Interreg North-West Europe
COTEMACO
European Regional Development Fund

Success Story

Process Automation Opportunities

for Norvik Ltd., UK

Opportunity for Cobotics

Company description

Norvik Ltd is a small food business that produces "the famous Grimsby fish cake" as well as other frozen products and shanties. They are based at premises on Humber Street, adjacent to the docks in Grimsby. Their business is split into both their own range of products as well as branded ranges for customers. The company was taken over in November 2020 and modernisation of the factory, chilling facilities, production line and layout have begun. They aim to double production within the next few months. In order to achieve this, Norvik will have to undertake a substantial hiring process, or optimise their current production process with the addition of technology and automation to simplify job roles and allow staff to focus on the more people-friendly (and people-requiring) tasks. Norvik's preference is to automate rather than hire.

Goal

The aim of this COTEMACO support is to assess the current production processes at Norvik Ltd and provide an automation assessment to underpin future business growth. This will assess the current process and propose automation to support a doubling of production with the same number of staff through the usage of process flow optimisation, automation, and robotics.

Current processes

The current production is between 5 and 7.5 tonnes per week with the projection of sales to double to between 10 and 15 tonnes per week. Currently all packing of products, as well as all movement of products (on and off the fryer, freezer trays and racks, and in and out of the freezer) is performed manually and these non-value adding processes are prime targets for automation to double production with the same number of staff. Norvik Ltd engaged with the COTEMACO SME support programme to devise methods to increase fish products production capacity whilst limiting the number of people employed in unrewarding roles.

The current basic production operations are:

1. Product intake (and QA checks),
2. Mixing of ingredients (for fishcake production),
3. Forming of products (fishcake production),
4. Separating of frozen products supplied in,
5. Place items into the process line;
   - Battering,
   - Crumbing,
   - Frying,
6. Transfer products onto trays and load trays onto racks,
7. Ambient cooling,

8. Freezing,
9. Unload trolleys
10. Packing (and metal detection).

An initial assessment of the production operations was carried out to identify bottlenecks, effort intensive operations, and issues where automation could provide business benefit.

Our initial assessment suggests:

- No technological advancement is required for mixing/forming but an increase in capacity may be required.
- There is an opportunity to stream-line the factory by re-arranging equipment to feed product directly from one process to the next via conveyors (including the addition of tunnel freezer(s) This will be dependent upon the dwell time requirements.
- There is an opportunity for ro/co-botic deployment in tray handling to/from trolleys post-fry, pre-freeze and post-freeze.
- There is a possible opportunity for ro/co-botic deployment in packing, but more information is needed to define this further.

The initial assessment also identified challenges in:

1. Ability of grippers to:
   a. grasp and release frozen, and potentially oily, fish cakes,
   b. flexibility to pack non-fishcake and or non-frozen products,
2. Line speeds (units/second). This will vary dependent upon the particular product and could be up to 5 units/s for the smaller products.
3. variable robustness of different products.
4. variable packing formats and arrangements.
5. non-uniformity of existing trays and trolleys.

The current site configuration is as shown in Figure 1. The flow is reasonably smooth, assuming that product goes straight from intake into the fryer or mixing and forming processes (transfer required from incoming packaging to Norvik tote bins). This movement is unlikely to ever happen in practice and the frozen holding stores are located on the other side of the factory. This will lead to double handling and an interrupted process flow if products are not going straight from product intake into the fryer/mixing and forming processes. Incoming products (fishcake ingredients) are stored in the chilled store by product intake until they are called for mixing.

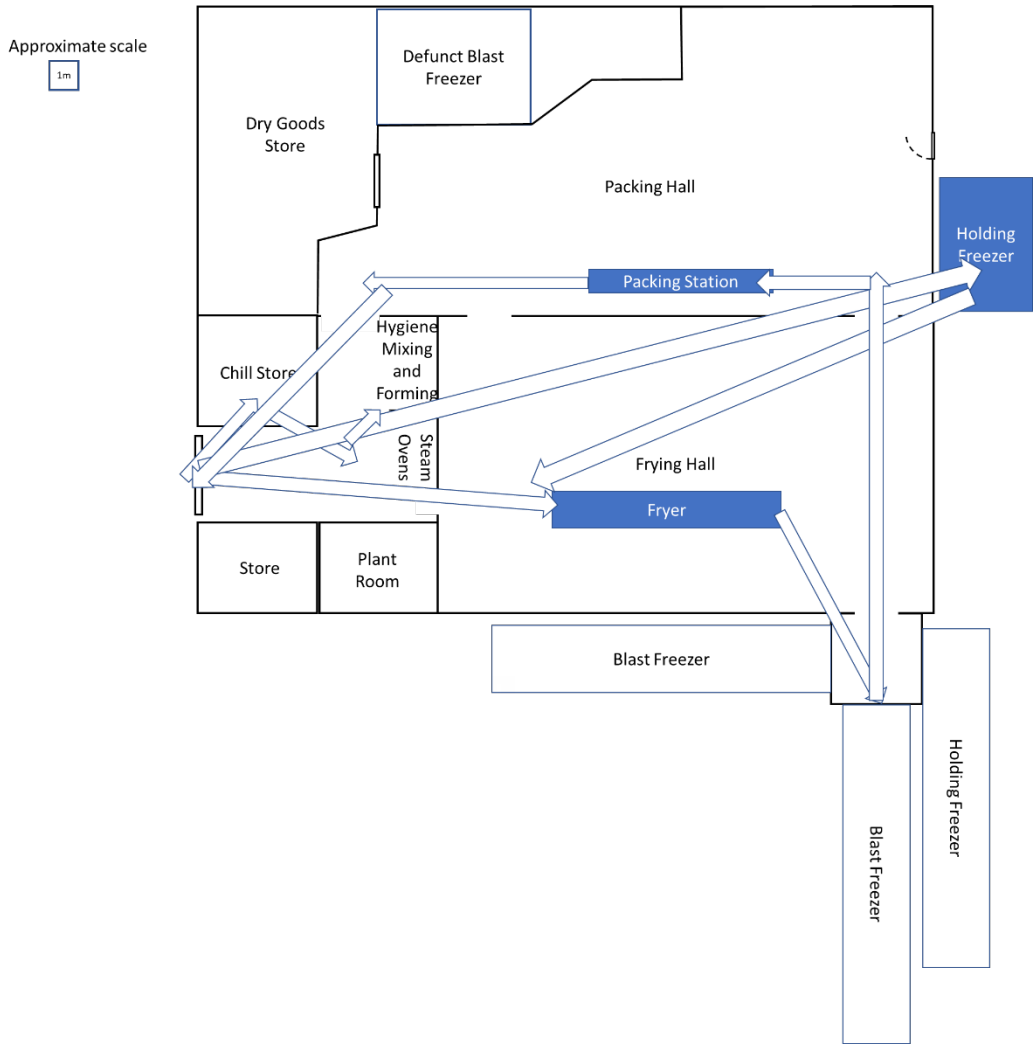

Figure 1. Site plan for Norvik Ltd. including a basic product flow through the facility.

Automation Roadmap

As illustrated above, Norvik Ltd have aims to double production capacity within 6-12 months without hiring more staff. In order to achieve this goal, technological advances will have to be made within the factory. As the majority of loading/unloading/packing throughout the factory is manual, these non-value adding processes are the obvious places to seek automation opportunities. In the longer-term, Norvik Ltd have plans to introduce a rapid freezing system (either a freezer tunnel or a spiral freezer) and a new higher throughput frying system. Along with the removal of defunct equipment, the equipment could be re-positioned to create a layout similar to Figure 2 with a more linear flow throughout the factory. In this situation, as it would be assumed product would be conveyed from one process directly to the next, the opportunity for robotic handling of products on and off processes would be reduced or removed entirely. Due to this, any robotic solution would likely need to be flexible and applicable to other tasks to justify the investment. This, however, is one of the main benefits of robotic implementation – the equipment is often easily adapted to new tasks.

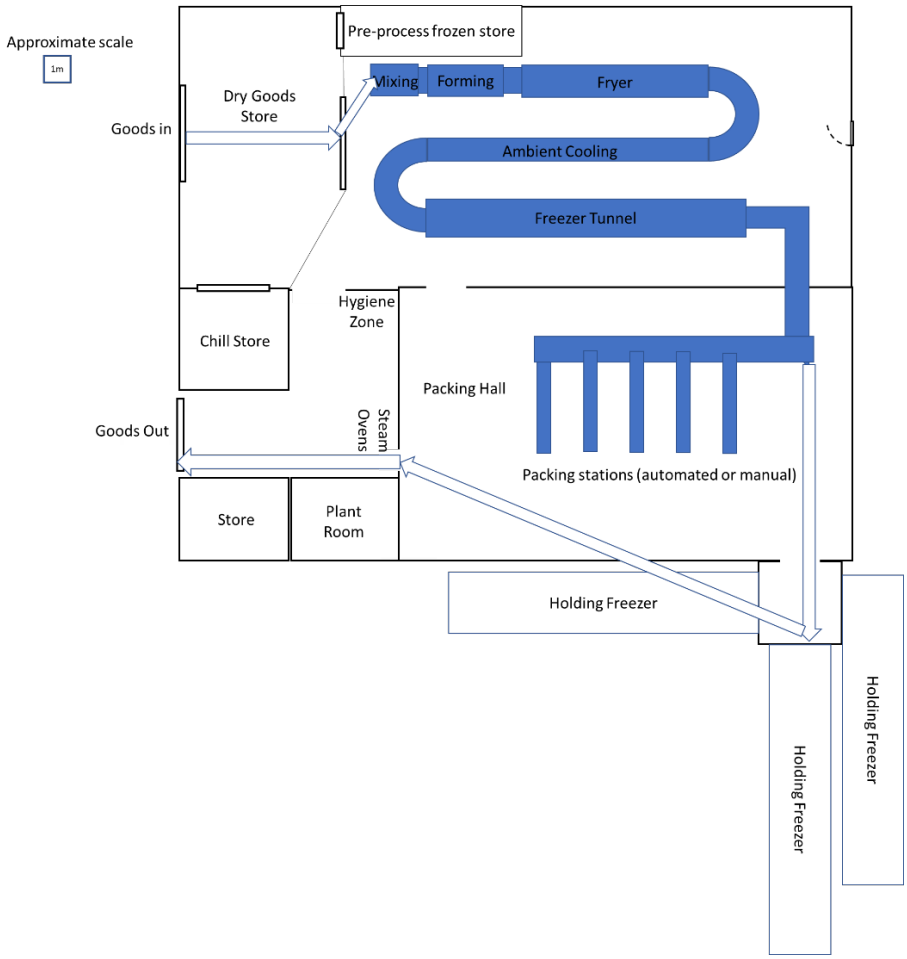

Figure 2. A potential updated site plan with the introduction of a new fryer, an end-to-end conveyed process, and an in-line freezer tunnel.

In the meantime, an intermediate arrangement with robotic handling off the frying line and onto trays to be moved into the blast freezer would be logical. This would have a layout similar to Figure 3 and is described in more detail in the next section.

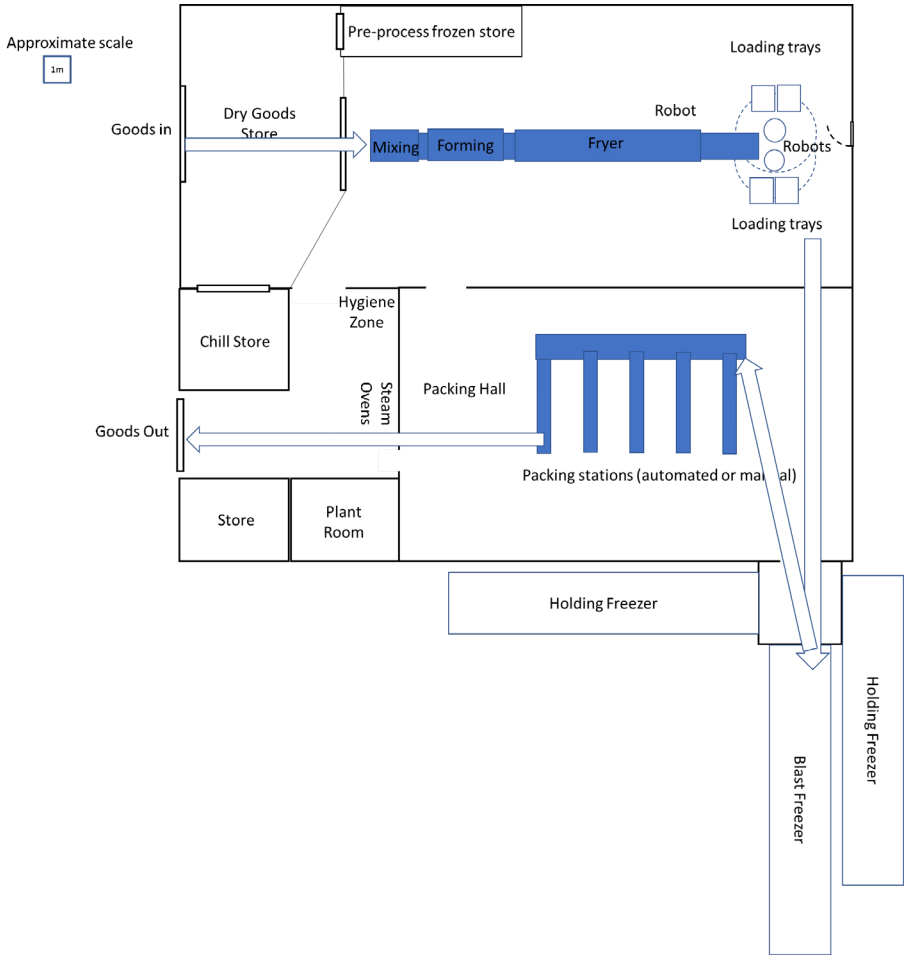

Figure 3. An intermediate stage factory layout with robotic deployment for tray loading.

Mixing

Mixing is currently not limiting overall production capacity, but if the capacity of the rest of the factory is substantially increased, it will become a limiting factor. No extra technology is likely to be needed here, but an increase in capacity and therefore speed of mixing will be useful in the long-term.

Forming

As with mixing, forming does not currently need any addition technology, but an increase in capacity will likely be relevant if a doubling in production rate is to be realised. Product movement from mixing to forming is currently manual but augmented lifting technologies could be applied to make this operation easier (e.g. [12] Counter Balanced vacuum gripper).

Frying Line (including battering and crumbing)

In order for a more free-flowing process through the factory to be achieved, it would be beneficial to form the fish cakes directly onto a belt that leads to the fryer with a person checking quality as they pass. As this belt leads directly to battering, crumbing, and the fryer, it would avoid unnecessary handling and stock building in a process buffer prior to the fryer.

For this to work, the fryer would need to be able to process at an equivalent (or greater) rate to the forming operation speed. Otherwise, a process buffer will still be required here. As for the frying itself, the rate limiting factor is the physical amount of product that can pass through. A larger or secondary fryer would need to be bought if it was necessary to increase this. Other work carried out for Norvik Ltd. suggested that the maximum capacity of the current former/batterer/crumbing/fryer combination is 383kg/hr. Assuming no breakdowns, this would mean that the fryer must operate at maximum capacity for 39 hours per week in order to achieve a 15 tonne/week output in single shifts. Therefore, in order to achieve these goals, a secondary or higher throughput fryer may be required without hiring more staff unless staff shifts can be increased or split to create more potential hours per day frying. Automated solutions in other parts of the factory (e.g., packing, tray loading etc.) may free up staff in such a way that this becomes possible, and the target throughput becomes achievable without additional frying capacity. If a new fryer is purchased, it is essential to make sure that it will cope with a further increase in production (past 15 tonnes per week) to ensure that the operation is future-proofed.

Frying to Freezing (stage 2 before Tunnel/Spiral is implemented)

Currently 2-3 staff are required to move products from the fryer outfeed belt and place them spread out on trays and loading trays to trolleys for the subsequent blast freeing operation. There is a robotic handling opportunity (if a freezing tunnel is not yet installed) for automating this task using technology transfer from the bakery sector. The 'BakerBot' from Apex Automation [1- BakerBot] collects dough patties from a belt and spaces them onto trays for cooking. Trays are then loaded to racks. This process has great similarities with the need to space fish cakes on trays for even and rapid cooling/freezing. A robot is deployed to move a tray below an outfeed of singulated items to space the products on the tray (Figure 4).

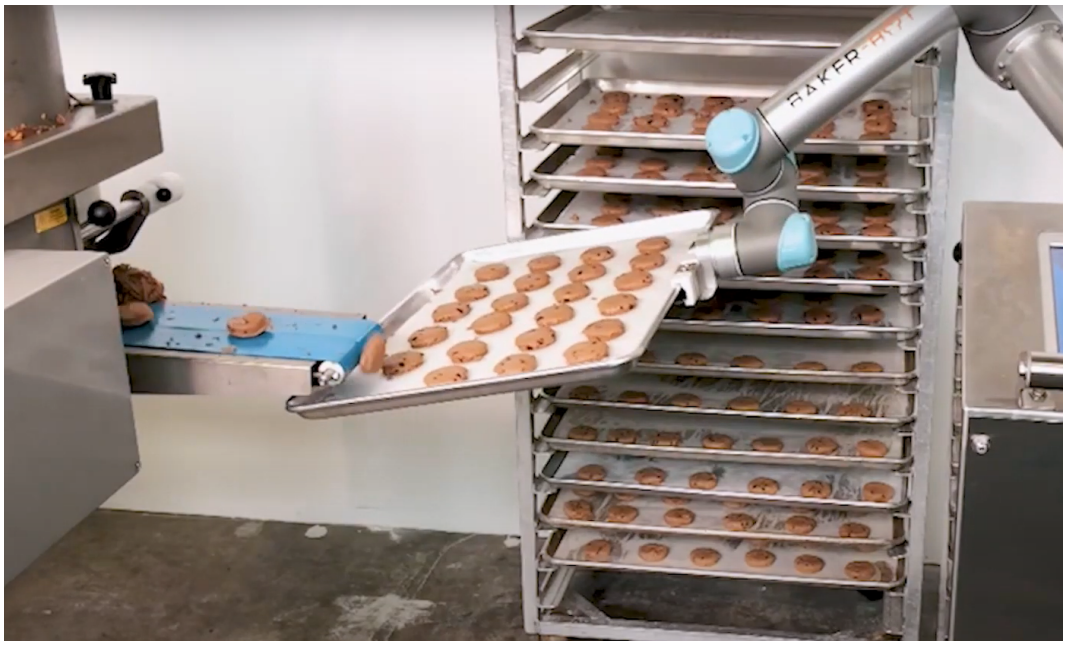

Figure 4. BakerBot collecting dough patties from a belt onto a tray. This is a similar process for placing fishcakes onto a tray before freezing.

This would require a singulated flow of fish cakes from the fryer which could likely be achieved using combination of baffles, diverters, and belts of different speeds (some trials would be needed to confirm). Item placing rates of c. 1 item /second are demonstrated on the BakerBot, however measures to allow time for the filled tray placement to and empty tray collection from the trolley would be required. Conceptual options for this include:

a. Using variable speed belt after the fryer output to create temporary gap in flow.
b. Using a 2-armed robot or 2 robots operating in same space so that a fresh tray is ready and there is no need to interrupt flow. The kinematic control of a single 2-armed robot would be easier than 2 separate robots operating in the same space.
c. Using single robots but on 2 parallel tray loading stations, with a diverter channelling fish cakes to one or the other to allow tray swapping time, and/or reduce cycle times necessary at each station.

Additionally, in order for this to be successful, uniform, and standardised trolleys and trays would be required.

Frying to Freezing (stage 3: with a tunnel/spiral in place)

Product surface temperatures at outlet from the fryer are 45-80°C. Since this is substantially above room ambient temperature initial cooling can take place without need for a freezing tunnel/spiral. This 'ambient cooling' would reduce the duty on the freezing system and allow the removal of an amount of moisture before entering the freezer to protect the coil from excess icing up.

From previous FRPERC/Norvik Ltd work, it was determined that air moving at 5m/s at -30°C with a residence time of 55 minutes would be required to freeze the largest product to -18°C. The specification of the freezer tunnel/spiral would need to be in excess of the 383kg/h rate of the fryer.

The Air Products Freshline EF 1000.6 tunnel freezer [2- TunnelFreezer] states a capacity to freeze up to 500kg of product per hour and sits at 7.8m in length.

Once a freezer tunnel is implemented, the robots as described for stage 2 would no longer be needed for tray handling and racking. Therefore, it should be determined prior to purchase that a). any robots/cobots can be repurposed or b). the tray loading and unloading jobs will persist even beyond a tunnel/spiral freezer being installed.

Freezing to Packing Transfer

Before the installation of a tunnel or spiral freezer, trolleys (potentially loaded robotically as discussed above) would be manually wheeled into and out of the blast freezers. However, there is an opportunity for robots to empty the trolleys by sequentially tipping trays onto a packing line. This frees up more staff to pack the products as fewer are being used to manually empty the trays. Currently, for some products, trays are

emptied into bulk bins after freezing primarily to free up the trays for the next batch of products to be frozen. This is, however, another example where products are double handled.
Once the in-line freezer is implemented, and packing operations are adjusted to keep pace with the rest of the line then products could flow in a continuous production line directly from forming through frying and freezing to packing. This would i). allow the full Norvik process from mix to pack to be done in a continuous line, ii). remove several instances of double handling, and iii). remove the need for the process buffer in the current batch freezing process (an example factory design for this is shown in Figure 2).

Packing

The following ideas assume that the current output packing formats are retained. There will be further opportunities if alternative packaging formats were possible. For example, flow wrapping of individual fishcakes could be accomplished at high speed and provide individual barriers to contamination and freezer burn moisture loss for each item, and also the wrapper could provide a uniform consistent surface for any subsequent automated or robot packing to outer cartons or bulk bags.

Frozen items packing

Packing of frozen fishcakes is another area where the potential of co/robotic handling exists. Hard frozen products will be substantially easier to handle as they are more robust, and technology transfer from other sectors can be suggested, notably frozen meat patty (burger) handling.
Singulation is an important first step in automated packing. Rotary table singulation is used for frozen meat patties. (e.g., [3] PattySingulation1 , [4] PattySingulation2, also see Figure 5). Practical experimentation would be required to establish the degree of roughness of handling that each type of fish cake could tolerate.

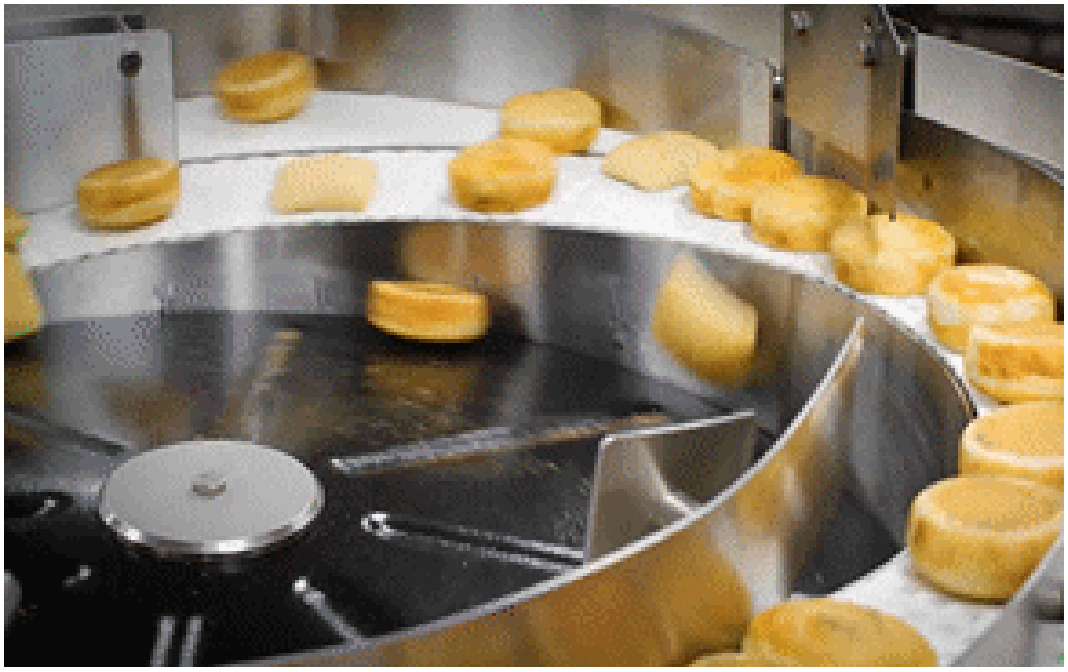

Figure 5. Centrifugal singulation of products

Collating fishcakes into stacks would ease the requirement for high handling speeds by moving multiple items as one. Dedicated automation patty stackers (e.g., [5] PattyStacking) could provide a solution here, for either subsequent manual or automated transfer of the stack to an outer carton. Alternatively, co/robotics could build freestanding stacks (e.g., [6] FreeStackBuilder) with long finger grippers then (e.g., [7] LongFingerGripper) moving stacks for automated packing into outer cartons. Another approach could be to build the stack within the gripper (e.g., [8] StackWithinGripper) and then deliver it directly to the outer carton (Figure 6).

Figure 6. Patty Stacking alternatives for ease of movement

Non-frozen items packing

Soft finger grippers and high speed co/robotics for handling bakery products such as muffins, could give some opportunity for technology transfer for these softer more delicate product types (e.g., [9] SoftGripper1 [10] SoftGripper2)

Fully automated packing

Fully automated robotic packing lines are technically feasible (e.g.,[11] FullAutomation), but this is likely to be excessively large and costly for this stage in Norvik's business evolution. The example [11] uses 9 ABB flex-picker robots to pack frozen fish into cartons at 120 cartons/minute, with an overall item pick and place capability of up to 900 pieces/minute.

Initial Gripper Trials

Practical gripper trials (Figure 7) with Norvik Ltd products were undertaken to make an initial assessment of which gripper types were appropriate for products:

a. Fresh out of the fryer – hot, delicate, soft
b. Fully frozen (before-pack) – cold, robust, hard

Frozen pork cutlets (c.132g), cod burgers (c.113g), two different types of fishcakes (c.88g and c.55g), and fresh battered cod fillet (c.175g) were trialled with various gripper types.

The main findings are given in Table 1.

Figure 7. Images from initial gripper trials. Clockwise from top left; twin Bernoulli on frozen product, 4 finger on frozen, twin Bernoulli on fresh, high volume flow on frozen

Table 1. Initial Gripper Trial Findings

Gripper Type	**Observations**	
	Fresh Fried product	**Hard Frozen Product**
Plain vacuum cup gripper	No grip (due to the rough surface of a breaded product);	
1 large Bernoulli gripper	Intermittent lifting Often caused the items to spin and thus a pin to prevent rotation would be required	
1 large and 1 small Bernoulli gripper	Intermittent lifting No spin of products	
2 small Bernoulli grippers (with counter rotation airflows)	Frequently grasps Good lift and grasp stability (if the product was large enough for them to fit)	
4-finger soft gripper	Good grasping and lift. Some damage to product as it deformed under own weight	Good grasping and lift.
High-volume air-flow vacuum gripper.	Excellent grasp and lift all products Some damage to the surface.	Excellent grasp and lift all products Minor surface damage with repeated lifting

Bibliography and Videography

[1] BakerBot dough patties onto a tray
[2] Air Products Freshline EF 1000.6 tunnel freezer
[3] Frozen Patty Singulation (1)
[4] Frozen Patty Singulation (2)
[5] Patty Stacking
[6] Free Standing Stack Building
[7] Long Finger Gripper Stack Moving
[8] Stack within Gripper
[9] Soft Finger Gripper (1)
[10] Soft Finger Gripper (2)
[11] Fully automated packing line
[12] Counter Balanced vacuum gripper

Interview

How could COTEMACO support you?

Via the SME support programme, COTEMACO engages with SMEs from the automotive and food sectors through field labs. These regional field labs in the UK, the Netherlands, Belgium and Germany are showcasing key production steps in the automotive and food industries, in order to tackle current low sectorial awareness and knowledge gaps. The field labs will exchange knowledge on different manufacturing tasks, such as handling and (un)loading.
With the COTEMACO programme, manufacturing SMEs are guided through the process of adopting collaborative robotic and shop floor digitalisation technologies, from the exploration of technological opportunities to the detailed definition of a business plan.

What is COTEMACO?

The project, which is an initiative of Interreg North-West Europe, aims to support around 60 SMEs in the automotive and food manufacturing industries with so-called „test environments“ and to encourage them to integrate collaborative robotic systems and digital technologies into their business. Accordingly, in addition to increasing production flexibility, the relocation of production abroad will be curbed and the number of jobs in manufacturing increased, which will generally lead to an improvement in the competitiveness of the companies involved.
In the project new technologies are implemented in application examples - the aim is to move from the prototype in the laboratory environment to the transfer to production, taking into account the legal situation and certifications.

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Then visit our website at:
www.robot-hub.org/cotemaco

Implementation partner:

University of Lincoln
National Centre for Food Manufacturing

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Food Refrigeration and Process Engineering Research Centre

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