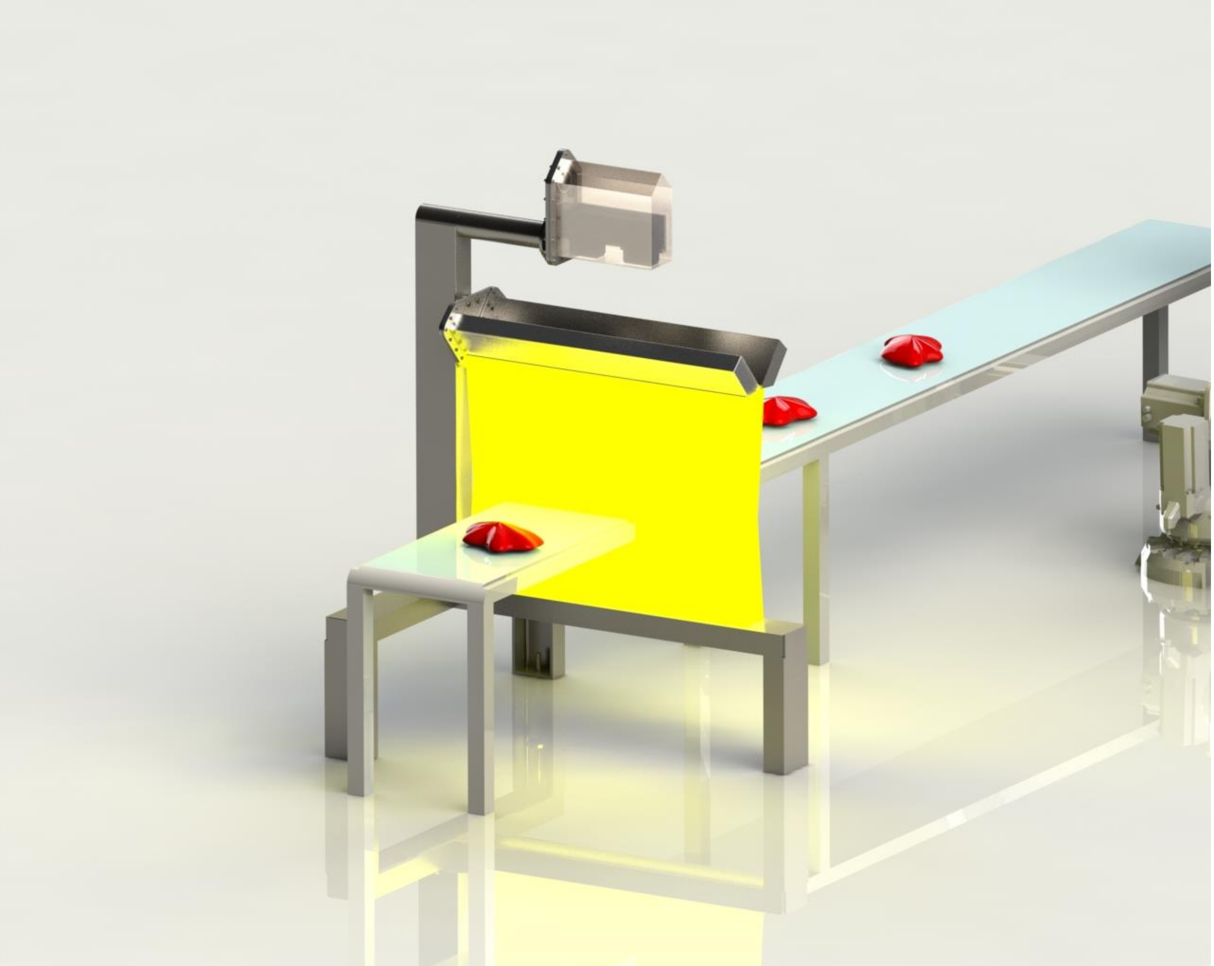

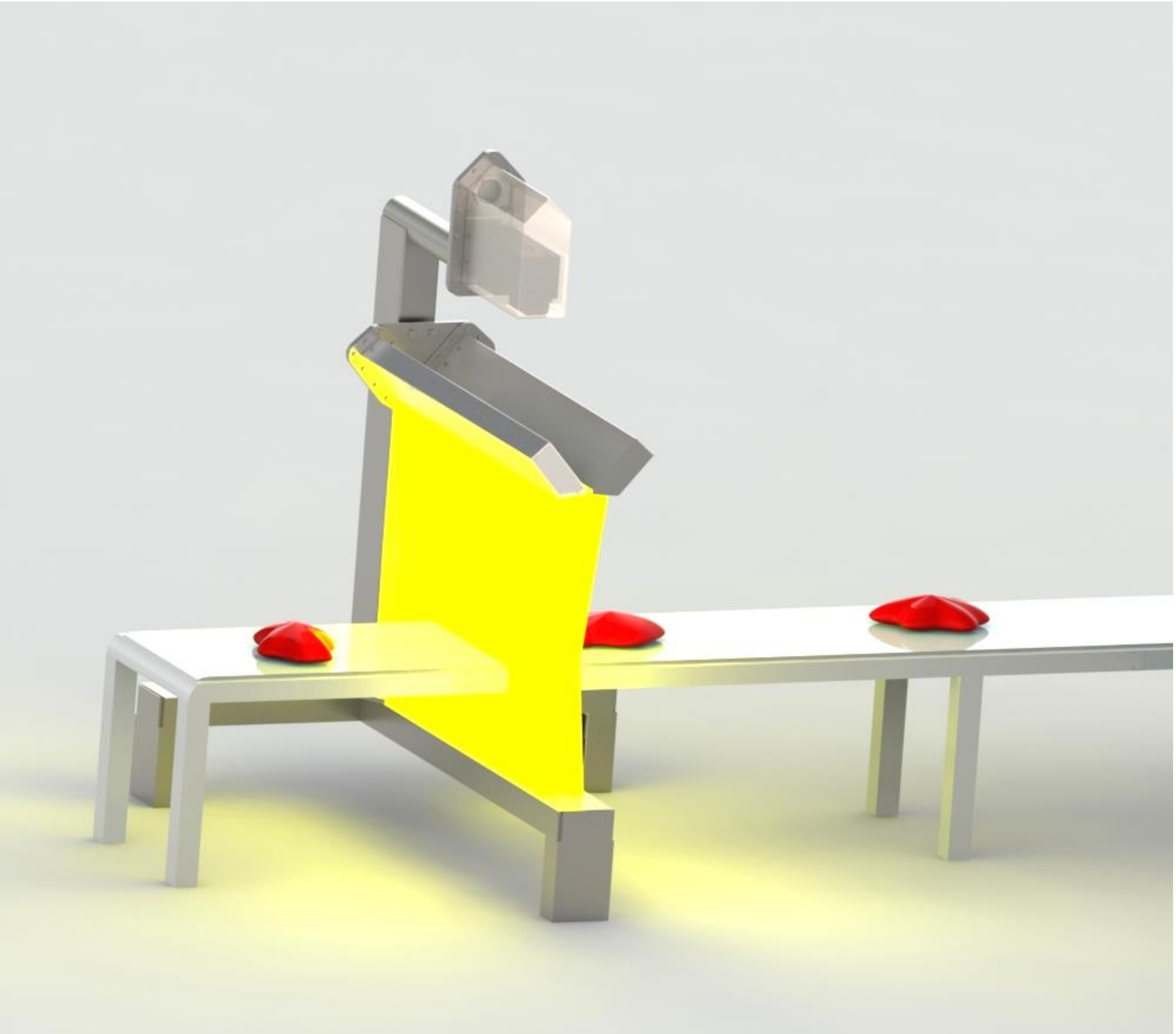

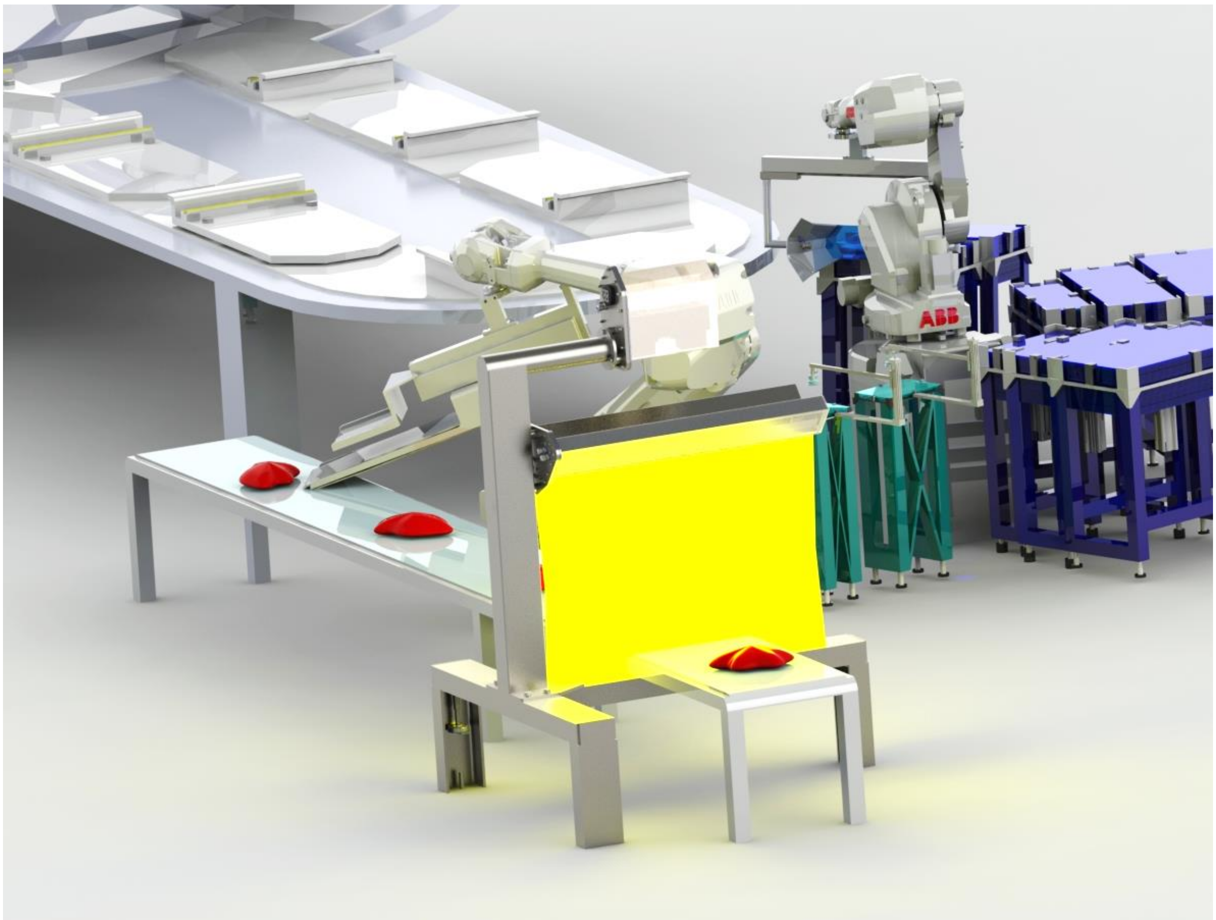
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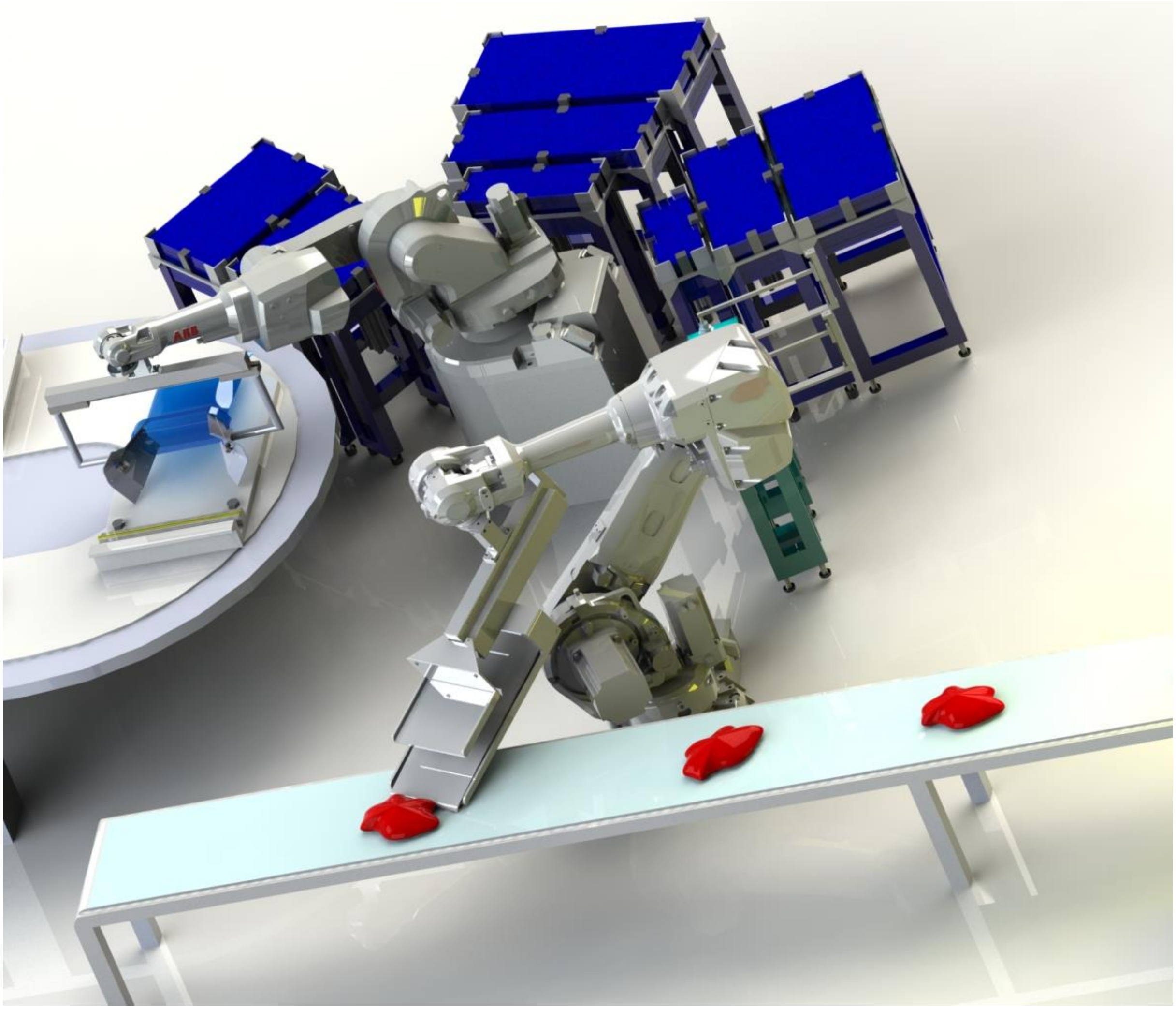

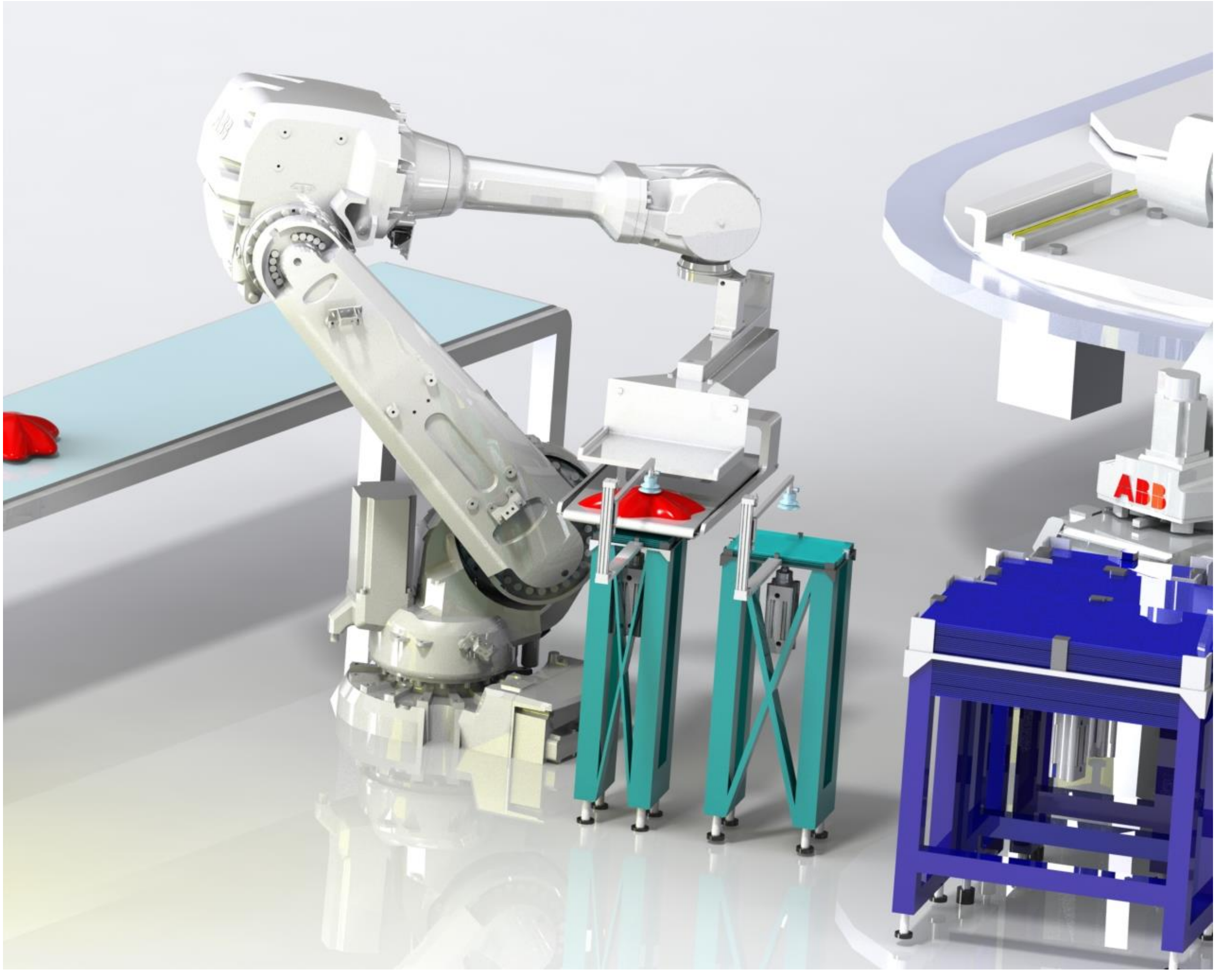
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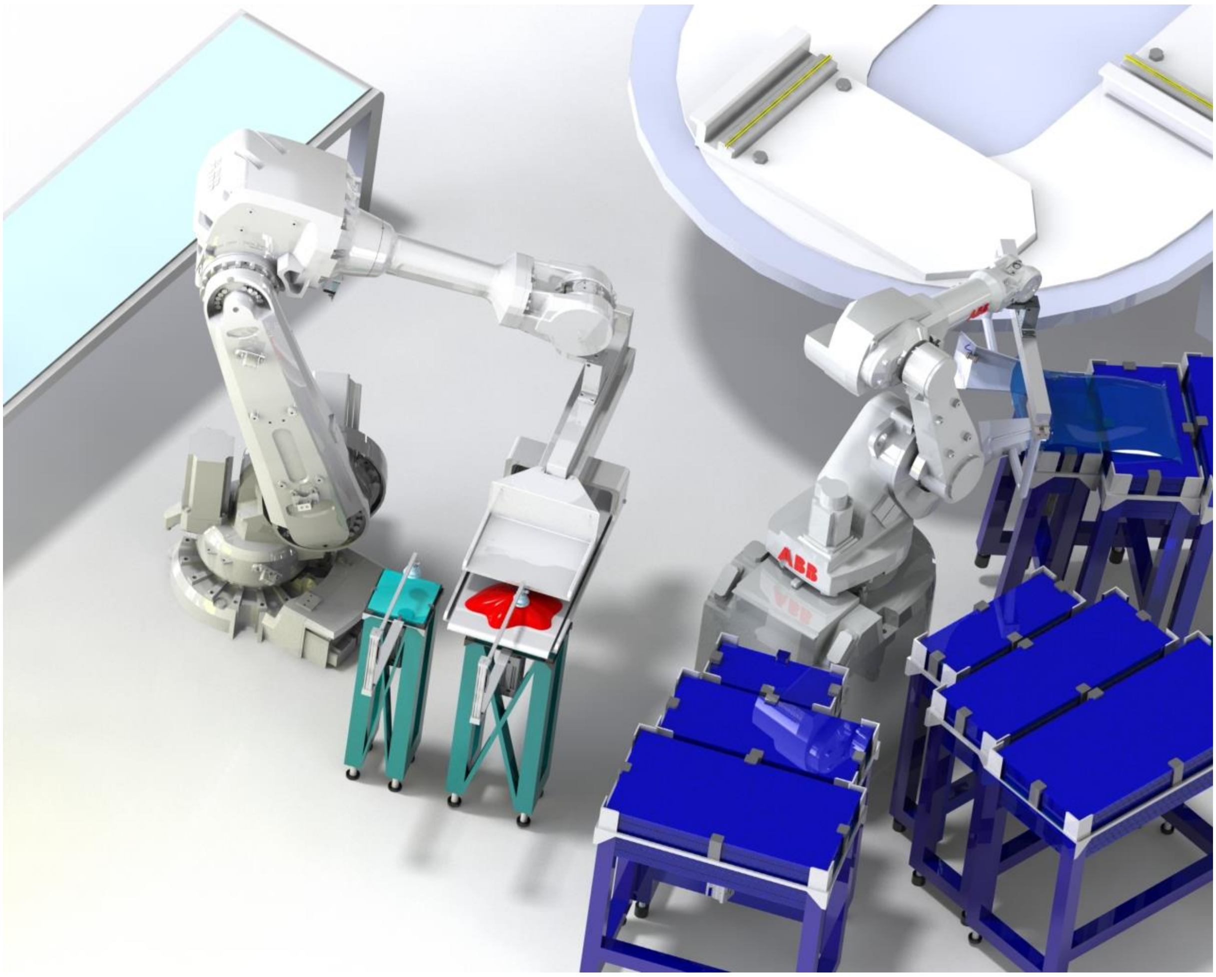
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