Freeze (Cryogenic) Grippers for Flat Sheet Foods

Recent studies at FRPERC have investigated cryogenic gripping techniques for the food industry

Thin, delicate, sheet-like food materials such as lasagne pasta, sliced salmon, cheese and ham are difficult to handle automatically. This project funded by the Food Processing Faraday Partnership investigated cryo (cryogenic) grippers that grasp products by freezing them to the gripper.

Time-temperature combinations for ice bond formation and gripping were established using pre-cooled (-30°C, -20°C, -10°C, -5°C) aluminium blocks pressed in turn against samples of sheet foodstuffs (lasagne, sliced cheese, ham, etc). The times taken to establish a frozen grasp and for that ice bond to thaw naturally at room ambient for a range of were determined.

Table 1. Inital cryo-gripper pickup tests.

Block temp (°C)	Sample type	Hold down time (s)	Grip thaw time (s)	Sample weight (g)
-30	pasta	<1	>60	<93
-30	cheese	<1 to 5	5 to >60	<30
-20	pasta	<1	>60	<93
-20	cheese	<1	11 to >60	<30
-10	pasta	<1	>60	<94
-10	cheese	<1	>60	<34
-5	pasta	1	55 to >60	<100
-5	cheese	<1 to 1	15 to >60	<39

If a small water spray was applied to the product immediately before gripping, a -5°C surface temperature was sufficient to grasp within 1s, and lift most samples tested. Thaw times were highly variable. Experimental work then concentrated on gaining a controlled release of the cryo-grip. Mechanical and thermal approaches were evaluated with none showing great potential. Mechanical breaking of the ice bond often resulted in product damage, leaving product stuck to the gripper surface. Thawing of the ice bond was relatively slow as the latent heat of fusion had to be supplied for each grasp cycle. Enhanced heat transfer mechanisms such as heat pipes showed little benefit because of the time required for the internal flow patterns to become established.

Whilst accepting the limitations, a thermal product release method was adopted. The gripper basis was changed from a block to a thin foil to reduce thermal mass of gripper, thus speeding the processes. A range of techniques of applying the heat and cold sources were experimentally evaluated, with a combination of refrigerant gas and hot air giving the highest rates of temperature change. A manually activated cryo-gripper was built and used to evaluate cryo-gripping on a range of flat sheet food products from a variety of surfaces (Table 2). The application of a water spray was found to be vital for reliable grasping.

Table 2. Final cryo-gripper pickup tests without and with surface water spray.

Slice type	Sample weight (g)	Hex mesh (no water)	Stainless (no water)	Worktop (no water)	Hand (no water)	Hex mesh (water spray)	Stainless (water spray)	Worktop (water spray)	Hand (water spray)
Ham	3.4	OK	2	OK	OK	OK	2	OK	OK
Ham	6.0	OK	2	OK	OK	OK	2	OK	OK
Ham	12.3	1	2	-	-	OK	2	-	-
Cheese	5.8	2	2	2	OK	OK	2	OK	OK
Cheese	14.1	2	2	2	2	OK	2	2	2
Lasagne	5.8	1	1	1	1	OK	OK	OK	OK
Lasagne	14.1	1	1	1	1	OK	1	OK	OK
Salmon	7.6	OK	OK	OK	OK	OK	OK	OK	OK
Salmon	21.0	OK	1	1/2	OK	OK	1	OK	OK

TABLE KEY:

OK: Successful lift and hold (5s).

1: Failure - Product partially lifted from surface but gripper failed to hold.

2: Failure - Product stuck to base surface

3: Lifted OK but product damaged

-: No experiment

The surface from which it was that was most difficult to lift products was stainless steel - the most common food industry material! Because of the energy inefficiencies, slowness and fundamental lack of control, we concluded that cryo-grippers in their current form are not particularly useful for the food industry.

For more information on this project, Please contact us on +44 (0)1472 582400 or email us on frperc@grimsby.ac.uk