Rice packaging automation

Jay Shambhu Food Industries Pvt. Ltd, Nepal

(Mehta Heino Industries Oy, Finland)

HÄMEEN AMMATTIKORKEAKOULU
HÄME UNIVERSITY OF APPLIED SCIENCES

Bachelor's thesis

Mechanical Engineering and Production Technology, Riihimäki Campus

2018

Santosh Mehta

HÄMEEN AMMATTIKORKEAKOULU
HÄME UNIVERSITY OF APPLIED SCIENCES

ABSTRACT

Mechanical Engineering and Production Technology
Riihimäki

Author	Santosh Mehta	Year 2018
Subject	Rice packaging automation	
Supervisor(s)	Jussi Horelli	

ABSTRACT

The aim of this thesis project was to find or develop a solution for automatic rice packaging for Jay Shambhu Food Industries Pvt. Ltd (JSFI), Nepal and in collaboration with Mehta Heino Industries Oy, Finland. Rice is currently packaged manually in bag sizes ranging between 3kg, 5kg, 10kg, 20kg and 50kg and the daily production of the commissioner is several tens of tons of rice of different types. The demand for Automation is high in this field.

Background research on rice and food packaging machines was conducted for this project and the existing automation solutions were examined. A solution for the factory was finally suggested as an outcome of this thesis project.

Keywords Packaging automation, rice production, weighing hopper, automation

Pages 42 pages

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1 INTRODUCTION

This thesis project aimed to examine rice packaging machines and to provide information to help in the design of such machines.

In South Asian countries, most of the Industries do not have automation mechanisms which make work easy and fast. The reason behind not having automation is that the workers are available at a low cost. There are also problems with load shedding of electricity, and the cost of electricity is quite high, and competition is very tough.

The thesis was done for Jay Shambhu Food Industries Pvt. Ltd, Nepal (JSFI) in collaboration with Mehta Heino Industries Oy, Finland (MHI). The company was founded in 2016 by local professional businessmen who had an experience of more than 30 years in the rice business. This company processes high-quality rice, such as Basmati and Sona-Masuri Rice, and other varieties of rice are being processed.

As mentioned above, also with this company, manual work is conducted in packaging and weighing. Since this kind of work is repetitive, and workers are making weighing errors of 150-300 grams with every packet of rice and the sizes are 3kg, 5kg, 10kg, 20kg and 50kg. In this case, the packers cannot slow down the process to minimize errors or mistakes because there is a high demand for rice and they must work fast to meet the demand.

To solve the above problem, this thesis project aimed to find solutions for weighing and packaging / bagging of rice packages. The aim was to replace manual work with factory automation for weighing and bagging and to thus optimize the process.

The commissioning company is as of writing (December 2017) constructing a new factory where also automation is to be included. The findings of this thesis project could provide useful information for real-life applications. The company has given its approval for the author to communicate with the local engineers to discuss the solutions and problems in the process.

1.1 Rice production

In Nepal and India agriculture is the most popular occupation. Food is cultivated in huge amounts. Rice and other food demand are very high, and rice is one of the main foods used. The most popular rice sold is Parboiled rice and Brown rice. There are many rice processing factories which buy raw rice (paddy, as seen in Figure 1) from local farmers and process it for the consumer market. Figure 2 illustrates rice ready to be eaten (FAO 2018.)

Figure 1. Rice Paddy Field (Photoshelter n.d).

The factories (range from small to large in size, with an of approx. 15 tons – 200 tons /month) buy the raw rice paddy, filter and clean it and then process it in different ways to make the final product.

Rice processing plants usually do, besides cleaning, gravitational separation, polishing and separation by length. These processes together are is also called rice milling. Besides rice milling operations like parboiling, puffing of rice or flattening (beaten rice) can be done at the factories. (IRRI 2010.)

Figure 2. Rice ready to be eaten (Epicurous n.d.).

2 PACKAGING MACHINES

Historically packaging machines date back to the 1930's when their development started. The first packaging machines were patented in 1936 by Walter Zwoyer who invented the first Vertical Form/Fill/Seal (VFFS) Machines. (Triplemexpo n.d.)

In VFFS machines as illustrated in Figure 3, plastic bag material is provided to the machine in the form of a plastic sheet in a roll. The roll is fed to the machine and formed into a round or rectangular shape simultaneously as the material is inserted inside it and then the bag is heat welded shut. This forms a fully sealed plastic package readily filled.

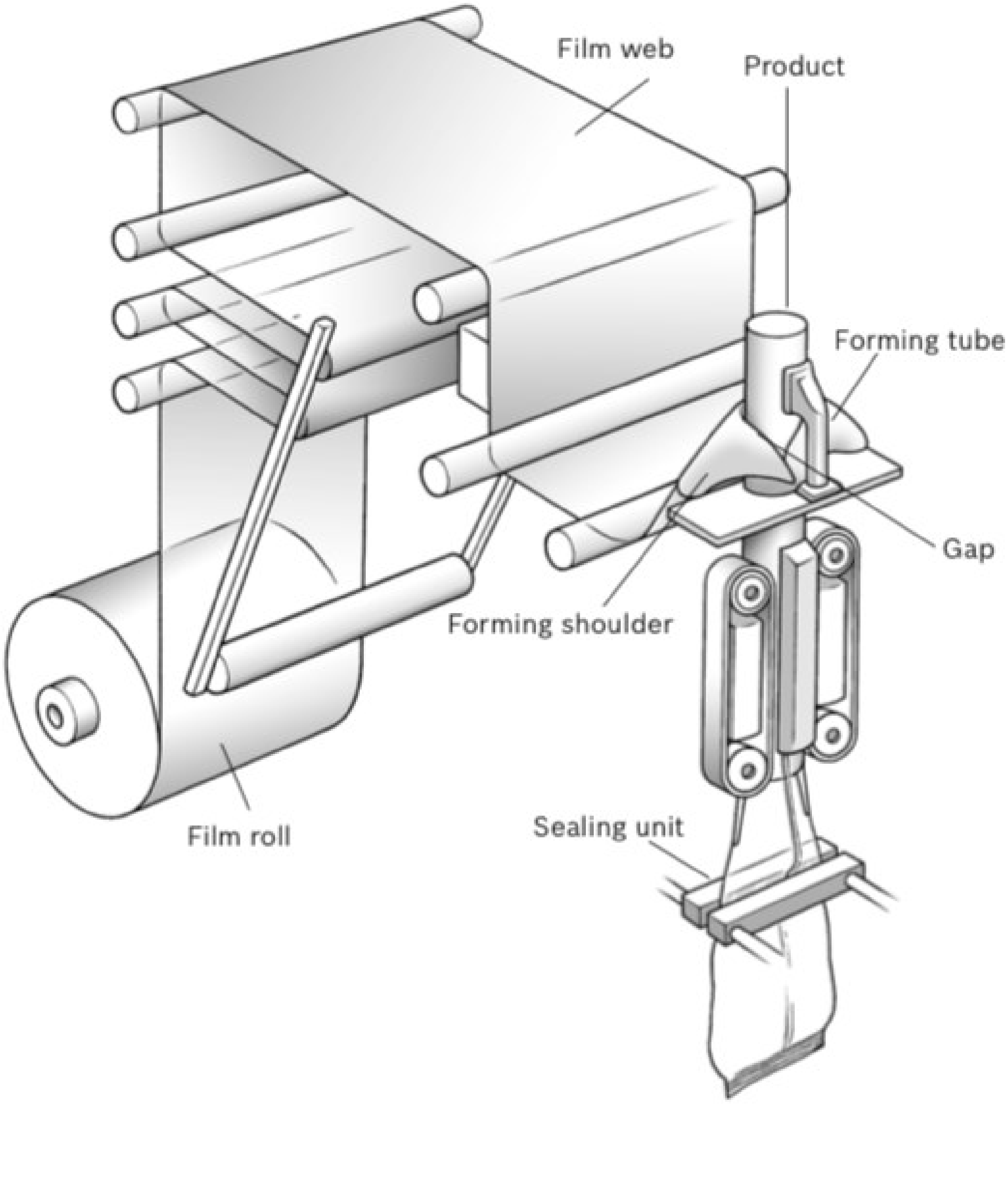

Figure 3. Vertical Form/Fill/Seal machine (Bosch Packaging 2014).

Also, similarly functioning horizontal packaging (Horizontal Form/Fill/Seal – HFFS) machines exist and many other different types of machines for ready-made bags and packages also.

Open-mouth bagging machines as seen in Figure 4 usually use ready-printed bags with package labels, logos etc. The bags are handled by special-made machines as singles, opened to be filled and then sealed after packaging.

Besides bagging, complete packaging machines usually consist of several units that complete the whole process, such as weighing, sealing etc. The machines are made in all sizes ranging from desktop-sized machines to factory sized ones and bag sizes of few tens of grams to several tens of kilograms. (Bosch Packaging 2014.)

Figure 4. Open-mouth bagging machine (Bratney n.d.).

2.1 Steps in rice packaging

For rice (and other food) packaging many fully automatic and semi-automatic machines already exist in the market with manufacturers ranging all over the world.

Ready solutions are available for both VFFS and open-bag systems. The machines are usually made for a specific work with quite a limited range of weight (for example 5 – 10 kg) and sizes of bags and the machines are not widely scalable for different package weights or types. (Bosch Packaging 2014.)

Rice is a free-flowing media that is commonly factory-processed in hoppers or tanks – therefore vertical (or flowing) way of transfer with the help of gravity is popular with it. (JSFI 2018.)

2.1.1 Convey/transfer of rice

Free processed rice is usually conveyed by means of bucket conveyors as seen in Figure 5, belt conveyor or vibrating conveyor at the factories. Different conveying methods are more suitable than others in means of hygiene and dust generation (rice grains breaking).

Free rice flows quite easily, and it can be even dropped several meters in processing without several damages depending on its processing.

A standard rice conveyance type, especially with large quantities, is the bucket conveyor. It moves rice gently and it is one of the simplest types of systems available.

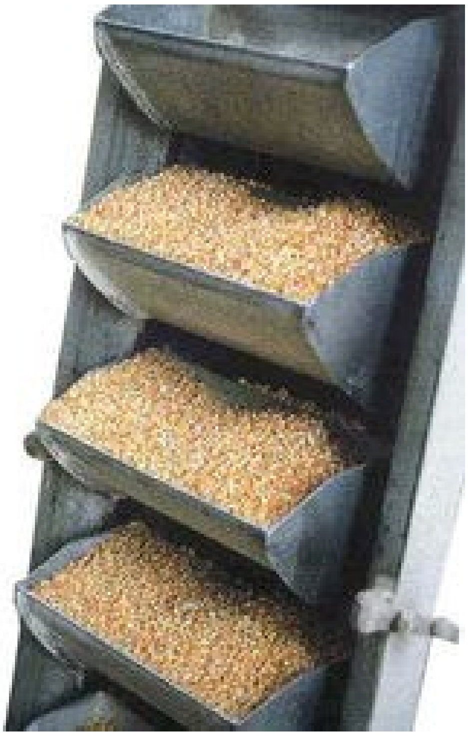

Figure 5. Rice bucket conveyor (Indiamart n.d.).

Screw conveyors (also called transfer screws) have a rotary motor that turns the screw to move that media inside linearly.

Screw size and motor type and motor power define its capacity, speed and accuracy.

Screw conveyors have to be installed in an inclined way as seen in Figure 6, for example, 10 – 30-degree angles – they are not suitable for purely horizontal conveyance at least with rice. (JSFI 2017.)

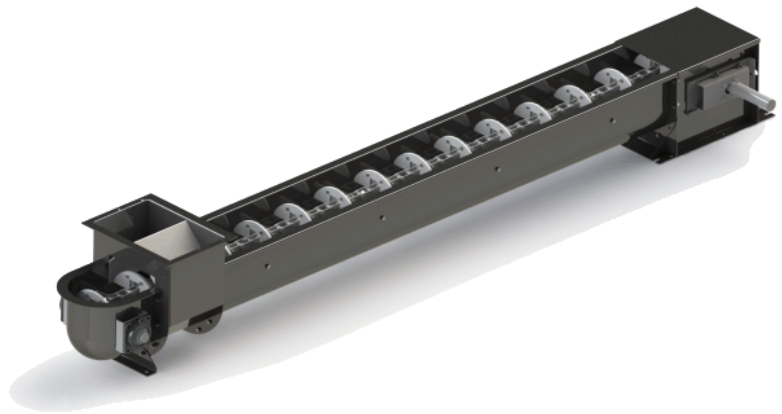

Figure 6. Screw conveyor (Screwconveyor.com n.d.).

Vibratory conveyance shakes the platform or container of the rice in such way that the pieces start rolling down the container as seen in Figure 7.

Figure 7. Horizontal transfer with vibratory conveyor (Meyer n.d.).

Vibratory conveyors can be used for many applications combined or mainly for horizontal conveyance in a small inclination. The period and magnitude of vibration can be controlled to adjust the amount conveyed. (Meyer n.d.)

Figure 8. Screening with vibratory conveyor (Meyer n.d.).

After packaging the rice, the ready-made bags can be transported on, for example, a conveyor belt or by robotic grippers. Grippers can be of a mechanical type or of a vacuum type.

Figure 9. Belt conveyor with a single bag conveyed (Rollcon, n.d.)

Figure 10. Vacuum sack and Bag Lifter (Palamatic n.d.).

2.1.2 Weight Measuring

Packaging machines usually include a separate or an integrated weight measuring machine. The machines usually operate by measuring the loss-in-weight of the system. Weight measuring is done by load cells that measure usually the weight of the whole assembly. The amounts of weight added or removed from the machine are detected. (Bosch Packaging 2014.)

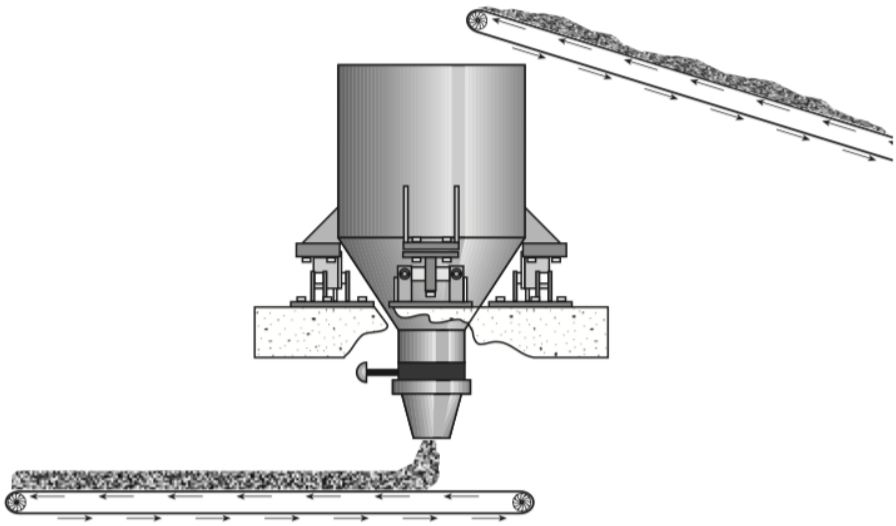

Figure 11. A typical loss-in-weight weighing hopper. Notice the three supported legs mounted on load cells in the picture (Rice Lake Weighing Systems 1997).

Load cells are a standard industrial component to measure the weight of structures. Load cells use strain gages to detect structure deflection under stress electrically. The weight measuring feedback and bag filling is controlled by the packaging machine's electronics. Calculation of the strain gages data requires advanced circuitry and calculation from the weighing machine.

Figure 12. Shear type load cells of different sizes (Meltrons n.d.).

Weight measurement of this type usually consists of a combination of a hopper collector for material and controlled valves of flow in and out. Material discharge can be controlled by means of gravity and chutes (opening gates), transfer screws, bucket elevators, conveyor belt etc. (Siemens Level and Weighing n.d.)

Besides weight measuring systems also volumetric ways could be used but this method is especially not suitable for rice. Rice weight is highly dependent on its type and moisture level and its density can have variation depending on its processing.

2.1.3 Bag filling

Bagging the product in plastic bags can be done in mainly two ways; VFFS or open-mouth bagging machines. Usually the machines pre-weight the amount to be inserted in the bag and then when the bag is ready, it is filled.

VFFS machines are widely popular especially in packaging products for the European market where bag sizes are usually quite small (less than 2 kilos) but VFFS method is also suitable for large bags (several tens of kilograms). (Bosch Packaging 2014.)

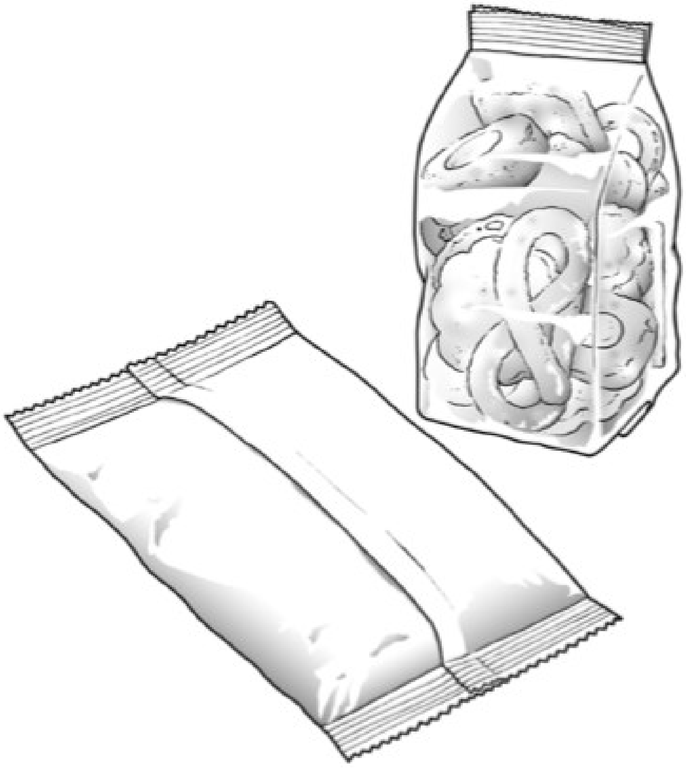

Figure 13. Some VFFS bagged products examples (Bosch Packaging 2014).

In open-mouth bagging machines, bag handling is divided into tasks consisting of at least bag opening, bag holding/placing and bag closing. Bag handling machines usually consist of precise bag handling mechanism implementing vacuum suction cups and/or mechanical grippers to open, hold and move the bags.

Figure 14. Open-mouth bag filling (Imeco bagging 2012).

Also, semi-automatic bag filling machines are available on the market where the machine operator inserts the bag manually in the machine's bag holder to be filled and the machine then automatically fills the bag.

Machines are available for all sizes of bagging. These types of machines are popular especially for heavy bags (several tens of kg) and low to medium quantity production.

Figure 15. Semi-automatic machine bag insertion (Premier Tech Chronos 2013).

2.1.4 Rice bag types

The type of bag material used in the machine usually defines the means of conveying, handling and sealing. Popular materials for rice packaging are of transparent or printed plastic bags and of non-transparent plastic nonwoven bags that can be also printed with product labels.

Bags made of food-safe Polypropylene (PP) or Polyethylene (PE) plastics widely used in food industries. Plastic properties such as density can be modified to make the bag permeable and adjust its strength.

Simple, basic plastic bags can be VFFS produced (heat sealed PP or PE bags) or separately purchased as open-mouth bags. The bags are supplied in different thicknesses usually starting from 0.02mm thicknesses. (Webstaurantstore n.d.)

Figure 16. Heat sealed food bag (Dreamstime n.d.).

Another type of bag is the nonwoven bags. These are heavy duty permeable bags that are easy to transport even in large bag sizes.

Nonwoven bags can be made of jute fibres and polypropylene and they can be eco-friendlier. The bags are usually produced by means of sewing them similar to woven type bags. (Vishal Synthetics n.d.)

Figure 17. Nonwoven fabric (Greenstorage n.d.).

Most sophisticated type of nonwoven bag is on which has an inside liner. The liners can be inserted in bag production or in the process of bag filling. They can be sewn together with the bag, so it is mechanically bonded to the outside.

Liners provide extra protection to the packed product against the environment and moisture whereas the nonwoven bag provides heavy duty mechanical protection on the outside.

Besides the mechanical properties, rice package type presents better or worse properties in the transport of rice. For example, fully sealed bags can be weaker than permeable bags especially if handled roughly. Sealed bags can get punctured and tear easier or then even explode if under high compression. These properties are especially important in larger bag sizes (more than 2 kilos).

Figure 18. Different nonwoven rice bags (Kalorful n.d.).

Also, special bags that try to combine both the strength of nonwoven bag and the use of liner into a more advanced engineered bag are available. These bags combine usage of woven or nonwoven fabric and are laminated from one side with a plastic film, and have different names, such as the BOPP bags.

BOPP bags handling is similar to thicker single-layer bags. They have their advantages and disadvantages.

In larger rice bag sizes, usage of BOPP bag is not so easy as two-layer non-woven bag since BOPP bags are mainly meant to be opened for single time use and it can be challenging to close it later on (for example they cannot be wrapped like the liner of two-layer bags to close the bag) and they cannot be recycled similarly.

Also, the price of BOPP bag can be several multiples of the price of two-layer nonwoven bags. (United Bags Inc. n.d.)

2.1.5 Bag sealing

After filling the bag, the rice package is sealed. Different sealing methods are available, but two methods are most popular for rice, heat sealing and sewing.

Heat sealing is a widely used method in food packaging. The plastic material is heated up, so it is viscous and then the pressure is applied to the sealing area usually presenting a set of jaws.

In the heat-sealing process, there are a lot of factors that affect the success of the seal. In VFFS machines the heat-sealing parameters play a big role since the process is fast and plastic may not have enough time to cool and relax to its proper strength.

Another challenge with heat sealing devices could be the cleanliness of the jaw surfaces, process (heating) parameters, variations in raw material etc.

Figure 19. Desktop size manually operated heat sealing machine (eBay n.d.).

Heat sealing methods vary from common heat pressed sealing, impulse sealing, ultrasonic sealing, high frequency sealing, induction sealing etc. (Labthink n.d.).

Sewing, especially for heavy (more than 2 kilos) rice packages, sewing is a very popular and widely used method used with nonwoven bags.

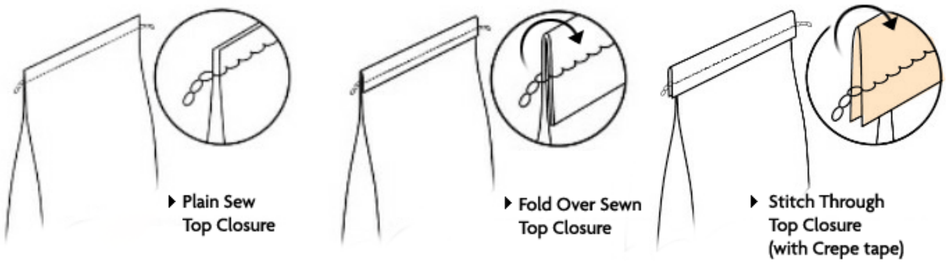

Figure 20. Bag sewing closure types (Inpak Systems 2017).

A thread is used to sew the bag closed providing a strong and durable connection that is air permeable and water resistant. (Vishal Synthetics n.d.)

Sewing machine systems range from integrated into the bagging machines to portable manually operated sewing machines.

Sewing machines normally use standardized stitches. The stitching leaves small gaps which are not an issue with double layer (liner added) packaging of rice.

Sewing systems can also integrate bag closures, tags etc. that are automatically inserted in the process. These may be implemented in products where leaking of the bag is an issue or additional protection is needed. (Inpak Systems 2017.)

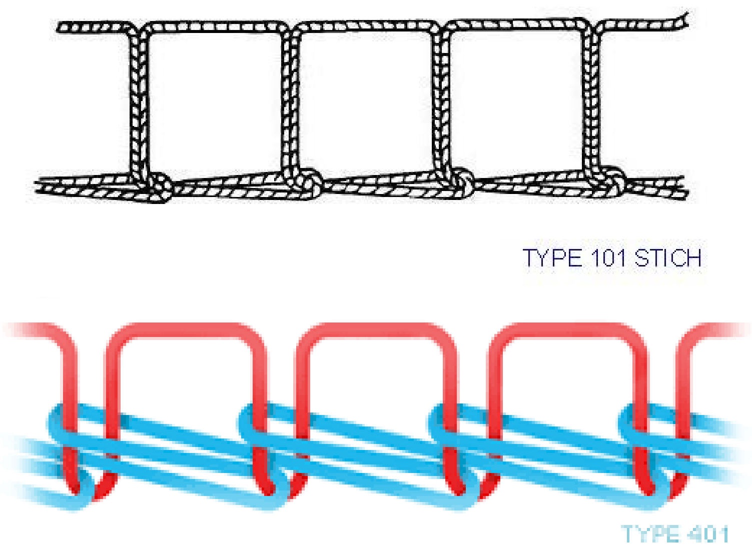

Figure 21. Standard stitch types. The pattern on the right, type 101 is normally used in portable sewing machines. (Inpak Systems 2017.)

3 FACTORY APPLICATION

The factory application was specified together with local engineers on site at Jay Shambhu Food Industries (JSFI) Pvt. Ltd, Nepal.

At the minimum, the packaging automation requires a new solution for weighing and packaging (bagging) the rice.

The factory has industrial pressure air capacity and basic control systems done with industrial PLCs. They also have long experience designing and building conveyor systems and other rice production equipment and integrating ready solutions to their processes.

If ready solutions are found that could be integrated into the process, they would be preferably used to save the time of construction and design.

One of the wishes was that the developed system would be able to be modified later in the future according to factory needs.

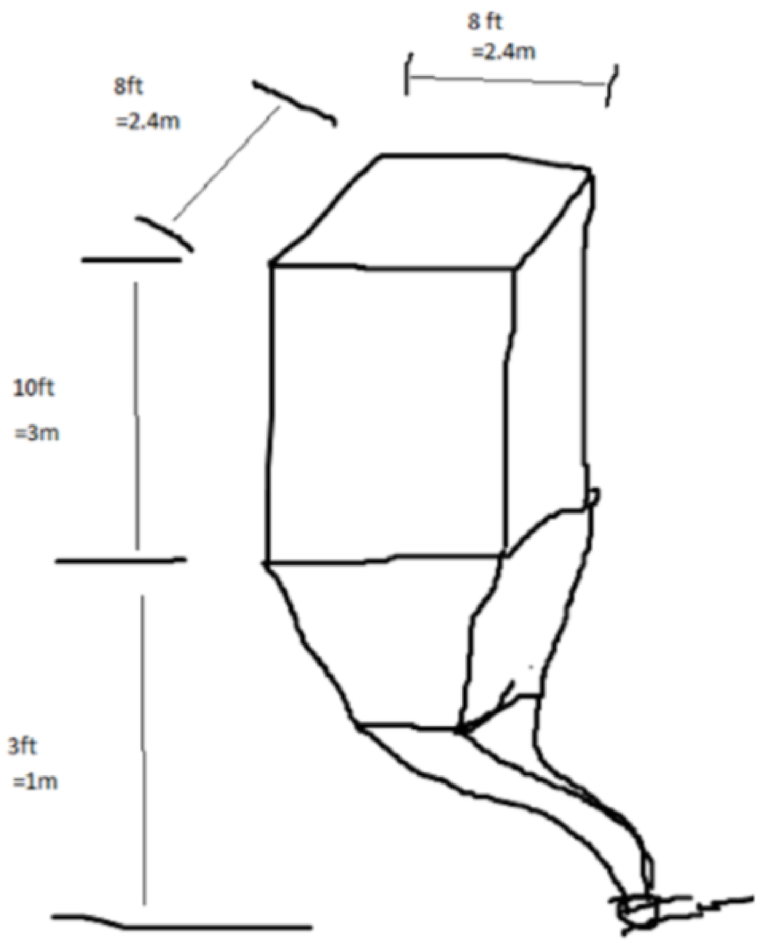

Figure 22. Rice tank / collector (JSFI 2017).

The machine has to fulfil the following demands (JSFI 2017):

- Rice tank volume at the factory: $\mathbf{2.4m * 2.4m * 3m = 17.3m^3}$
- Rice density: $\mathbf{900kg/m^3}$approx.
- Rice production (per single tank): 20-40 Ton/day
- Target for bag filling accuracy: $\mathbf{10kg\ \pm 0.1kg}$
  → max. error of 1% at 10 kilo bags
- Bag sizes: 3kg, 5kg, 10kg, 20kg and 50kg.
- Bag type: nonwoven bag with liner

The work is currently done manually in three shifts when needed and the bagging process involves 10 or more workers. The automation machine would optimally be completely independent or require only one or two operators.

Bagging speed, the approximate bagging speed requirement can be calculated from the data.

If per day 20 Ton minimum is bagged in 10 kg bags, daily production is 2000 bags.

Velocity (v) of bagging per hour is therefore

$$\mathbf{v = \frac{x}{t} = \frac{2000bags/day}{24\ hours/day} \approx 84\ bags\ per\ hour}$$

where,
x is the amount of bags
t is the amount of time

We want to find out the amount of time per bag in seconds:

$$\mathbf{t = \frac{x}{v} = \frac{1}{84\ bags/hour} * 3600\frac{s}{h} \approx 42\ seconds}$$

The answer is that bagging can take approximately 42 seconds per bag.

3.1 Approach

Ready commercial solutions are available for weighing the process materials and automatically feeding them forwards in the process. The findings are discussed in –chapter number 4.

Bag handling and filling machines are available for nonwoven bags with automatic sewing to close the bags but at the time of completing the thesis (end of the year 2017), no such machine was found for nonwoven bags with liner.

Usage of the VFFS machine was suggested to JSFI but the packaging style change was not preferred. Also, the VFFS machines mainly produce smaller size bags than JSFI production mainly consists of.

VFFS made bags are also heat sealed after filling – a solution also not very suitable for heavier bags as it may pose risks of bags exploding or tearing under compression. These types of bags could also demand changes in other transportation and retailers' side also.

Therefore, a plan for this type of machine was made and a design suggestion and guidelines were made based on the findings. Each category of the packaging machine is observed in detail in Chapter 4.

4 PROCESS DESIGN

A rice packaging process diagram was made in this project and it can be seen in Figure 23. A review of the main components to be used for each step in the process was made.

In this project, the use of ready solutions for each process step was a primary choice but as the JSFI factory requires the usage of nonwoven double layer bags (with liner), a customized bagging machine was designed.

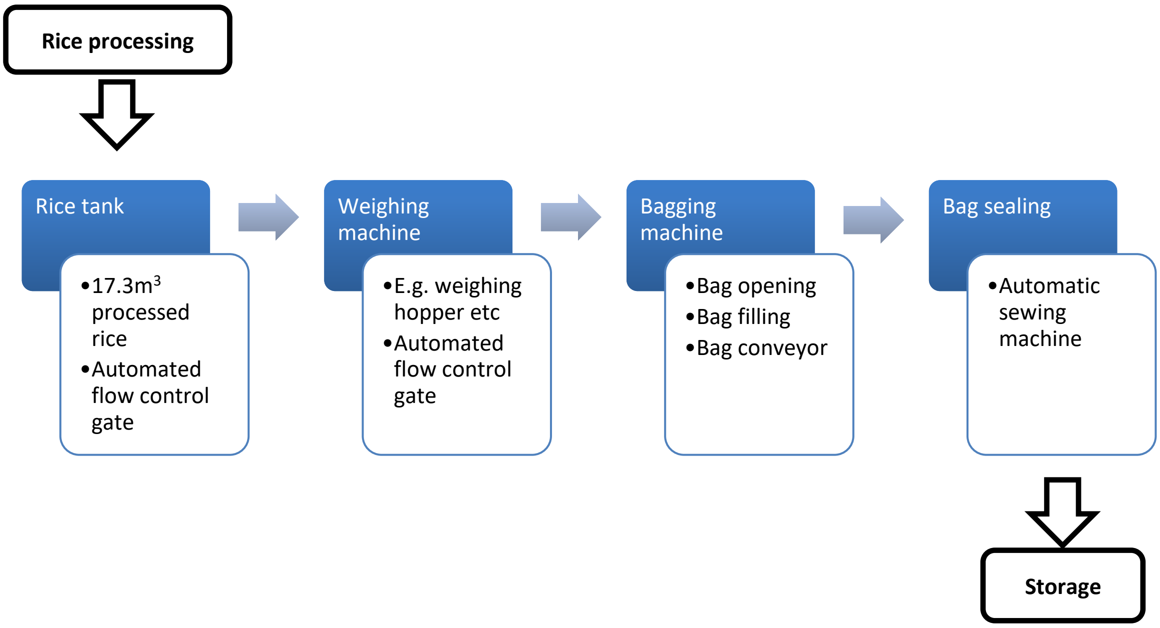

Figure 23. Diagram of the rice packaging process.

4.1 Weighing

A weighing system was needed in the process. A separate unit was selected for ease of operation and design and to ensure traceability of measurements and interchangeability if in need of service.

Figure 24. Imeco Weighing Hopper (Imeco n.d.).

Readymade solutions range from simple loss-in-weight hopper designs (weighing hopper) as seen in Figure 24, to more complicated machines such as multi-head hopper systems as seen in Figure 24 which can very accurately fine-adjust the material flow itself. (Bosch Packaging 2014.)

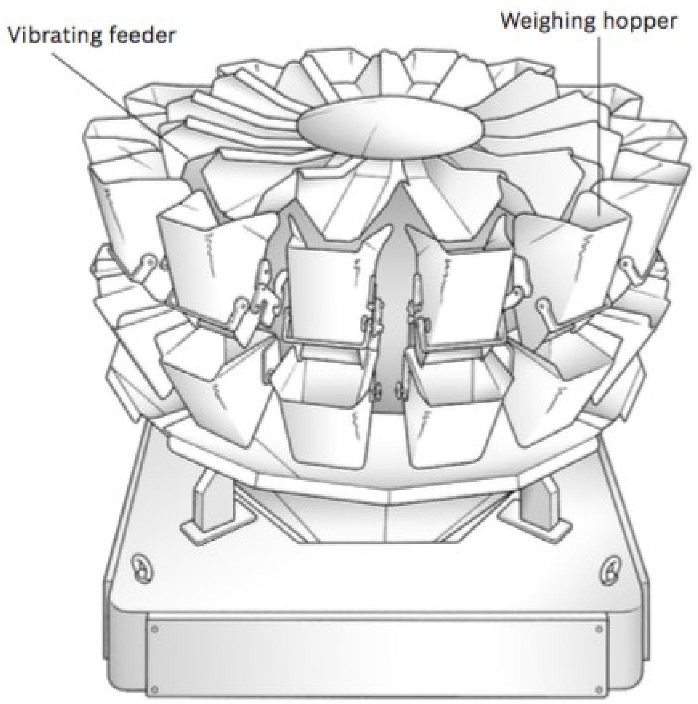

Figure 25. Multihead weigher (Bosch Packaging 2014).

At the factory, rice is supplied from a large tank. This tank has an automated door. The type of weighing machine sets requirements to the tank door, as depending on the weighing machine type the door acts as the method of filling it.

The tank door could be controlled accurately, possibly with a servo drive. However, cost and ease of design would support the usage of pneumatic cylinders to control the door.

The whole system design has to meet the criteria of accuracy, and high accuracy is required in a wide range of measurements (3 to 50 kg bags). Multihead weighing would be a primary choice for the start that could possibly be used with a less accurate tank gate.

The minimum filling graduation of multihead weighing machines' is as low as 1 gram or less. This way the filing can be slowed down, and high accuracy can be achieved by adding increments of 1g or less to reach the final measuring goal.

4.2 Rice tank gate

The use of a separate weighing machine requires an automated door to fill the machine from the main tank. Currently, a manual hand-slide gate is used for rice bag filling.

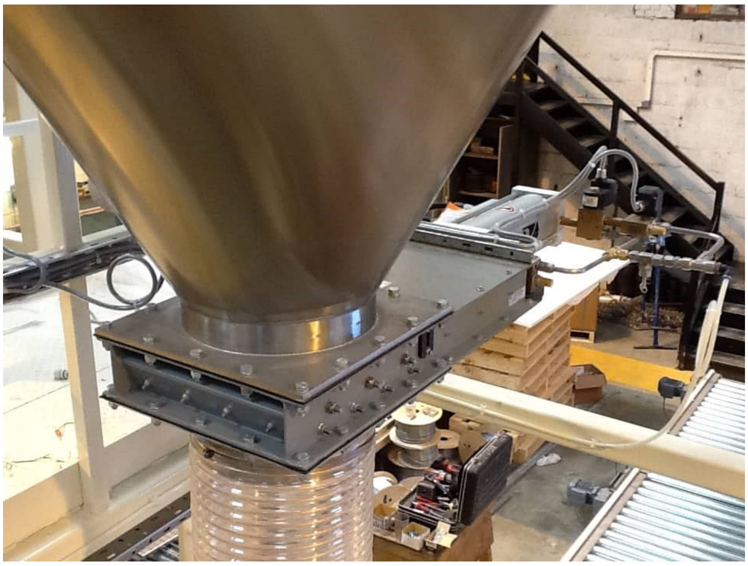

Figure 26. Tank gate (Salina Vortex 2016).

Some suppliers of weighing machines also supply inlet side door control or a direct connection to the tank, such as the ones provided by Imeco srl, Italy as seen in Figure 26.

The accuracy of the gate determines the accuracy of filling the weighing machine.

Figure 27. Imeco Weighing Hopper connected to tank directly (Imeco n.d.).

By the use of the before-mentioned multihead weighing system, a less accurate tank gate should be enough that still does not affect the bag filling accuracy. The simplest tank gates discovered in this project was a pneumatically or electrically operated sliding or rotating door.

Readymade industrial slide gates are also available from many suppliers worldwide. Some key points to remember while selecting such a gate are the service lifetime of the gate and a possibility to do maintenance without removing the gate out from the process line. (Salina Vortex 2016.)

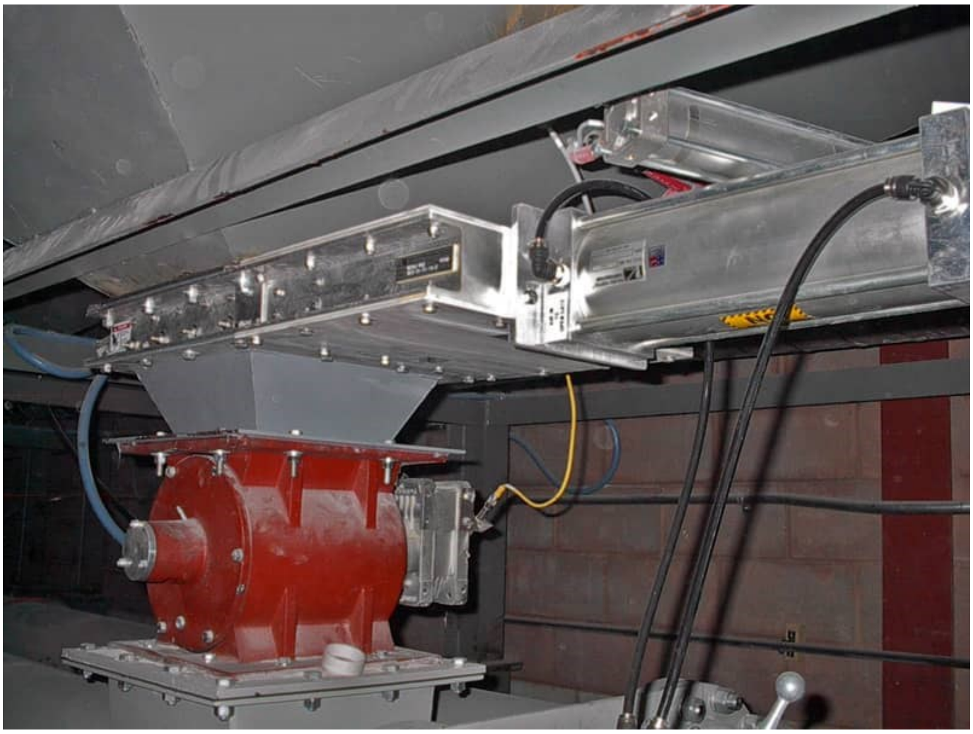

Figure 28. Salina Vortex Roller Gate under a tank (Salina Vortex 2016).

4.3 Bag sealing

The process of sealing the double liner bags includes sewing the bag shut from the open top side after filling. Currently, this is done with a manual portable sewing machine and for added safety, the sewing is done two times in parallel lines with approx. 10mm between the lines across the bag mouth.

Figure 29. Handheld portable bag closer (Hamer-Fischbein n.d.).

The automatic sewing machine is needed for the new process. Ready machines are available. For automation application, the machine needs an automatic infeed system that guides the top of the bag through the entire bag sewing process. Also, it is possible to specify that the machine will have two needles and is able to do two parallel sewing lines simultaneously. One such machine would be for example the Hamer Fischbein Ltd, USA, Model 400NS2TM.

Figure 30. Automatic Sewing Machine Model 400NS2^{TM} (Hamer-Fischbein n.d.).

5 BAGGING MACHINE

The bags arrive at JSFI factory in stacks of 500 or 1000 pieces. Both the nonwoven bag and the liner bags arrive in separate stacks.

The bagging machine needs to pick up the bag, open it and hold while filling. After filling it has to be sealed automatically by bag sealing machine and conveyed down the process.

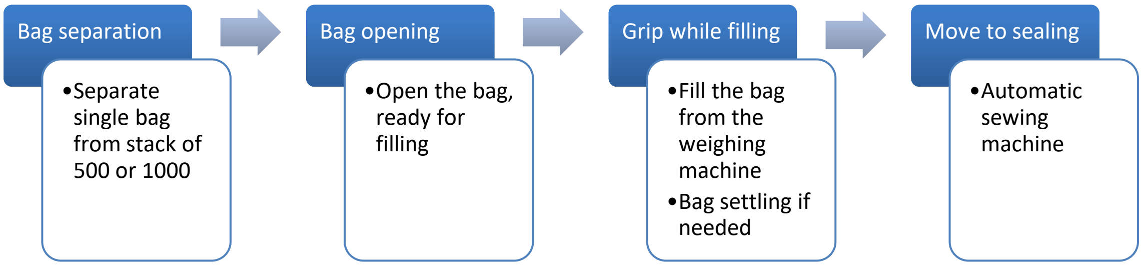

Figure 31. Bagging machine workflow.

No weight feedback is necessarily needed if separate weighing machine / hopper is used making the bagging machine simpler.

Mechanically the machine main components would be the bag grippers and linear or rotary actuators that move the grippers and bags. To develop the mechanisms a wide review of prior art and available solutions was made. Many patents on the field exist but most of them have expired tens of years ago. (US3830038A 1974 & US2684191 1954.)

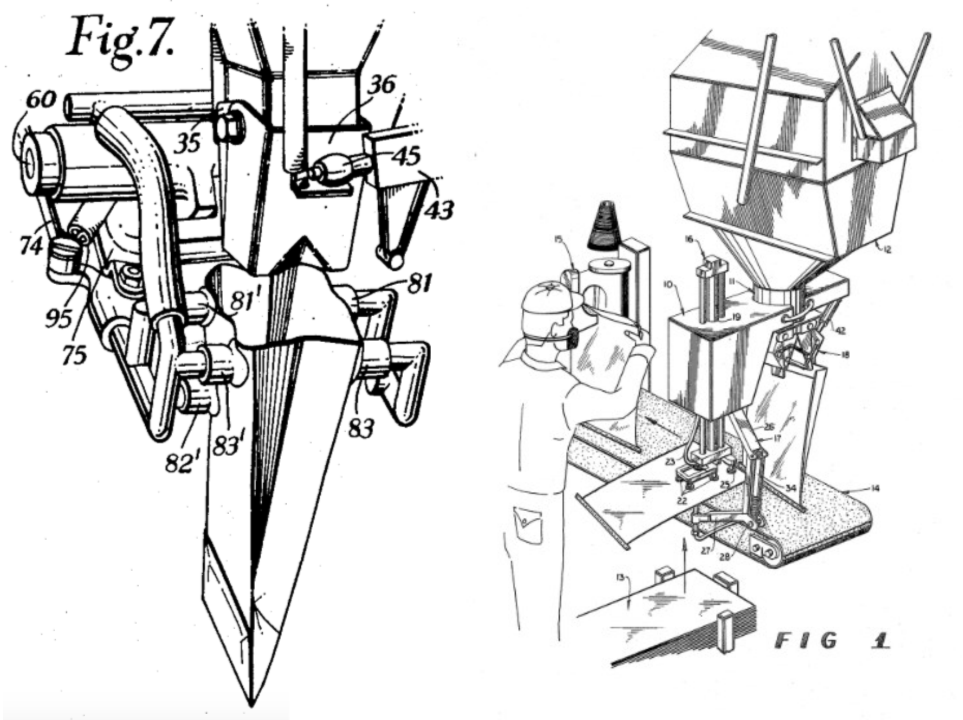

Figure 32. Patents review of bagging machines opening mechanisms (US3830038A 1974 & US2684191 1954).

The machine should be designed to be both food-safe and safe for the operating and service personnel. Also, it has to be able to integrate to the other parts of the process.

5.1 Overview

The bags are open-mouth bags that are supplied ready with final product printed graphics and labels etc. For the double layer bagging, two lines approach was taken. The used bags are quite different in their properties, as the nonwoven bags are thick, and the liner bags are thin.

Used bag sizes differ and therefore also the supplied bag stacks footprint differs according to weight.

For 10 kg bags the footprint (width x length) is approximately 600 x 1300 mm.

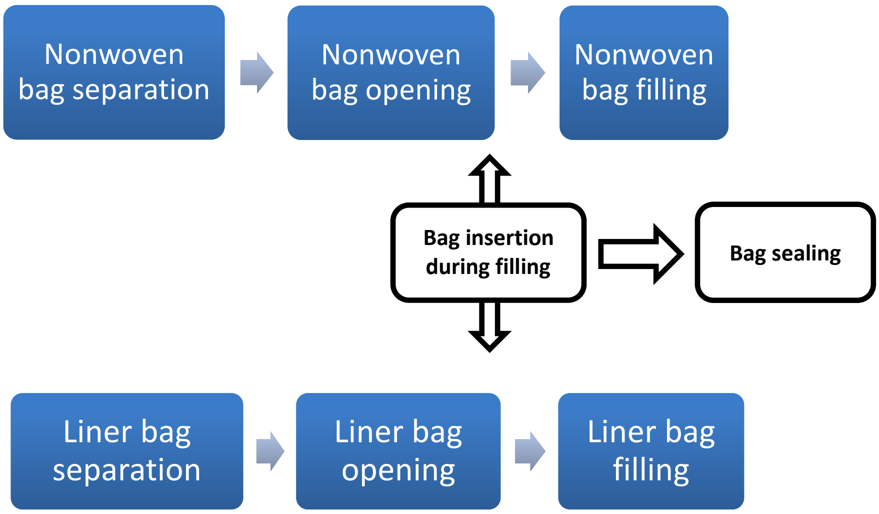

Figure 33. Two-layer bagging process workflow.

5.2 Automation

To implement the automation of the machine an industrial PLC would be the primary choice. These PLC units are highly standardized and supplied by worldwide providers such as Beckhoff and Siemens.

For example, possibly a Beckhoff embedded PC could be used for the whole system configuration. Weight and position (motion control) can be controlled in real time and can provide data to other factory systems. Beckhoff has a lot of ready solutions also, especially for packaging machines.

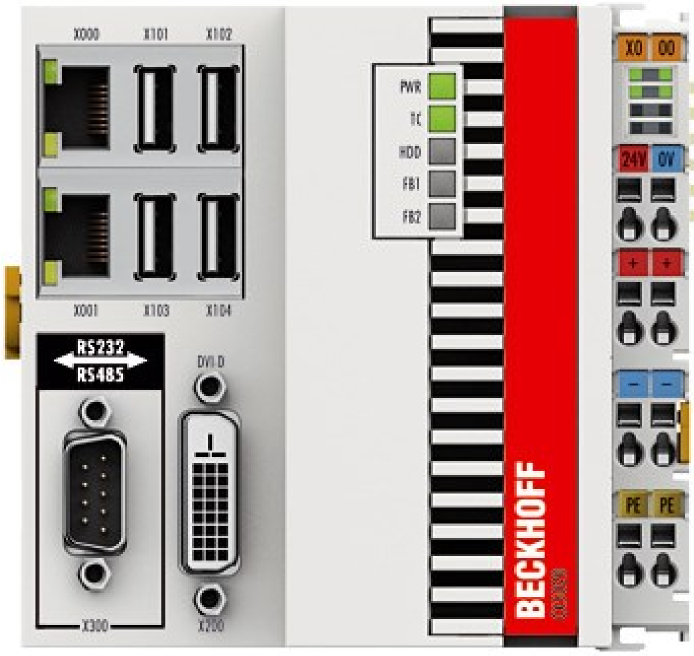

Figure 34. Beckhoff CX5020 Embedded PC (Beckhoff n.d.).

Beckhoff and other renown suppliers also provide control systems for actuators and drives. For example, electrically operated pneumatic valves and servo drives are also provided by them. (Beckhoff n.d.)

Also, data about the mechanisms position is necessary. At least for linear movements of the machine, some positional feedback is required. At the simplest, this could be done by the set of end-stop switches, which would detect if the movement is it home or end position.

Figure 35. Pneumatic cylinder (Festo n.d.).

The use of pneumatic cylinders is beneficial for keeping the costs of the machine down. In their simplest form, they are either simply on or off (pressurized or non-pressurized) and they may have return springs so that the control system is very minimal. This way it is simple to fully open or close a mechanism, but positional control in the between is more demanding.

For precise positional control of pneumatic cylinder an accurate and fast control electronics (capable of calculating the acceleration profiles etc.) is needed and also a fast-acting proportional valve is needed. The cylinder needs to also have a position or velocity (or both) and pressure sensors installed to monitor the motion and load dynamics. (Edwin 2004.)

5.3 Mechanisms

The machines main mechanisms involve bag handling and holding while filling.

To move the bags vacuum suction cups are needed. Suction cups are a widely used industrial component with many suppliers. They come in a variety of sizes and geometries and they are made from rubbers or silicones of different hardness's making them suitable for different operations.

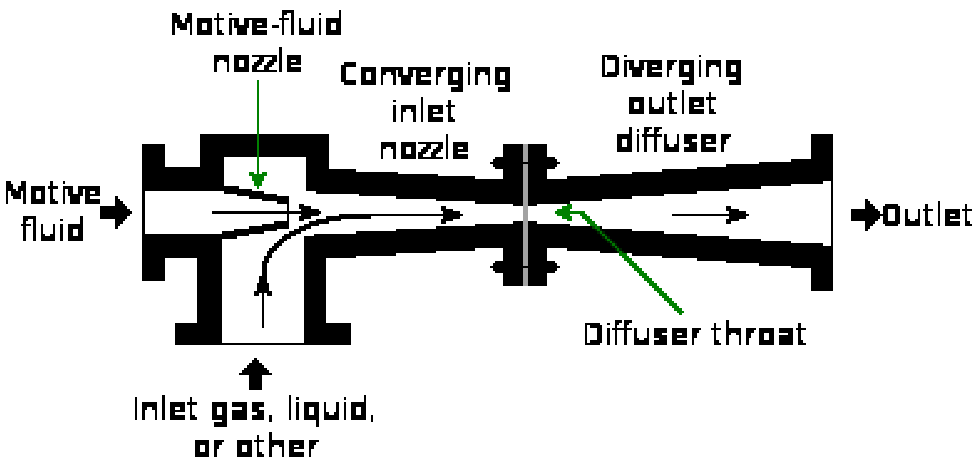

Figure 36. Typical vacuum ejector operation diagram (Wikipedia n.d.).

As the JSFI factory already has industrial pressure air system, the usage of ejectors for vacuum generation would be easy to create the needed vacuum possibly with the lowest cost. The simplest vacuum ejectors can be installed directly inline near the suction cup.

Figure 37. PIAB piINLINE® MICRO ejector based on COAX® technology (Piab n.d.).

Suction cup manufacturers have recommendations for different applications. For example, for bag handling of porous or surface leaking materials (wrinkled or textured), PIAB recommends using flexible lips with extra sealing capability.

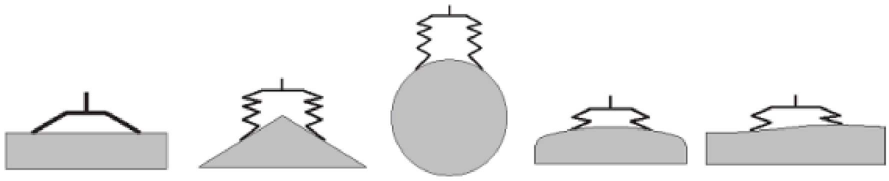

Figure 38. Different types of suction cup shapes. First one from the left is the standard suction cup and the rest are different types of bellows suction cups (Festo n.d.).

PIAB recommends specifically for thin bags and films usage of their specially designed bag lip. They can include high flow retainer geometry which prevents the thin bag from being sucked into the cup. (PIAB n.d.)

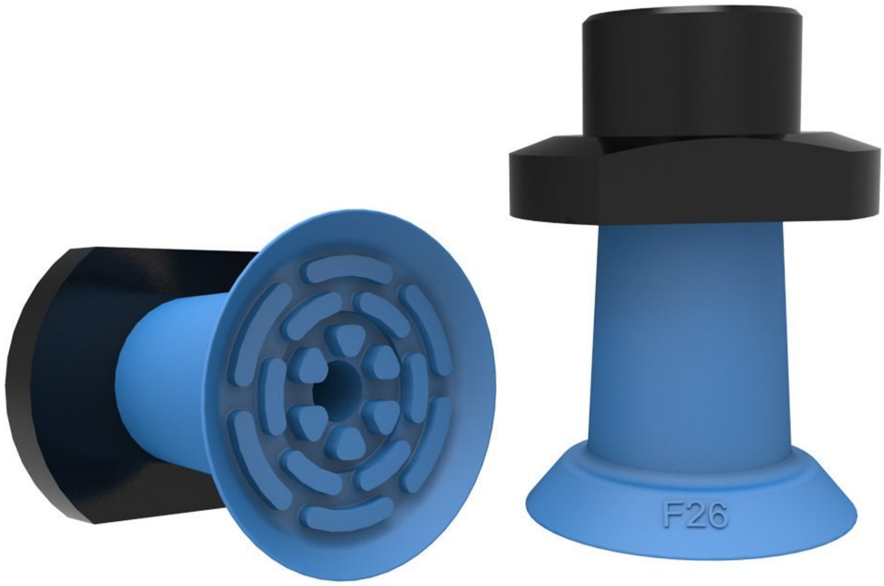

Figure 39. PIAB F26 FCM for thin bags with conformable lip. (PIAB n.d.).

The forces of suction cup can be calculated manually, but manufacturers such as PIAB also provide online calculators. The calculation is highly dependent on the position of the cup (vertical or horizontal) and the way of the forces (against or in favour of gravity and if surface friction forces also affect the calculation). Workpiece weight and acceleration also affect the holding forces of the suction cup. (Festo n.d.)

The suction cup's suction force (F) is simply calculated by pressure (P) times area (A) of the surface covered by the cup.

$$\mathbf{F} = \mathbf{A} * \mathbf{P}$$

Since in the bag opening application, the mass of the bag is very less (below 100 grams), usage of the highly over dimensioned system is applicable if it does not damage the bags and there are no extra costs.

Besides vacuum suction cups, insertion of a mechanism or bar / fork inside the bag can be used in the opening. Such mechanisms exist for a long time and many of them have been patented starting from 1930’s but as the patents have expired, they are widely used worldwide. Such mechanisms are not available or hard to find as sold separately but they are more integrated already in different bagging machines.

Figure 40. Wicket bag semi-automatic blower machine (Fastpack Packaging Inc. 2016).

Also, one method of opening bags is with the use of pressurized air or powerful airflow such as used in a wicketed bag opening machines.

Figure 41. Wicket of bags (Flexipol Packaging LTD n.d.).

5.4 Double layer bagging machine concept

For the mechanical construction of the bagging machine, an approach was locked down after a review of available machines, popular mechanisms were selected, and a concept was designed as seen in Figure 42.

The system consists of two assemblies. One of them is on a moving Z axis. The other one is stationary. Both systems consist of at least the following components:

- Bag separator
- Bag Opener
- Rotating fork
- Bag holder

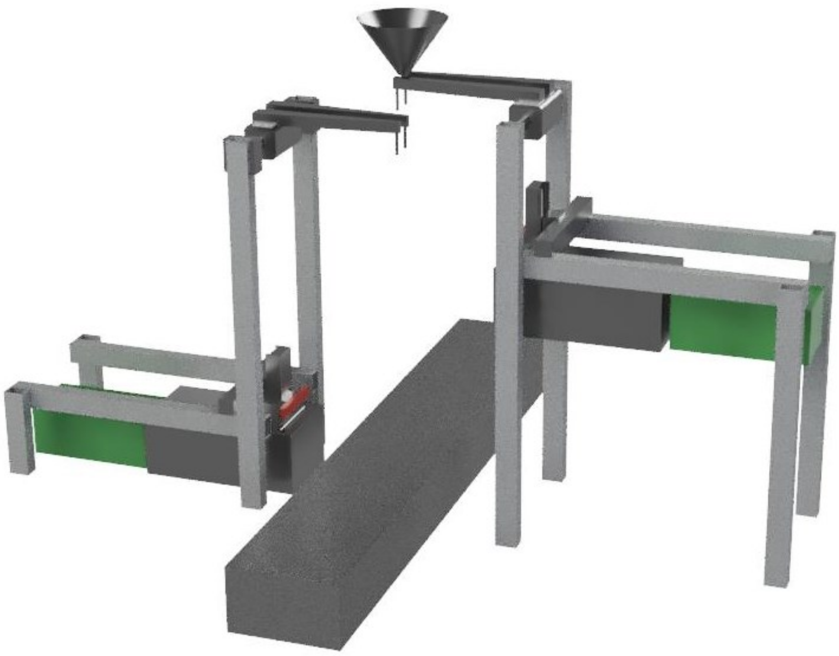

Figure 42. Overview of assembly concept (Mehta Heino Industries Oy 2018).

On the lower stationary mechanism, there may also be additional bag supporting mechanisms located that help to transfer the bag to an automatic sewing machine or other sealing methods. This will be added as an add-on to the machine later at the JSFI factory.

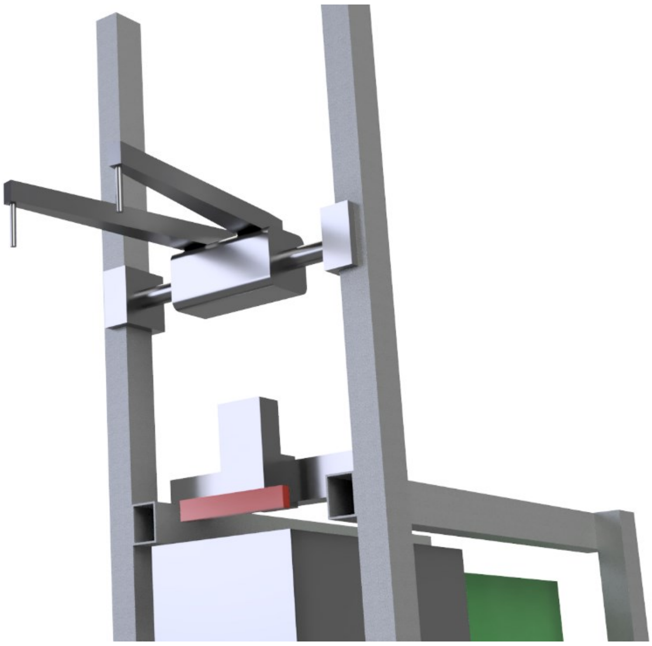

Figure 43. Bag opening concept (Mehta Heino Industries Oy 2018).

The bag separator and opener perform three different operations. First, the top-most bag is pulled apart from the stack. Then the bag is moved to another handling platform where it is simultaneously pulled straight and opened by two-side vacuum. After this, a rotating fork assembly is inserted inside the bag mouth and stretched apart to hold the bag.

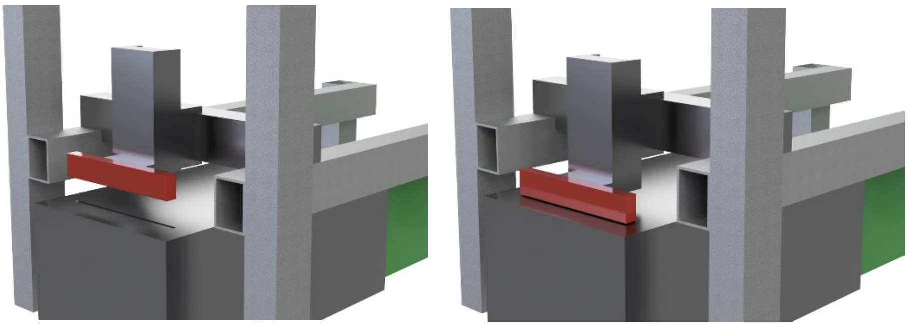

Figure 44. Bag mouth opening mechanism consisting of two sides vacuum (Mehta Heino Industries Oy 2018).

On the left, there is the open position and, on the right, ready to pull the bag open. Axis movement is about 10 cm. The opening mechanism top assembly has linear movement of approx. 1 meter to transition to bag stack (pictured green) to move the bag to the opening position.

Controlling the bag position is done by accurately opening the fork-mechanism that stretches the mouth of the bag open and holds it in the centre position while the bag is being filled.

Figure 45. Fork mechanism concept (Mehta Heino Industries Oy 2018).

In Figure 45 there is the fork mechanism concept. On the left, position when inserting in a bag. On the right, opened position for holding the bag mouth open.

The inserted forks then transform the bag to the filling position by rotating it 90 degrees. The spout design can be more complicated consisting of grippers etc. depending on the real applications demands on holding force.

After filling the bag, a separate bagging line prepares and positions the second layer bag on top of the first bag.

After insertion of a second layer bag, the first bag is released by closing the fork and dropping it inside the second, lower, bag. After this, the bags are conveyed for later processing, such as sealing machine, e.g. the automatic sewing machine. See Figure 45 for the machine’s movement positions in operation.

Figure 46. Overview of assembly concept (Mehta Heino Industries Oy 2018).

6 CONCLUSION

Together with the JSFI factory, it was concluded that the rice packaging mechanism described in the thesis may require more complicated controls, such as partial filling sequences and simultaneous lowering of the upper bag inside the lower bag and other mechanical assisting motions.

Following the completion of this thesis commercial development of the described process started and prototyping and development of the process further on is conducted in co-operation of JSFI Pvt. Ltd, Nepal and MHI Oy, Finland.

Overall, the thesis project resulted with the author in a much wider knowledge of the market, patents and machine design fields of the bagging industry to date.

Finally, many thanks to the close collaboration of the involved parties, Jay Shambhu Food Industries and Mehta Heino Industries for the completion of this thesis!

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