

MAGIC-HAND: A Bottle and Jar Opening Machine for People with Severe Disabilities

U Lorentzon¹, G Bolmsjö¹, M Doyle² and D Carus^{2*}

¹ Division of Robotics, Department of Mechanical Engineering, Lund University, Sweden

² Department of Mechanical Engineering, University of Strathclyde, Glasgow, UK

* *Corresponding author:* Dr David Carus, Department of Mechanical Engineering, University of Strathclyde, James Weir Building, 75 Montrose Street, Glasgow, G1 1XJ, Scotland, UK

E: david.carus@strath.ac.uk

T: + 44 (0)141 – 548 – 2592

F: + 44 (0)141 – 552 – 5105

ABSTRACT

This paper describes the development of a prototype product named *MAGIC-HAND* that has been developed to open bottles, jars and packages that require a twisting action. Its intended users are people with severe disabilities who are not capable of using the current range of package opening tools. It is a kitchen accessory device and fits into standard kitchen furniture. The machine uses novel design approaches applying human centred virtual prototyping methodology. It is highly automated so users need only place the package in the machine, close the door and activate the machine with a single touch of a button. The machine automatically centres the package, grips its base, senses the height of the closure, grips it and twists it open. Safety features are provided to ensure fingers cannot become trapped by accident. User trials have highlighted both the advantages and disadvantages of the machine. A comparison with current jar and bottle opening machine is provided. Routes to commercialisation are discussed.

Key Words:

Jar opener; bottle opener; assistive technology; smart homes

1. Introduction

The global packaging industry is one of the world's largest and most diverse manufacturing sectors, valued at over US\$400 billion. Estimates from the World Packaging Organization suggest the industry employs more than five million people in about 100,000 companies worldwide [1]. The industry cooperates with food manufacturers to supply products that are packaged for hygiene, safety, storage and convenience but it is recognized that some packages are difficult to open, particularly for the elderly population for whom muscle weakness, joint pain and neurological disorders are common.

As life expectancy increases, so does the time living with age-related changes and disabilities. The US Administration on Aging (AoA) reports that about one in every eight Americans is aged over 65 and the older population will continue to increase dramatically over the next 30 years [2]. Those over age 85 represent the fastest growing segment of the population. The European Commission reports that among the developed countries, Europe and Japan will experience the most pronounced ageing trends up to 2050 [3]. The share of the over 60 age group will be around 37% in Europe and even more in Japan, compared to only 27% in North America, where population growth will continue to be relatively strong.

The old-age dependency ratio is an indicator that the availability of assistance to older people is likely to diminish. This ratio is the total population aged 60 and over divided by the population aged 15 to 60 (Table 1). It is used to forecast financial implications of pensions policies but it is also useful for those concerned with management and planning of caring services [4]. The reduction in the availability of support promotes the development of assistive technology (AT).

Insert Table 1

2. Aims

The aims of the work described in this paper were, first, to develop a sophisticated home appliance named '*MAGIC-HAND*' that would open jars and bottles and secondly, to conduct a user evaluation. The machine would be suitable for people who find the task of opening these packages either extremely difficult or impossible, even with the aid of existing opening devices. The work was undertaken in the EU PACKAGE project (Provision for improved lifestyles via Access to Consumer packAGEs), funded by the European Commission's Information Societies Technology (IST) Programme. Full details of the project are described in its final report [5].

MAGIC-HAND was developed to promote independent lifestyles. Its users would need multiple assistive technology devices, so it is therefore better described as smart home technology, a term used for the electronic and computer-controlled integration of devices in the home [6]. They include controls for doors, windows, curtains and blinds; heating, lighting and security systems; communication aids; water taps; cookers and bed warmers but currently do not include opening machines for food packages.

3. Target users

The target users are people with impaired upper limb function who have major difficulty in opening packages with screw-top closures, even with the aid of the variety of openers available on the market. Their impairments include reduced strength and dexterity, pain & paresthesia and their conditions (in no specific order) include rheumatoid & osteo-arthritis, cerebral vascular disease (stroke), Parkinson's disease, cerebral palsy, multiple sclerosis, muscular dystrophy, motor neurone disease, mal-

united fractures, carpal tunnel syndrome, arthrogryposis and cervical 5 level spinal cord injury.

4. Jar and bottle opening machines

A number of inexpensive non-powered jar and bottle opening devices are available from retail stores and supermarkets. They include semi-rigid cone shaped rubber mouldings with finger grips, flexible rubber mouldings to grip small tops, fan shaped openers with serrated inside edges, and rubber straps which self-tighten around a closure when a handle is turned in the opening direction. In addition there are a number of tools to break vacuum seals and also holders that grip containers prior to opening. These simple devices are unsuitable for the target users, who need powered openers. Two commercially available powered jar and bottle openers were identified. *LIDS-OFF*™ is supplied by Applicia Consumer Products, a licensee of Black & Decker household products. It is a portable device that is intended for one-handed operation and requires no hand strength. To operate, the user places the jar on the machine's bed, rotates the bed to hold the jar in place, lowers the top of the jar opener to the top of the jar and presses a button. It is designed to be accessible to people of all levels of dexterity and strength, and to work with a wide range of jar and lid sizes. Its market is the general population, especially women who have difficulty in opening jars, particularly lids on vacuumed sealed jars.

OPEN-UP™ is the second jar and bottle opener for the general consumer market. It is a battery-powered device that can fit to the underside of a kitchen cabinet. It operates when a jar or bottle is pushed into an opening cone to activate a pressure switch. The cone rotates slowly, applying a frictional torque to the closure. The user is required to hold the bottle's base and exert a reaction torque.

The *JAROMATIC*™ is a prototype device, similar in concept to *LIDS-OFF* and has been designed to open jars and bottles. It also has one-handed operation and no hand strength or effort is needed. Its owner and inventor (Jerry Russell) developed his original prototype in 1998 to meet the needs of a friend. It is not yet a retail product due to production delays.

5. Human Centered Virtual Prototyping (HCVP)

The definition of *MAGIC-HAND*'s functional specification was done within the framework for the Human Centered Virtual Prototyping (HCVP). This is a methodology for designing and manufacturing prototypes using computer tools as an aid during the entire design process. Lorentzon and Bolmsjö have provided a full description of this methodology [7], for which an important aspect is information integration, not only between computer tools but also primarily between human resources and their different expertise areas. It is a holistic approach that places human resources at the centre of the developing process.

To implement the Human Centered Virtual Prototyping methodology, a User Group Forum (UGF) was established early in the PACKAGE project, comprising potential users of *MAGIC-HAND* recruited from caring and charity organisations in Stoke, Central England. Its members were invited to comment upon the existing range of non-powered opening devices. People with arthritis reported that manual opening tools were painful to use due to twisting actions, wrist rotation and squeezing movements. They complained they could not position their fingers and wrists correctly because of joint deformities and pain. Plastic handles were often regarded to be too rigid and many preferred longer handles. People who had suffered a stroke were able to use only one hand effectively, whereas some tools require two hands, one to hold the jar and the other to use the tool. It was quite common for people with tremor to have difficulty in

positioning opening tools, for instance people with cerebral palsy have uncoordinated jerky movements. Lack of dexterity was a common problem; comments such as some tools are 'too fiddly and awkward', 'difficult to handle' and 'keep falling off' were common. Some concern was expressed that tools with sharp or serrated edges might cause injury, especially to those people with poor eyesight. Others reported the contents might spill because it is difficult to apply high torque in a controlled manner. The jar and bottle holders were popular and it was not unusual for users to say that they were indispensable. Members of the User Group Forum participated in the development of the functional and technical design specifications of *MAGIC-HAND* and later in the testing of prototypes.

6. Specifications

The criticisms and concerns of the members of the UGF were considered in the development of the functional specification. It was decided that *MAGIC-HAND* would be a functional aid within a suitably modified kitchen environment. A major reason for rejection of AT is the stigma attached to an assistive product, so it was decided that *MAGIC-HAND* would be fitted inside a standard kitchen unit, hidden from view. The unit could be fitted at either floor or shoulder level for a wheelchair user. The opener would have a very high level of functionality; the only tasks required of the user would be to place the bottle or jar on a tray that would slide in and out of the cabinet (motorised if necessary), close the door and push a start button. The process of removing the closure would be fully automatic. It would not matter if the user was unable to position the jar or bottle accurately in the centre of the tray, because the machine would centre it prior to opening.

The principal functional specification criteria for *MAGIC-HAND* were (i) simple and intuitive controls; (ii) a grip range for jars and bottles with diameters between 30 and 100 mm; (iii) a clear opening height of 380 mm; (iv) an opening torque in excess of 5 Nm; (v) outer dimensions less than $W = 350$ mm, $H = 660$ and $D = 520$ mm so it could fit inside a standard 400 mm wide kitchen unit; (vi) an aesthetic 'non-orthopaedic' appearance, (vii) virtually silent operation; (viii) a variety of handle sizes and locations; (ix) a mass center close to the bottom to facilitate safe installation. Excluded from the specification were features to (i) open products with child resistant closures (CRCs) that require lateral pinching action; (ii) re-apply closures because of the likelihood of cross-threading.

MAGIC-HAND differs from *LIDS-OFF*, *OPEN-UP* and *JAROMATIC* in a number of critical aspects and is not a direct competitor. *MAGIC-HAND* is specifically intended for people with severe disabilities, whereas *LIDS-OFF*, *OPEN-UP* and *JAROMATIC* are for the general consumer market, albeit with emphasis upon people with reduced strength. *MAGIC-HAND* is a permanent fixture, hidden within a kitchen unit; *LIDS-OFF* and *JAROMATIC* are portable machines with aesthetic designs intended to be attractive appliances on kitchen work surfaces and *OPEN-UP* is a fixed unit but can be re-located easily. Finally *MAGIC-HAND* has the highest level of functionality, since it is able to open the largest range of sizes of jars and bottles, it can open plastic bottles that are easily distorted and it has a centring feature (Table 2).

Insert Table 2

None of the machines offers all the functionality that might be needed by users; for instance, bag slitters, cork pullers, openers for flexible cellophane wrapped packages and cartons, though a version of *LIDS-OFF* includes a can opener.

7. Development of *MAGIC-HAND*

Preliminary technical tests with a prototype machine showed that the task of opening jars and bottles is considerably more difficult than it initially appears. Smooth sided vacuum-sealed jars are difficult to grip securely and twist open; grippers suitable for one jar diameter might be unsuitable for other diameters; plastic bottles are distorted by crushing forces. The solutions adopted in *MAGIC-HAND* to these problems were first, to use only lateral forces to grip the base and closure of a package prior to opening and thereby avoid the application of compressive forces and secondly, to use the segment of a tractrix curve as the gripping surface for the base of the container. This curve has two advantages; it has self-locking characteristics and it is suitable for a wide range of container diameters. The final 3-D model of a finger formed a base for the generation of NC-milling programming (Fig. 1).

Insert Fig. 1

7.1 Description

MAGIC-HAND, illustrated in Fig. 2, comprises three units, namely the base unit, a vertical linear actuator and the top unit. The base unit has two functions, to move the bottle or jar to the centre of the base plate and to grip it. These functions are achieved with four fingers that are rotated by a belt that turns a plate to which are connected ball joints on the finger shafts. A screw-driven linear actuator, encased in an aluminium extrusion, moves the top unit with respect to the base plate. The actuator was supplied by Warner Tollo, Sweden, and was chosen for its good reliability, structural stiffness and strength, reasonable size and low noise.

Insert Fig. 2

The top unit grips and unscrews the closure. Its gripper was based upon the oil filter wrench, modified to give a larger gripping range. Its main component is a 12 Vdc geared motor with an output torque of 22 Nm. When the Warner Tollo actuator lowers the top unit onto the jar or bottle, the unit moves upwards on an internal spline connection. This vertical movement interrupts a light beam, which initiates the operation of both the upper and lower sets of grippers.

The control unit comprises two printed circuit boards (PCBs), the driver card and the logic card. These cards drive the motors and provide the logic for the unit. The driver card outputs a pulse width modulation (PWM) signal to the appropriate motor. System control is achieved with a Motorola MC68376 microcontroller chip and flash memory. Two separate power units are used for the 12Vdc and 24Vdc supplies. Five sensors are used for the position control for the lift unit (top and bottom positions), the infrared (IR) photodiode for the top unit, closure detection of the cabinet door and the start button.

7.2 Kitchen Unit

The base unit, vertical linear actuator and top unit are assembled together and secured on a sliding tray that fits inside a standard 400 mm wide kitchen unit. Wheelchair users can access the tray from the side (Fig. 3). Besides disguising the opener, the kitchen unit is a safeguard to prevent finger entrapment and provides protection for children. For safety purposes, an electromagnet locks the door and a light detection circuit checks the door is fully closed before the machine can operate.

Insert Fig. 3

7.3 Operation

A light touch of the user's finger upon a capacitance charge switch operates the machine (Fig.4). This switch is not recessed and can be positioned at the user's preferred height. A ring of light emitting diodes (LEDs) illuminates the switch to assist users with impaired vision. The base unit fingers centre & grip the base of the container and current sensing in the controller detects when the fingers have firmly gripped the package. The linear actuator moves the top unit down until it touches the top of the bottle or jar. The shaft in the spring-loaded unit is pushed up, its spring is compressed and the height detection element is activated, stopping the downward movement of the actuator.

Insert Fig. 4

The pressure that is generated on the top of the bottle results in friction between the top unit and the package. This friction is required to close the opening mechanism of the top unit when it starts to rotate. Continued rotation applies a torque to unscrew the

closure. The opening unit then rotates in reverse, thus opening the fingers. The top unit moves up to its top position, leaving room for the user to remove the package from the machine. A piezoelectric sounder is incorporated to provide audible indications to the user. A series of short sound beeps indicates that the system is commencing a cycle of operation; a series of longer beeps indicate the machine is ready and the door can be opened. For safety, commercially available EU-standards compliant power supplies are used and all power cables are shielded to avoid the generation of high frequency electro-magnetic fields.

7.4 Accessibility

MAGIC-HAND meets key recommendations of the Rehabilitation Research and Training Center on Independent Living Management (RRTC-ILM) team in Buffalo, NY to promote accessibility within the kitchen [8] (Table 3).

Insert Table 3

8. User Evaluation

User evaluation of the machine was conducted at the Innovationcenter in Housing for Adapted Movement (In-HAM), Gits, Belgium. There were forty-two participants (21 male, 21 female) with an average age of 39 (minimum 21, maximum 59), who had been selected on the basis of their disability. All but one required assistance to open packages. They were given unlimited time to evaluate *MAGIC-HAND* with a variety of jars and bottles and were invited to provide spontaneous comments upon functionality, usefulness, appearance, size, practical issues such as installation, cost and maintenance. Their responses were grouped into positive and negative comments, as

well as suggestions for further improvements. This was the first round of user testing and no statistical analyses were attempted. It could not be described as Beta testing.

8.1 Positive Reactions

MAGIC-HAND would promote independence and is suitable for people with severe disability because it has a high level of functionality and a single switch control. It is easy to use, intuitive and can be operated at the user's own speed (no hurry, no pressure). It has an acceptable non-stigmatising appearance. Difficult packages such as pickled cucumber in large glass containers can be opened. The design had focussed on cylindrical packages but the trials showed that it works for square and oval packages as well. The internal light and LEDs were helpful for people with poor vision. A number of variants could be provided to suit differing needs (height level, position of control, etc). Every participant considered the noise level satisfactory. Finally, the participants were not aware of any comparable product on the market.

8.2 Negative Reactions

The size of the machine was a concern, particularly for people with small kitchens. Some opening operations required a second attempt if the first attempt was not fully successful. Some closures are damaged and difficult to reapply. Spilt fluids would be a problem for cleaning; components should be removable, so that they can be cleaned in a dishwasher. It would be an expensive product and views varied considerably on how much people would be prepared to pay. The majority expected the cost to be 250 euros. It would be a specialist product, not likely to be available from supermarkets and main street retailers. It is not a complete solution because other openers are needed for packages that do not have screw-top closures.

8.3 Further Improvements

A sizeable number of participants commented upon the value of a window in the door so that they can see when the machine has finished, like a clothes washing machine. A motorised tray would assist some users. Ideally, the functionality should be extended to open wine bottles and cartons.

9. Discussion

MAGIC-HAND is a novel mechatronic system with three principal technical features. First, rather than applying downwards pressure on a closure to generate sufficient normal force that a frictional opening torque can be created, grippers that use lateral pinch are used to hold and rotate the base and closure. Secondly, the mechanism is capable of producing 22 Nm opening torque if the surfaces can provide enough friction. Practical tests showed that difficult packages such as pickled cucumber and similar products in large glass containers could be opened. Thirdly, although the design focused on cylindrical packages, tests showed that it works well for square and oval shaped packages as well.

9.1 The Market

In order to promote methods to classify potential users of *MAGIC-HAND*, the authors have used the World Health Organisation's International Classification of Functioning, Disability and Health, known more commonly as ICF [9]. In 2001, the 191 member states of the World Health Organisation agreed to adopt ICF as the basis for the scientific standardisation of data on health and disability world-wide. It provides a standard language and framework for the description of health and health-related states and it is a universal classification of disability and health for use in health and

health-related sectors, including assistive devices. The formal definitions of the components of ICF are given in Table 4.

Insert Table 4

The predicted activity and participation limitations for *MAGIC-HAND* users are listed in Table 5, in accordance with ICF recommendations.

Insert Table 5

Although the ICF classifications provide some assistance in classifying potential users, the market (as opposed to users with perceived needs) for assistive technology such as *MAGIC-HAND* is difficult to define. The profiles of potential users have a wide range, so it is difficult to target purchasers solely on the basis of disability. For instance, a person who is severely disabled might gain major improvement in his or her quality of life through the ability to occasionally prepare a meal for the family, but would such a person buy *MAGIC-HAND* for occasional use? On the other hand, a person who prepares all the meals for the household but has painful arthritis might be satisfied to ask a family member or neighbour to open jars and bottles. Would such a person buy *MAGIC-HAND* for daily use? A product such as *MAGIC-HAND* is sensitive to life-style factors such as the support of family members and quality of life expectations, but it is not sensitive to laws and regulations, healthcare prescriptions and quality assurance demands.

9.2 Long-term commercial potential

The authors consulted manufacturers, retailers, charities and government bodies to promote *MAGIC-HAND* as a commercial product and concluded there are many major

obstacles. There will be a long haul to market for the following reasons. First, there is a lack of clarity about funding models. Assistive technology has a low priority in health and social care strategies [10], so public and insurance funding schemes are strictly limited. Potential purchasers of *MAGIC-HAND* are likely to be private individuals who would have to find the product in catalogues or from the very small number of specialist retailers. An individual who is likely to benefit from *MAGIC-HAND* might also need multiple AT devices for tasks such as washing, toileting, door and curtain opening, security and environmental control, etc, so the total cost of a 'complete package' could be daunting. Secondly, the market demand for such a product is unlikely to be high because it is a specialist product for the AT sector and will not have the benefits of large market volume and hence reduced manufacturing costs. Marketing for the *LIDS-OFF* product was estimated at \$1.5 million [11] but marketing costs of that scale cannot be expected for *MAGIC-HAND*. Even the terminology for assistive technology is confusing, with the terms electronic assistive technology (EAT), environmental control systems (ECS), smart homes and domotics used interchangeably. 'Buzz' words such as 'intelligent devices' abound. Assistive technology is poorly defined and described. Erika Feinberg, CEO of ActiveForever a company that markets a wide selection of assistive daily living aids was reported to have said, "This market is so far behind, it's very, very antiquated" [12]. Thirdly, the authors encountered significant resistance from mainstream kitchen appliance manufacturers, which are reluctant to enter the 'disability market' in which they have no previous marketing experience. Finally, there is a brand image issue; some manufacturers approached by the authors stated that their brand images must remain associated with lifestyles that are projected as modern and attractive. Their advertising is targeted at youth and vitality, not age and fragility.

The next stage for commercialising *MAGIC-HAND* will be comprehensive beta group testing, from which definitive functional claims could be obtained from a variety of prospective purchasers.

10. Conclusions

The bottle and jar opening machine offers a high level of functionality for people with severe disabilities but it is only one of a range of devices required for independent living. It is currently believed that the machine is most likely to be used in communal kitchens in sheltered housing, where its availability would support a level of independence but within a supported environment. The current design was focussed on providing a high quality prototype for demonstration and trial purposes, so its cost is high. Information about the development of the machine has been widely circulated to disability support groups and charities to obtain their views and opinions about further development and exploitation.

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References

- [1] Rothwell T. The packaging marketplace: a global view. Summary article of: The global packaging market; the top 100 players; publisher AWA Alexander Watson Associates, Amsterdam, The Netherlands. *Packaging World*, 2002;10:191. Available from www.packworld.com/articles/Features/15082.html
- [2] Greenberg S (ed). A profile of older Americans: 2005. Administration on Aging, US Department of Health and Human Services, Washington DC. Available from www.aoa.gov/PROF/Statistics/profile/2005/2005profile.pdf
- [3] European Commission Directorate-General Health and Consumer Protection, Brussels, information sheet, 2006. Available from http://ec.europa.eu/health/ph_information/dissemination/diseases/age_en.htm
- [4] World Health Organisation, Non-communicable Diseases and Mental Health Cluster. Active ageing: A policy framework. Report reference WHO/NMH/NPH/02.8; 2002 Available from www.euro.who.int/document/hea/eactagepolframe.pdf
- [5] Carus D A *et al.* Final report on PACKAGE (Provision for improved lifestyles via access to consumer packages); funded by the European Commission's Information Society Technology Fifth Framework Programme, contract number IST – 1999 – 12223 (1999-2004). Department of Mechanical Engineering, University of Strathclyde, Glasgow, UK. 2004; 166 pp. Available from www.mecheng.strath.ac.uk/package_final_report.pdf
- [6] Cowan D, Turner-Smith A R. The role of assistive technology in alternative models of care for older people. Appendix 4 of: With respect to old age: long term care – rights and responsibilities: Alternative models of care for older people. Research Volume 2, by Tinker A, Wright F, McCreadie C, Askham J, Hancock R, Holmans A; for The Royal Commission on Long Term Care (UK) London: The Stationary Office, 1999;325–346
- [7] Lorentzon U and Bolmsjö G. A methodology using computer tools in the product development process. In: Proceedings of 8th mechatronics forum international conference, mechatronics 2002, Twente, The Netherlands, June 2002. Available from ww.robotics.lu.se/ulimage/mechatronics2002.pdf
- [8] Fraas L F. Report: Home Modifications. Part 10 in: Centers for Independent Living (CIL) Pathfinder for Services & Programs for Older Americans: Rehabilitation Research and Training Center on Independent Living Management (RRTC-ILM), Department of Rehabilitation Science,
- [9] University at Buffalo 2004. Available from www.wnyilp.org/RRTCILM/pathfinder/index.html
- [10] Ústún T B. Towards a Common Language for Functioning, Disability and Health, ICF. World Health Organisation, Geneva. Report number WHO/EIP/GPE/CAS/01.3. 2002. Available from www.designfor21st.org/documents/who_icf_2002.pdf

- [11] Tinker A *et al.* AT home with AT; introducing assistive technology into the existing homes of older people: feasibility, acceptability, costs and outcomes. King's College London and the University of Reading. Institute of Gerontology, King's College London. 2004. ISBN 1-872342-17-5. Available from [ww.kcl.ac.uk/kis/schools/life_sciences/health/gerontology/pdf/reki.pdf](http://www.kcl.ac.uk/kis/schools/life_sciences/health/gerontology/pdf/reki.pdf)
- [12] Mitchell C. applica Consumer Products Inc introduces Black & Decker Lids-Off automatic jar opener. PR Newswire United Business Media press release. May 2003. Available from www.prnewswire.com/mnr/applica/10799/
- [13] Feinberg E. Interviewed in The Wall Street Transcript (TWST). July 2004. Available from www.twst.com/ceos/YAP612.html

FIGURES AND TABLES

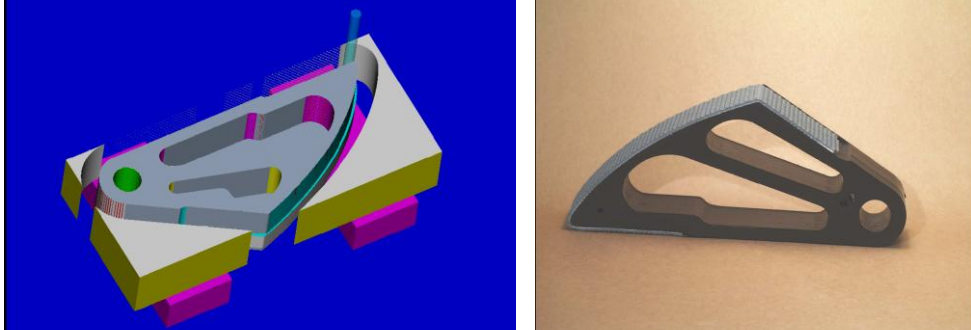


Fig. 1. Tratrix curves used in base grippers

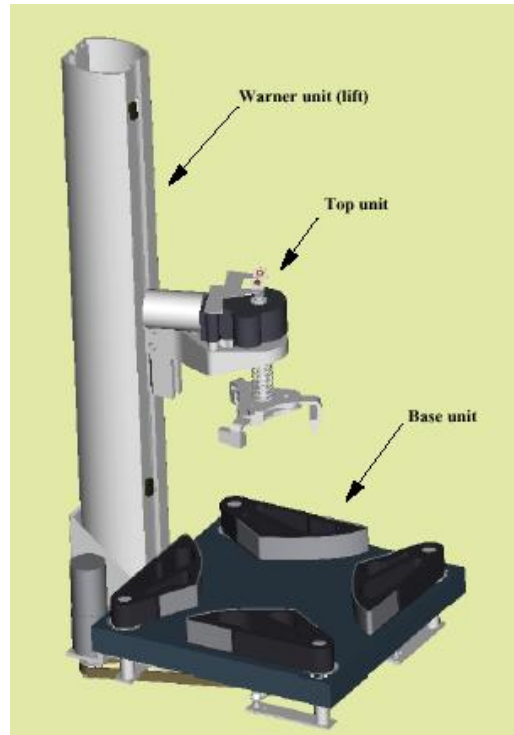


Fig. 2. Bottle and jar opening mechanism



Fig. 3. Opening mechanism in a standard



Fig. 4. Single touch control button illuminated by a ring of light emitting diodes

Table 1

Old age dependency ratio for Japan, the European Union and North America
(extract from World Health Organisation report reference WHO/NMH/NPH/02.8; 2002)

2002		2025	
Japan	0.39	Japan	0.64
European Union	0.36	European Union	0.56
North America	0.26	North America	0.44

Table 2: Functional features of *MAGIC-HAND*, *LIDS-OFF*, *OPEN-UP* and *JAROMATIC*
 (Some data is taken from marketing literature)

	<i>MAGIC-HAND</i>	<i>LIDS-OFF</i>	<i>OPEN-UP</i>	<i>JAROMATIC</i>
<i>Target market</i>	disabled people older people	general consumers older people	general consumers older people	general consumers older people
<i>Level of disability</i>	severe - complete	mild - moderate	mild - moderate	mild - moderate
	jars and bottles	jars	jars, some bottles	jars
<i>Location</i>	inside kitchen unit; non-portable due to size	countertop & portable	wall or surface mount	countertop & portable
<i>Hands-free operation</i>	yes	yes	no	yes
<i>Limitations</i>	expensive	not intended for tall slim bottles	requires user to apply resistive torque	not yet available
<i>Secondary features</i>	incorporates tractrix grippers; centring feature	for opening jars but also includes a can opener		
<i>Grip range</i>	1.2 – 3.9" 30 – 100 mm	up to 4½" 115 mm	½ - 4" 13 – 100 mm	¼ - 5 ½" 7 – 140 mm
<i>Jar/bottle height</i>	15" 380 mm	up to 8" 200 mm	no limit	1 – 10¼" 25 – 260 mm
<i>Dimensions</i>	14 x 26 x 20" 350 x 660 x 520 mm	8.5 x 10 x 7.75" 215 x 250 x 200 mm	not specified	5½ x 8¼ x 11½" 140 x 210 x 292 mm

Table 3: Accessibility features of *MAGIC-HAND* within the kitchen

	<i>RRTC-ILM Recommendations for Accessibility</i>	<i>MAGIC-HAND</i>
1	Additional lighting	Internal light provided in kitchen unit.
2	Open cabinets for wheelchair accessibility/cabinets with removable fronts	Kitchen unit door can be fitted to open about either a vertical or horizontal axis
3	D-ring cabinet handles/large knobs	Fitted
4	Easy glide drawers	Fitted – could be motorized if required
5	Height adjustable cabinets	Kitchen unit can be fitted at preferred level
6	Appliances designed for accessibility - controls in front or side (installed 30 - 42" high)	Charge capacitance switch operated with a light touch of a finger. It can be positioned at any preferred level
7	Consider turning radius for wheelchair manoeuvrability (minimum 60" x 60")	Should be provided in kitchen design
8	Matte surfaces / avoid glare and reflection	Kitchen unit can be selected to suit
9	Push button, large knobs/visual/tactile cues on controls	A light touch of the user's finger upon a capacitance charge switch operates the machine. Switch not recessed; placed in preferred position Ring of LEDs around the operating switch
10	Automatic control faucets	Audible indication when machine is working and ready

Table 4: Definitions of WHO's international classification of functioning, disability and health (ICF) components

ICF Component	Definition
Body functions	Physiological functions of body systems (including psychological functions)
Body structures	Anatomical parts of the body such as organs, limbs and their components
Impairments	Problems in body function or structure such as a significant deviation or loss
Activity	Execution of a task or action by an individual
Participation	Involvement in a life situation
Activity Limitations	Difficulties an individual may have in executing activities
Participation Restrictions	Problems an individual may experience in involvement in life situations
Environmental Factors	Make up of the physical, social and attitudinal environment in which people live and conduct their lives

Table 5: Predicted activity and participation limitations for *MAGIC-HAND* users

Health conditions	Impairment <i>Problems in body function or structure such as a significant deviation or loss</i>	Activity limitation <i>Difficulties an individual may have in executing activities</i>	Participation limitation <i>Problems an individual may experience in involvement in life situations</i>
Rheumatoid and osteo-arthritis, cerebral vascular disease, Parkinson's disease, cerebral palsy, multiple sclerosis, muscular dystrophy, motor neurone disease, mal-united fractures, carpal tunnel syndrome, arthrogryposis and cervical 5 level spinal cord injury.	Restrictions in joint movement, weakness, joint pain, tremor, limited coordination, paraesthesia	Unable to open jars (particularly vacuum sealed), unable to open bottles	Unable to prepare full range of meals, reduced care for family members, social life restrictions, social status reduced, embarrassment