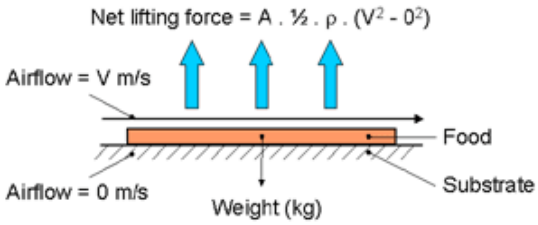
Airflow (Bernoulli) Grippers for Flat Sheet Foods

Studies at FRPERC illustrate potential for Bernoulli grippers as an alternative for suction for grasping flat sheet-like foodstuffs



Bernoulli gripping principle (see below)

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 the use of grippers based on the Bernoulli airflow principle to handle such foodstuffs.

The Bernoulli principle states that if a high velocity air stream is passed over the surface of an object, the local pressure will drop. If a higher pressure exists on the other side of the object a net force towards the high velocity side is produced. If this force exceeds the resistance to motion (typically weight), the object will be drawn towards the low pressure side. Because airflow is outwards from the gripper there is no risk of blockage as with suction cups.

Commercially available Bernoulli grippers are typically targeted at handling rigid products such as silicon wafers and circuit boards. Attempts were made using these to grasp sample sheet foodstuffs. The flexible foods would vibrate rapidly on the basic gripper as the food would deform and alternately block and be blown away from the airway. This caused unacceptable product damage. A range of support structures to prevent the foodstuff deforming sufficiently to block the airway were investigated. Radial designs gave the best performance as the airflow was not impeded, yet 'land' to 'airway' ratios could be adjusted for the product deformation characteristics.

In addition to the modifications to the commercial gripper, flat Bernoulli grippers consisting of a flat box with one open side were built at FRPERC. Product supports were incorporated into the design. The product to be gripped formed the remaining side of the box, and when air from a blower was passed through the box, the product was held against the supports. Various sizes were built, the smaller performed better than the bigger units as the since both units were connected to the same blower, there were higher air velocities and thus greater Bernoulli gripping forces with the smaller, lower cross section box gripper.

These tools were used to lift fresh lasagne pasta, sliced ham, soft cheese, and salmon samples from mesh, stainless steel, worktop and skin surfaces. The trials were carried out at 8-10°C to give product flexural properties as would be seen in food industry applications.

Table 1. Final large flat Bernoulli gripper tests.

Slice type	Sample weight (g)	Hex mesh	Stainless	Worktop	Hand
Ham	3.4	1	1	1	1
	6.0	1	1	1	1
	12.5	1	1	-	-
Cheese	5.8	1	1	1	1
	14.1	1	1	1	1
Lasagne	5.8	1	1	1	1
	14.1	1	1	1	1
Salmon	7.6	1	1	OK	OK
	21.0	1	1	1	1

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

Table 2. Final small flat Bernoulli gripper tests.

Slice Type	Sample Weight (g)	Hex mesh	Stainless	Worktop	Hand
Ham	3.4	OK	OK	OK	OK
	6.0	OK	OK	1	1
	12.5	1	1	-	-
Cheese	5.8	2	2	2	2
	14.1	2	2	2	2
Lasagne	5.8	OK	OK	OK	OK
	14.1	1	1	1	1
Salmon	7.6	OK	1	OK	OK
	21.0	1	1	1	1

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

Table 3. Final modified commercial Bernoulli gripper tests.

Slice Type	Sample Weight (g)	Hex mesh	Stainless	Worktop	**Hand**
Ham	3.4	OK	OK	OK	OK
	6.0	OK	OK	3	3
	12.5	OK	OK	-	-
Cheese	5.8	3	3	OK	OK
	14.1	2 or 3	2	OK	OK
Lasagne	5.8	OK	OK	OK	OK
	14.1	OK	OK	OK	OK
Salmon	7.6	OK	OK	OK	OK
	21.0	OK	OK	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 modified commercial Bernoulli gripper performed the best with the majority of samples. The cheese was the most difficult product to lift as it was the stickiest, yet soft and tore easily. Ham slices appeared to be the most robust and easy to handle. The surface from which the products were lifted had a combined effect with the product. The commercial gripper showed ham to be lifted more readily from mesh and stainless, whereas cheese was more readily lifted from work surface and the hand.

This work has demonstrated the usefulness of Bernoulli airflow grippers in handling of soft flexible, delicate, sheet-like foodstuffs.

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