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This report presents detailed research on the Citrus Juicer CCJ-100 by Cuisinart. First, information about history and development of the juicer is discussed. Next, results from the usability test of the product are presented. With data and studies collected from the testing, a redesign of the product is shown. Extra documents are also attached at the end of the report.

Credits for this research paper can be found on pages 44-45

Table of Contents

Content **Page**

Executive Summary

For this project, we were given the task of analyzing and improving on the Cuisinart citrus juicer model CCJ-100. Our project was essentially divided into three parts: product research, testing and redesign.

Product research involved not only looking into the evolution of this juicer, but the evolution of juicing fruit as a whole and the history of Cuisinart. We found Cuisinart to be an older company that was centered around kitchen appliances, specifically food processors. Once it attained new ownership in the late 1980's when they are bought out by Conair Corporation, it had the capacity to expand its brand name into every type of kitchen appliance, including the juicing market.

When we analyzed the evolution of juicing fruits, we found that before the invention of the electrical motor there were essentially two methods of manually extracting juice. One involved manually twisting the citrus fruit on the ridges of a juicing cone, which serves as the foundation of the CCJ-100's design. The other involved a hand press which pinched the fruit between two concentric cones. With the invention of the motor came a few different methods of juicing. Designs ranged from high spinning blades that were more similar to blenders, and hydraulic presses which applied high amounts of force to pulp in order to extract the juice.

Our testing step was the more laborious and hands-on of all the steps. We conducted a usability test where we observed subjects using the juicer and asked them for feedback. During this test we learned a lot, but the three biggest complaints were that it was noisy, tiring and that the excessive pulp caused clogging. One positive thing about our juicer was that it proved able to make two cups of orange juice in under ten minutes. After conducting tests, we dismantled

the juicer and figured out how it worked and took measurements regarding size, weight and power of the assembly. Extensive material studies were done on a few components to determine whether the materials used were practical or if they could be improved upon.

Finally, we began the step of redesigning this juicer. Our redesign is broken into three objectives to resolve three problems identified during the usability tests, which were noise, user fatigue, and pulp buildup. Our redesign tackles the problem of noise by lining the inside of the juicer with sound-absorbing foam. Polyurethane foam has the capacity to absorb 30% of noise and is cheap enough to not drive up the price of the product. Our largest design change was our solution to make the juicer easier to use. We proposed adding a lever with a cone on it to limit the amount of work the user has to do and the amount of vibration the user feels. The lever mechanism is designed to simplify the user's efforts by means of adding a lever and eliminating the user's contact with the vibration of the juicing cone. Lastly, we developed a solution to pulp buildup with a dual purpose. We included a speed control, which has the ability to decrease pulp buildup and decrease speed, and vice versa. This speed control allows for the user to decide between extracting juice quickly with a large amount of pulp buildup or slowly with minimal pulp buildup.

Our overall project evolves the cheap-yet-inconvenient juicer that many people have into a convenient luxury. Our redesign makes juicing easy on the user and offers the ability to adapt to each user with our proposed speed control. The lever allows for juicing to be a simple, clean task and will make people's juicing experiences enjoyable. Lastly, our quieter design will not disrupt conversations or wake people up in the morning making it more practical.

History and Development of the Product

History of Cuisinart

Carl Sontheimer founded Cuisinart in 1971 on the idea of developing a food processor and other kitchen appliances ("Cuisinart Corporation History"). With his degree from the Massachusetts Institute of Technology, Sontheimer was able to make a food processor that soon spread into many kitchens in the United States. He then developed various sizes of his food processor to fit the differing needs of the consumer. Cuisinart was carried by this food processor design for almost 20 years before it was sold to Conair Corporation. Conair made use of the renowned name of Cuisinart to turn it into a brand for all kitchen appliances. In the 1990's, they expanded their market with new products such as blenders, coffeemakers, hand mixers and toasters ("Cuisinart Milestones"). After 40 years, Cuisinart has established itself in the competitive market of kitchen appliances with products in 70% of all small appliance categories ("Over 40 Years of Culinary Excellence"). Cuisinart has become a large brand and has grown far larger than Sontheimer probably ever thought it would with their food processor as their most popular product.

History of Cuisinart Juicer

Juicers seem to have originated in eighteenth century Turkey ("Lemon Squeezer"). The oldest known lemon squeezers were ceramic and resembled the traditional style of eighteenth century Turkish pottery. On the surface, it looks as though the original juicers are similar to modern-day press equipment with cones, but in actuality their design is much different. The earliest juicers were made one at a time, and they were specifically designed for making the then-popular citrus drink, sorbet. Cuisinart first made the Citrus Juicer in 2003. The company entered the juicer market with this Citrus Juicer, inventing the device from scratch ("Cuisinart's First-Time Citrus Juicer Combines Style with Efficiency").

Figure 1. Cuisinart Citrus Juicer (Source: "How a Citrus Juicer Works")

Product Evolution

Elementary Juicing Cone

Initially, citrus juicers were extremely simple in their design and appearance. The earliest "lemon squeezers," as they were called, were made of ceramic. Eventually, these primitive juicers were built using alternative materials such as glass or plastic. However, their design remained intact: a cone with which the citrus was juiced, a reservoir which collected the juice,

Figure 2. First, Earliest Embodiment of a Citrus Juicer (Source: “Lemon Juicer”)

and in some cases a spout which allowed for quick transfer of the drink. In order to extract the juice, one needed to press the flesh of a citrus fruit into the tip of the cone, and manually squeeze and twist the fruit in unison.

Patent No. 7,117,784, titled “Juicer and Grater Assembly,” describes the juicing cone as an invention that “[allows] extracted juice to flow through the plurality of second apertures, or [allows] juice and pulp to flow through the plurality of first apertures.” This patent is significant because it protects a juicing mechanism that, like our device and all its predecessors, utilizes the juicing cone to extract juice from cut citrus fruit. Moreover, this patent mentions several advancements in the juicing cone that have contributed to the evolution of the citrus juicer. For instance, the invention’s features include the ability to “[provide] both juice and juice with pulp when desired”; usability “with any juice reservoir or container by placing the assembly on top of the juice reservoir opening”; two interchangeable, variably-sized cones that can be used to extract juice from small or large citrus fruit; and a "plurality of longitudinal ridges" which maximize juice extraction.

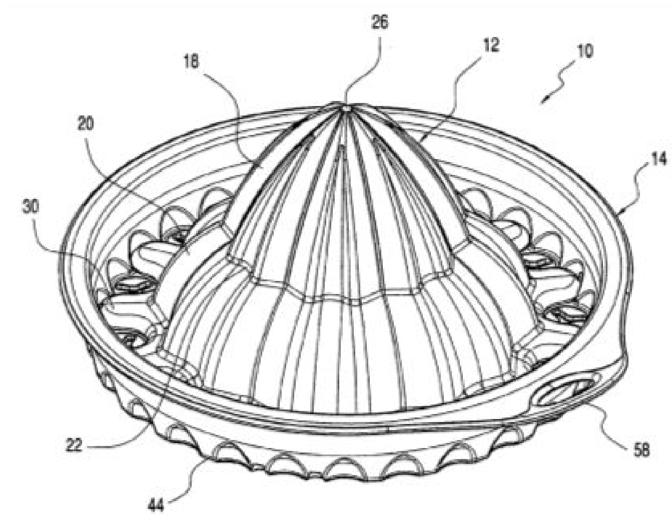


Figure 3. Juicer Assembly ("Juicer and Grater Assembly")

Hand Press

An important change that led to citrus juicers' present-day form is the addition of a press mechanism. Similar to its predecessor, the hand-held citrus juicer is cone shaped. Two concentric cones with handles are adjoined so that when one grasps both handles, the smaller of the cones fits inside of the larger one. To extract the juice, one must place half a citrus fruit into the device so that it fits conveniently in the larger cone. By squeezing both handles together, one presses the fruit to obtain its juice. In contrast to the first-ever juicer, the hand-held citrus squeezer is less laborious and more time-efficient. Rather than squeezing and twisting simultaneously, the hand-held model only relied on squeezing. Because its cones are concentric and nested, even pressure is distributed to all parts of the citrus when pressed, maximizing the juice output in one swift motion.

Figure 4. Hand-Held Citrus Squeezer (Source: “Design Resource on Kitchen Products”)

Electric Juicer

The largest change that occurred in the evolution of the juicer was the addition of an electric motor. The motor allowed for different methods of juicing to be implemented, which would have required too much physical exertion to do manually. Thus, many various types of juicers were born out of the integration of an electric motor and a juicer such as pressing or masticating and rotating citrus juicers.

Press Juicer

The press juicer (Figure 5) was an electric juicer, which produced juice in two steps, grinding and pressing. The grinding step involved feeding the fruits into a hopper where they were ground into pulp by a spiraling cutter. The next step involved placing this pulp in a linen bag where it was pressed. The linen bag allowed for the juice to flow out while the fabric strained out any pulp and kept it in the bag.

Figure 5. Press Juicer (Source: “Norwalk Juicer”)

Electric Cone Juicer

Electricity also allowed for improved versions of the classic “ridged-cone” juicer, such as the CCJ-100 in Figure 6. These types of juicers had the cone attached to a motor, which rapidly rotated the cone when the fruit was pressed onto it. This removed the tedious back-and-forth rotational motion that was normally required for this method of juicing. The resulting pulp then fell into a plastic, large-holed strainer that was also attached to the motor, allowing the pulp to be extracted and then juiced with one mechanism. This type of juicer was developed some time after the press juicer came about.

Figure 6. Cuisinart Electric Rotary Juicer (Source: "Cuisinart CCJ-100 Citrus pro Juicer.")

United States Patent No. 5,193,447, "Citrus Juicer," specifies a "cone driven by a drive shaft of a motor and surrounded on all sides by a strainer provided with passageways under which a bowl having an inner wall and collecting the fruit juice is disposed." You can see in Figure 7 the very basic design of a cone attached to the motor shaft, which is the foundation for our specific citrus juicer model. This patent vastly increases the functionality of a citrus juicer as it requires much less physical force because the device rotates automatically and the user simply has to apply minimal downward force on the cone. This design is also key to reducing the amount of time it takes to juice fruit and getting the maximum amount of juice yield.

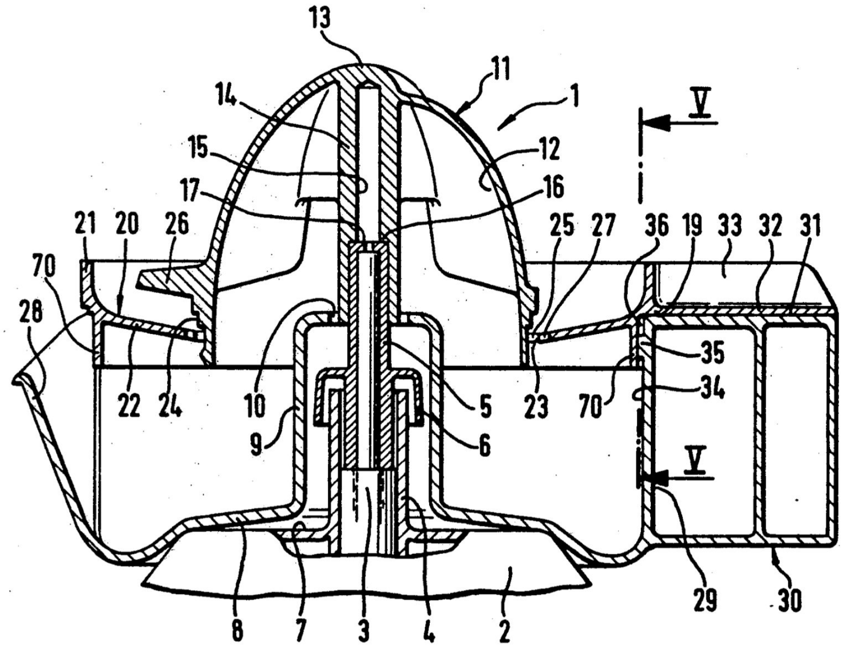


Figure 7. Motor-driven Juicer Cone (Source: "United States Patent: 5,193,447")

Patent No. 6,945,162 was a further refinement of the electric rotary juicer. As seen in Figure 8, it incorporates "a rotatably disposed, upwardly tapering, projecting element" (Claims:1; Img: #11), oriented such that it pushes "the fruit pulp between said blade and said annular surface [strainer]" (Claims: 1; Img: #5) as the strainer is revolved. This increases the amount of juice extracted from the pulp, allowing one to use less fruit for a given amount of juice.

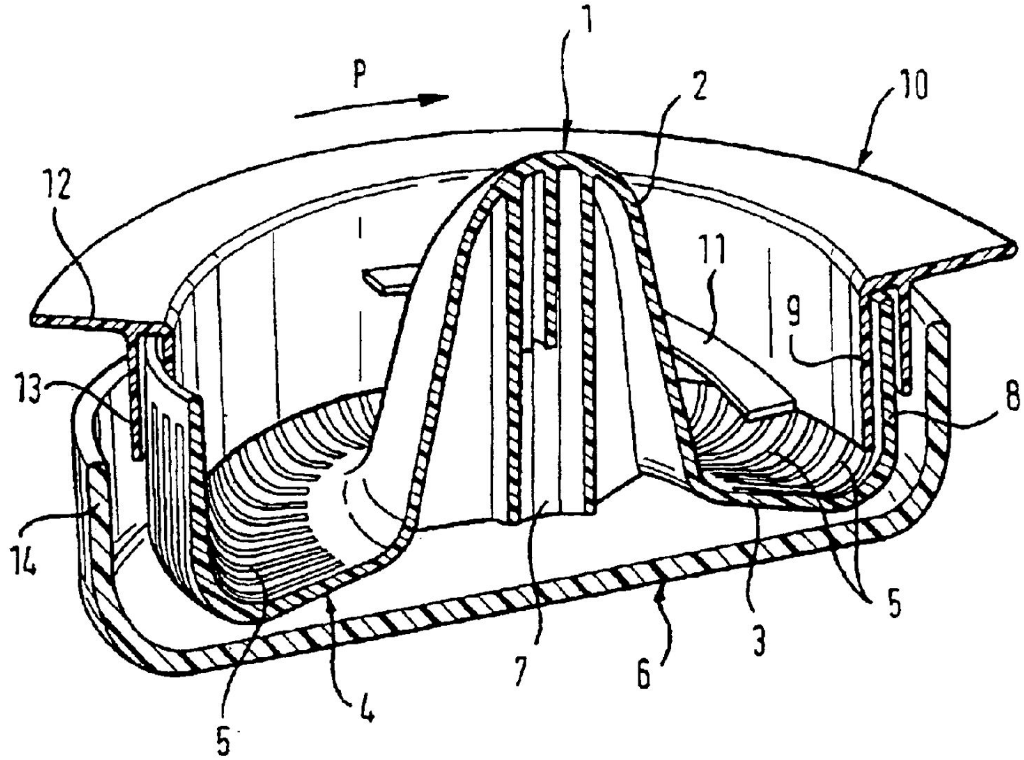


Figure 8. “Fruit juicer with increased juice yield” (Source: “United States Patent: 6,945,162”)

Recent Models

Our version of the product (Figure 9) is the Citrus Juicer 100, or CCJ-100, by Cuisinart, which has been discontinued. The latest version that Cuisinart has announced, the CCJ-500, was announced in March 2011, and released May 2011 (“Cuisinart Pulp Control Citrus Juicer”). The CCJ-500 (Figure 10) has a body shaped like a rectangular prism, with a large, cylindrical indent for glasses under the elongated juice spout, while the CCJ-100 has a more conical body, with no ident under the juice spout. Our version also lacks any type of speed control or special functionality, while the CCJ-500 has a variable speed control with 3 options, and speeds on the last spin to extract more juice from the fruit. The CCJ-500 also features a safety lock mechanism.

Figure 9. CCJ-100 (Source: “Submarino”) Figure 10. CCJ-500 (Source: “Belk”)

United States Patent No. 7,871,196, “Juicer Safety Device,” describes how the invention of a safety device on the juicer lets the consumer handle the machine safely and conveniently. When conventional juicers were used, there was a risk of ingredients rushing out of the container if it was not fully closed. In addition, the rotor would still spin even if the rotary cover (Figure 11) was not atop it. In a second situation, the device could directly hurt the consumer, for instance if their hands came in contact with the rotor while the machine was turned on. In order to minimize dangers, a safety mechanism was invented.

Figure 11. Cuisinart Rotary Cover (Source: “Cuisinart Booklet”)

There is now a cap that covers the motor and rotary member of the machine. The extra layer gives the consumer protection from the motor and rotor while also keeping large residual pieces

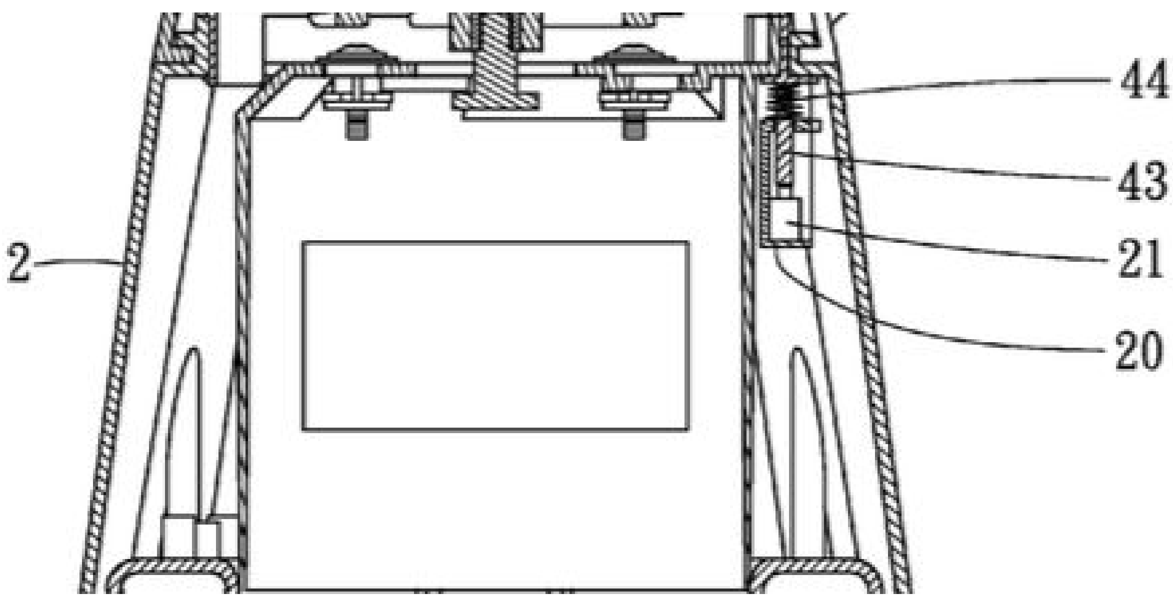


Figure 12. Juicer Safety Device (Source: “United States Patent: 7,871,196”)

from getting stuck. In addition, any ingredients and juice can be prevented from splashing out with a safety switch. When the container is not fully closed, switch 44 automatically turns off, stopping the motor from operating. The safety device operates even if the button for turning on the machine is pressed.

Another recent model by Cuisinart, CJE-1000, can process whole fruits even if they are not as soft as oranges or lemons. This is perhaps the most significant improvement in modern juicers, increasing the versatility of products where customers can throw in any types of fruits or vegetables to make a beverage.

Figure 13. Cuisinart Juice Extractor CJE-1000 (Source: “Cuisinart Products: Juicers”)

The usability of juicers has also been enhanced. The CJE-1000 model comes with an LED-lit knob, making it easier to be used in the dark. Due to a faster and more powerful motor, the juicer not only processes more quickly, but it also operates more quietly. In addition, due to the structure of the juicer, it is easier to take apart and clean. Accessories that now come with the device, such as a brush, also help clean the machine more conveniently.

Market Forces and Customer Needs

Among the most important things that led to each of the device's evolutionary steps were: a high demand for easier yet more effective ways to juice; advancing technologies; growing obsessions with nutrition; and, cut-throat market competition. Without market competition, companies like Cuisinart would not have been as innovative, productive, or responsive to the wants and needs of customers. Therefore, output of new products would have likely become stagnant.

Testing

Usability Test

The Cuisinart Juicer CCJ-100 is the first juicer of its kind to be produced and sold by Cuisinart. This juicer is capable of extracting the juice from any type of citrus fruit by grinding the pulp with a rotating cone. The pulp is then strained to produce freshly squeezed juice. It is designed to extract juice quickly so the user may enjoy juice at home. It is also relatively compact with a height of 10.8”, a diameter of 6” and a weight of 2.25 lbs (Table 1).

Table 1. Metrics of Juicer

Height of juicer	10.8”
Diameter of juicer	6.00”
Weight of product	2.25 lbs
Weight of cone	0.25 lb
Weight of reservoir	0.25 lb
Diameter of widest part of cone	3.00”
Diameter of depressed part of cone	2.25”
Height of cone	2.75”
Diameter of draining holes	0.115”
Cord length	2’ 2”

Figure 14. Cuisinart Citrus Juicer

Test Method and Results

We conducted a usability test with two different methods. The first method involved one test subject juicing two cups of juice while measuring the amount of time and number of oranges required to produce two cups of juice. The second method involved having six test subjects juice two to four oranges each. We again measured the total time and total oranges to collectively produce two cups of juice. This gave us a value to compare to the first method as well as a broader perspective on how various people use this product.

We were able to collect data to compare the time and number of oranges it takes to produce two cups of orange juice (Table 2). We found that it takes an average of 9 minutes and 15 seconds to produce two cups of orange juice (Figure 15). We also found that this product has a very simple design, as none of the subjects had difficulty with figuring out how the juicer worked. We offered no assistance or direction in how to juice the oranges, yet they all were able to figure it out and juiced the oranges by the same method.

Table 2. Usability Test Results

Test Subject	**# of oranges**	**Time**	**Amount of juice produced**	**Total time to produce 2 cups**
Subject 1	8	7:30	2 cups of juice	7:30
Subject 2	4	3:15	2 cups of juice	10:32
Subject 3	2	2:00		
Subject 4	2	5:17		
Subject 5	2	3:52	2 cups of juice	9:43
Subject 6	3	3:30		
Subject 7	3	2:21		

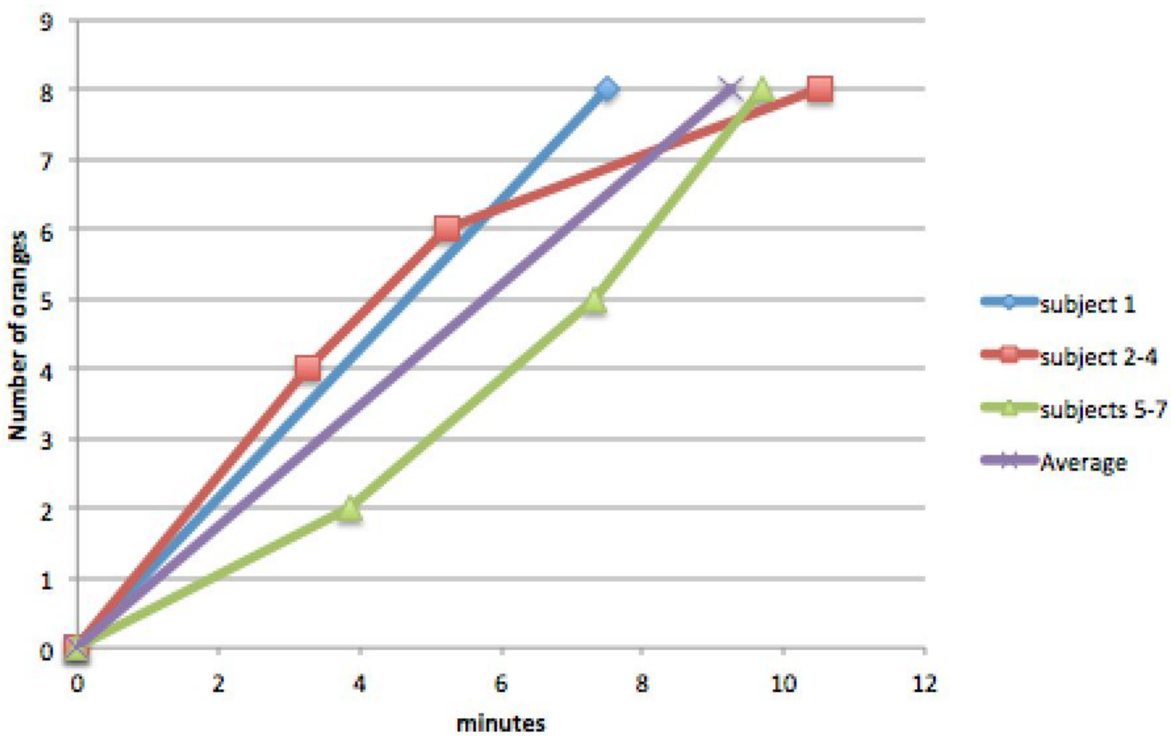


Figure 15. Test Results Plot: Oranges Juiced Versus Time

<u>User Feedback</u>

During the usability test, we took note of any comments that the subjects made about the juicer and asked questions about the effort and overall experience of using the juicer. All of the subjects independently made comments on how tiresome the juicer was and the amount of noise it made.

When we analyzed the mechanics of the juicer, we found that the juicer required far too much effort on the user's part, especially when the user was juicing for an extended period of time. The user must exert a minimal downward force of 2.5 lbs onto the cone to activate the motor (Table 3). Due to the design of the juicing cone, the user also had to exert a squeezing force on the sides of the orange so that the sides of the orange would come into contact with the juicing cone, while also resisting the rotational motion of the juicer. The combination of these three forces exerts a great deal of strain on the user's arm and becomes exhausting after juicing only a few oranges.

Table 3. Motor Specifications

Specifications of the Electrical Parts (Running without a Load)	**Numerical Values**
Power of the product at 48 A	55 W
Electric Supply	122 V
Minimal downward force to engage the motor (at button)	1 lb
Minimal downward force to engage the motor (at reservoir)	2 lbs
Minimal downward force to engage the motor (at cone)	2.5 lbs

Every subject complained that the juicer made excessive amounts of noise. One of the subjects commented that when the juicer spun it made excessive amounts of noise and another subject thought the juicer was breaking when they heard the noise. Talking over the machine also proved to be somewhat difficult. To investigate further, some numerical measurements of the noise were collected. We found that from 3 feet away, a sound of 90 decibels was being emitted from the juicer and that sustained exposure to a noise of 90–95 decibels can result in hearing loss (Figure 16). Thus, noise proves to be a large problem, especially since the juicer is likely to be used in the morning and a sound of that volume will typically wake other people up in an average sized dwelling.

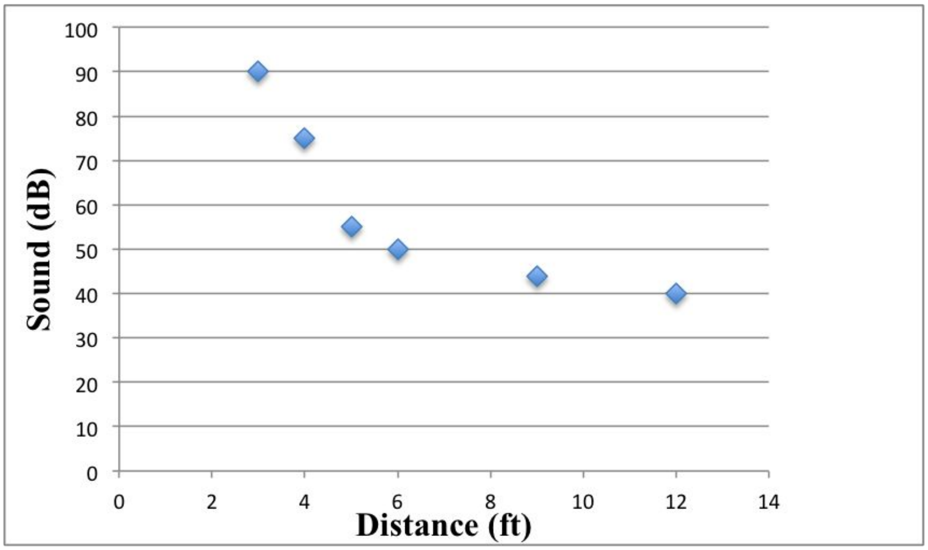


Figure 16. Loudness at Various Distances

Lastly, a problem that arose with a few of our subjects was the issue of pulp clogging the strainer. A few of the subjects attempted to extract the juice that was trapped inside the pulp buildup, but they found it difficult and messy to clean out. Other subjects would just throw away all the pulp as well as all the juice that gets trapped inside the strainer (Figure 17).

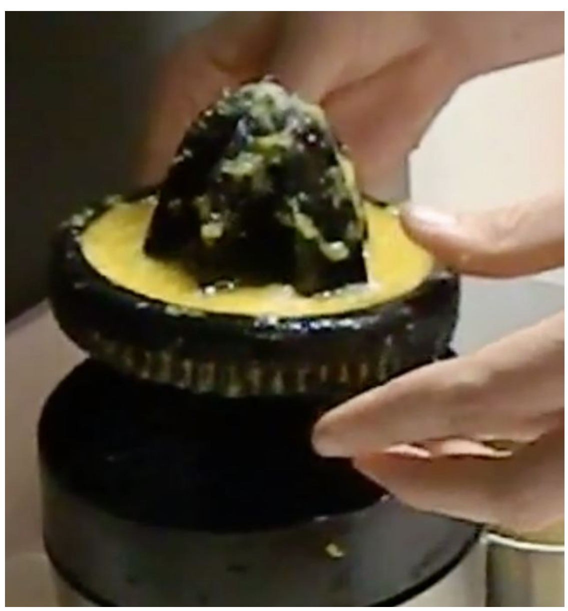


Figure 17. Clogged Juicing Cone

Material Study

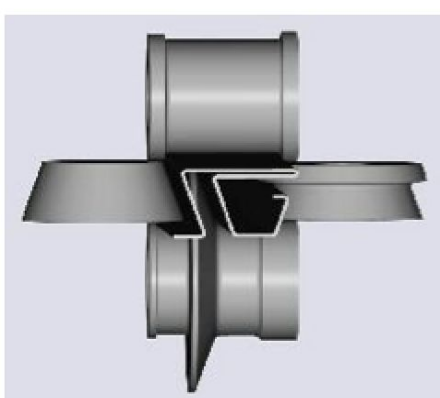
Induction Coils

Introduction

The Cuisinart CCJ-100 juicer utilizes a small, cheap AC motor to rotate the juicing cone. The motor uses coils formed from tightly wound, fine wire to generate the magnetic fields required for the motor. The wire used is composed of 99.0% pure copper.

Elemental Properties

Copper is an orange, metallic element, which is fairly ductile, and electrically and thermally conductive, with a Young's modulus of 110-128 GPa, shear modulus of 48Gpa, Mohs hardness of 3.0, resistivity of only 16.78 nanoOhms*m at room temperature, and thermal conductivity of 401 W/m/K. It is also cheaply and easy to locate, as it is available in a variety of purities and forms, at many different websites, for as cheap as $3.29 for 50 ft of 20 Gauge wire. It is fairly easy to anneal, which makes it more electrically conductive and more ductile. Copper is also moderately dense, at 8.96g/cm^3, and has a melting point of 1357.77K (1084.62 °C).



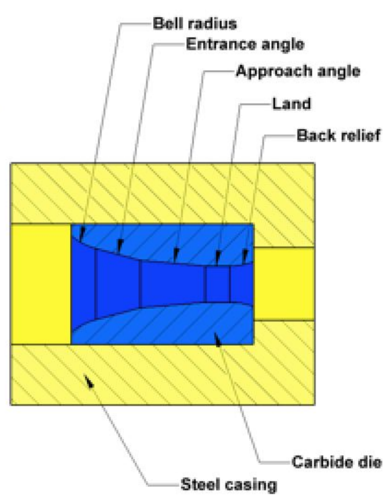


Figure 18. Rolling Process   Figure 19. Wire Drawing

Wire Forming

The copper wire used for the induction coils in the motor was most likely formed via a pair of processes, shown in Figures 18 and 19. The copper was initially formed into a 9 mm rod by hot rolling, which runs a hot ingot through a series of pairs of shaped rollers, which form the ingot into a desired shape. The rod, once cooled, is then formed into wire by being drawn through a series of successively smaller dies; hence the term, “wire drawing.” To form especially small diameters, such as those used in the coils, a bundle of wires of equal diameter are joined together by a material with similar physical properties, but different chemical properties–to better separate the wires easier–are then pulled through the appropriate draw plate.

Materials Choices

Copper was used for the coils mainly because it is an extremely conductive, moderately ductile material, is relatively cheap, and can generate strong magnetic fields for a given current; all factors which are important in the design of motor. It also has very few drawbacks, the main one being its relatively low capacity for current for a given mass when compared with similarly conductive metals such as aluminum. Despite this, better materials such as silver or even gold could have been used in place of copper, albeit at a significant price increase. As the coils’ weight does not significantly impact the juicer’s total weight, these other materials can be used in lieu of copper, as they are both more conductive, but also somewhat denser.

Gears

Introduction

The gears were made from hard plastic. This is an important part of the product to study because it is what delivers power to the rotor which allows the whole juicing cone to function. Characteristics and further descriptions are written below based on research.

Appearance

Figure 20. Motor Gearing

The bases of the gears have a circular shape with a set of teeth on the edge as shown in Figure 20. The gears are then attached to a cone-shaped structure that attaches to the product. All of the gears are white polyethylene as most of the inner parts are.

Availability and Cost

There is an abundant number of these types of gears on the market, available for about 10 cents. If ordered in a large quantity, the cost of these gears should be even lower.

Strength, Melting Point, and Density

Even though these gears cannot be compressed, they are strong and stiff enough to operate. According to a plastic moulding company, D&M Plastics Inc, the melting point of these polyethylene gears range from 110°C to 120°C. The density of the parts is about $1.28 g/cm^3$.

Ductility and Young's Modulus

The ductility of these gears is similar to other metals used in the industry. The graph of the ductility of typical plastic is shown below. It is clear that as more stress is applied, the

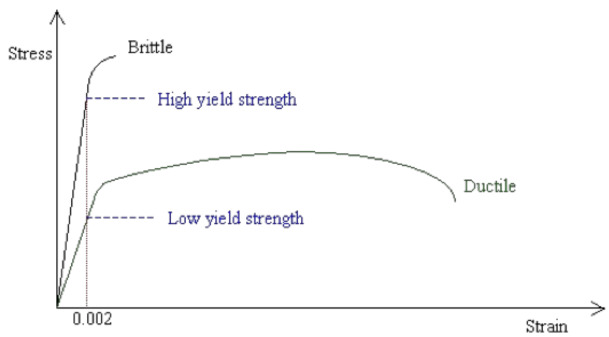


Figure 21. Stress v. Strain

material will eventually reach its breaking point. The hardness of the gears are approximately 110 Rockwell abd the Young's modulus is about 3.2 Gpa.

Conductivity

The gears have minimal thermal and electrical conductivity. They are significantly lower than metals such as copper or aluminum.

Manufacturing Plastic

Like most plastics made these days, they are derived from natural gas, cellulose, coal, and additional materials depending on the manufacturers. The process is completed through distillation and generally followed by either polymerization or polycondensation.

Gears Formation

Figure 22. Commercial CNC lathe (Source: Amtech)

Once the plastics are available, the company can begin building the actual gears. Many factories still use the traditional German molding machines to build the parts as they are versatile and precise. The key machinery need for the process include CNC lathes, CNC machining centers, and high-precision testing machines. CNC lathes are used to cut the correct shapes of the gears. In addition, as part of milling, another CNC machine is used to cut out outer surfaces of the gears and carve out the corresponding patterns precisely. Lastly, high-precision machines must be used to test the gears and ensure that they are perfectly rounded and rotate at a certain angle.

Reasons behind the chosen material

Gears are one of the most important parts in the product along with the motor. The choice of material for the gears was inspired by the cost, durability, and manufacturing process. Metal gears generally cost four times more than plastic gears. Manufacturing them would preserve a similar scenario. More work has to be done using appropriate machines since metal is much harder to cut than plastic. On the other hand, the gears still accomplish the job. They are relatively durable, and being hard plastic, they are stiff enough to be prone to breaking.

New Materials

Figure 23. Melted Gear

Even though the original parts accomplish the job, better materials could be used to improve the performance. Instead of using plastic for the gears, metal should be used. When the parts were taken apart, it was clear that parts of the gear had actually melted and left residue on the side which would disturb the rotation of the gears. Instead of using plastic, steel should be used. Even though they are harder to work with since they are stiffer and have a higher melting point, they will be more durable in the long run. They are also not as costly as other materials such as aluminum. Overall, with enough lubrication, metal gears, will be more suitable for the product than plastic gears.

Juicing Cone

Material

An essential component of the Cuisinart Citrus Juicer, or CCJ-100, is the juicing cone with a sieve. This part is made of “hard, gleaming plastic” (“Overstock Shopping”). Its markings, number 5 recycling and initials ‘PP,’ indicate that it is formed of polypropylene (“Plastics by the Numbers”).

Figure 24. Juicing Cone and Sieve (Source: “CCJ-100 Parts and Accessories”)

Characteristics

Our polypropylene juicing cone and sieve is smooth and black in color. Some characteristics of polypropylene plastic (PP) are that it is sheer and lightweight, yet rigid and heat-resistant. PP's hardness lies between 80 and 90 on the Rockwell Scale. Its Young's Modulus stiffness is between 1.0 and 1.4 Gpa. PP's ductility, or tensile strength, is between 25 and 32 Mpa. Its density is 905 kg/m^3, its melting point is 210 to 290 °C, and its thermal and electrical conductivities are minimal. PP blocks moisture, grease, and chemicals ("Polypropylene (PP)"). Its availability is relatively scarce, but recently supply has begun to grow ("The Plastics Exchange Market Update"). Platts Global Petrochemical Index states that in December 2014 the price of polypropylene was $1,165 per metric ton ("Platts: Global Petrochemical Prices in January Lowest Since Mid-2009").

Formation

Injection molding dominates the conversion process used for polypropylene products. This process consists of filling a mold with a liquid or pliable material, and letting it harden so as to conform to its intended shape. Polypropylene is a relatively easy material to injection mold because it has a low viscosity (flows easily), particularly at fast filling rates. Mold filling rates are generally high, ensuring good surface finish and strong moldings. Normally, melt temperatures for injection molding range from 200 to 250ºC.

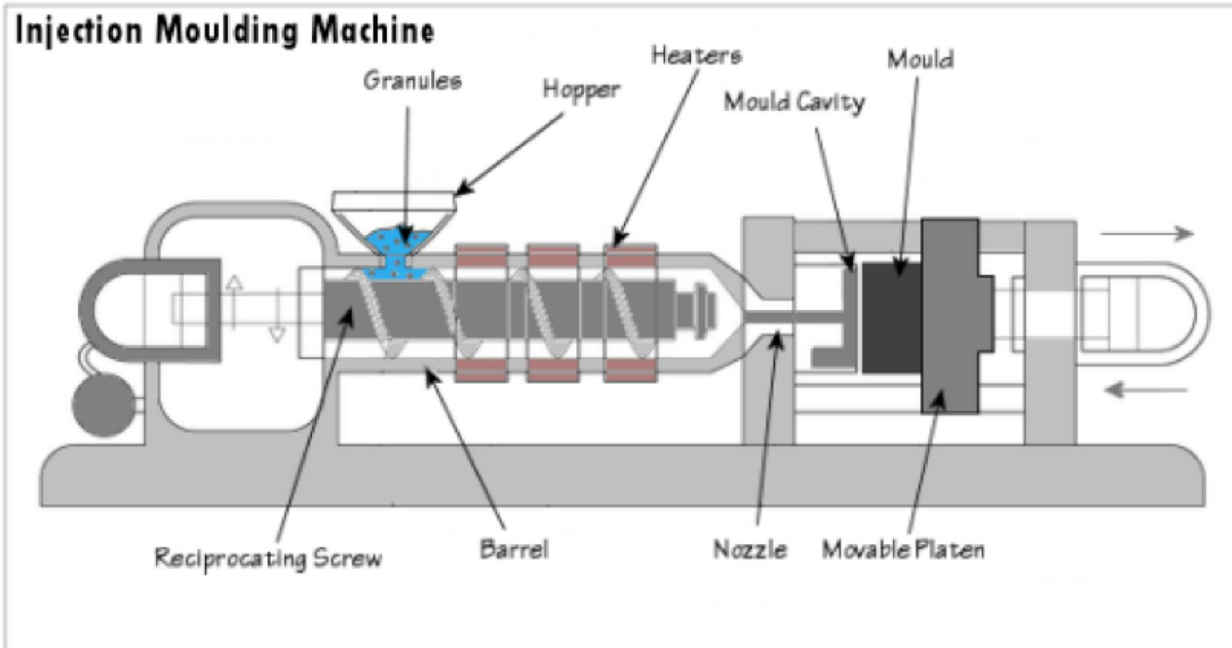


Figure 25. Injection Molding Machine (Source: “Engineerstudent”)

Why PP?

The lightweight polypropylene plastic minimizes the weight and makes for easier handling of the entire product. It also makes for convenient cleaning, as taking apart the juicer is effortless. PP’s high melting point contributes to the part’s expedient cleaning, as the juicing cone and sieve is heat resistant and, in turn, dishwasher safe. The plastic’s rigidity ensures the part’s durability, as well as its ability to extract a maximum amount of juice from the pulp of citrus fruit. Polypropylene’s low thermal conductivity prevents overheating and flesh burns, while its low electrical conductivity prevents electrocution. PP is easy to use and reuse, in terms or molding and recycling. Its strengths are chemical, fatigue, and temperature resistance, as well as relatively low density. Some of its weaknesses include thermal expansion, poor U.V. resistance, and oxidative degradation which is accelerated by contact with certain materials. Perhaps the cone and sieve could have been made from a stronger polypropylene.

Advancements

If the juicing cone and sieve was to be remade of a different material, super-strength polypropylene might be used to replace regular polypropylene plastic ("Plastics as Strong as Steel"). Super-strength PP, created by a new and improved catalyst, is the strongest version of the plastic that has been produced to date. Due to its heightened melting point and durability, super-strength PP requires less maintenance and has a much longer lifespan. It is non-toxic, biodegradable, lightweight, and energy-efficient. In terms of energy consumption, it is less expensive and more efficient to make.

Outer Housing

Introduction

The main housing of the juicer is the largest component of the assembly and thus the material used is very crucial to the cost, durability, and functionality of the

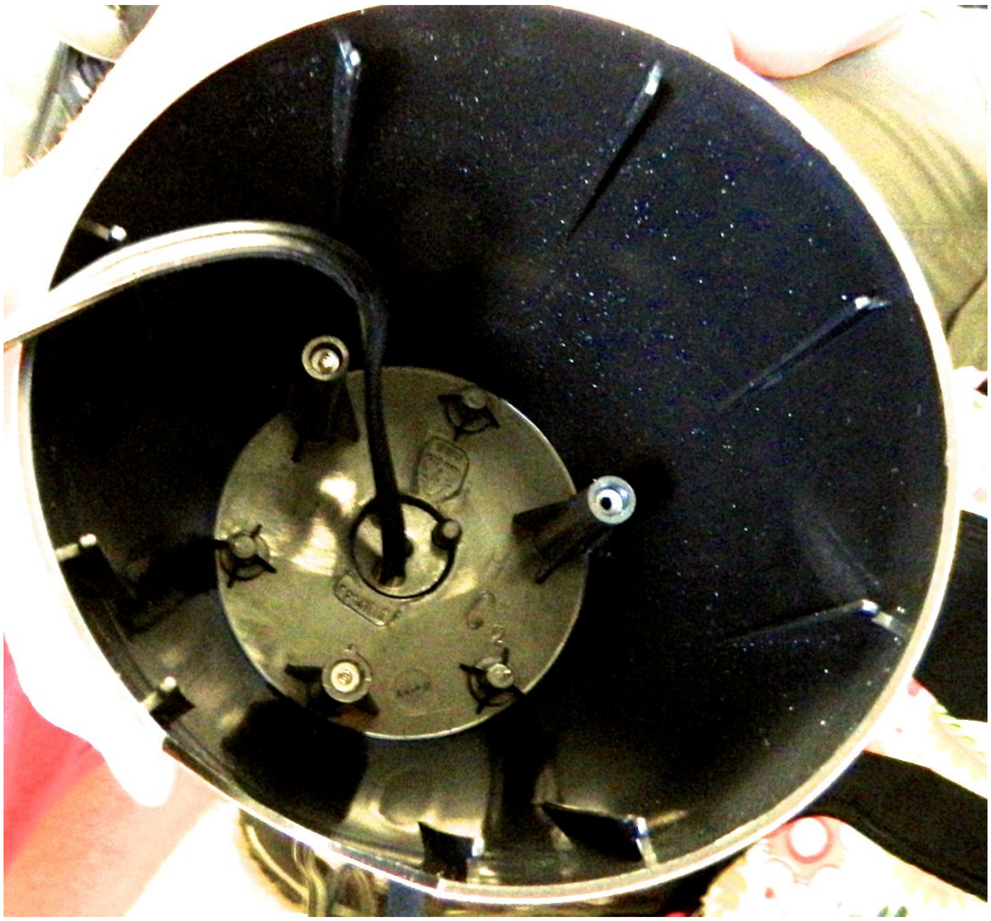


Figure 26. Inside of Main Housing (Top View)

entire product. This part is labeled with the initials ABS, which stands for acrylonitrile butadiene styrene and it has a thin lining of stainless steel surrounding it to give it style. ABS is a type of plastic that has a wide variety of applications and is commonly used for making "housings and other mechanical parts" ("Insulating Material List").

Figure 27. Side View of Housing

Acrylonitrile Butadiene Styrene (ABS)

ABS is a smooth material that has the potential of having different levels of gloss as well as the capability to be dyed different colors. ABS is a versatile plastic that is good for insulation ("Insulating Material List"). It has a relatively high melting point, which depends on its method of molding, of around 385–475°F for extrusion and 407–501°F for injection molding ("Typical Properties ABS"). This high melting point allows for it to be used for the motor housing and sustain a significant amount of heat. It also has a thermal conductivity of 1.0–1.5 Btu·in/hr/ft²/°F, which is the ability of this material to conduct heat ("Typical Properties ABS"). The lower the conductivity, the more suitable it is as an insulating material. For electrical conductivity, ABS has a surface resistivity of anywhere from $1x10^{10}$ –$1x10^{16}$ ohms, which makes ABS a good insulator for electricity as well as heat. ABS is also a sturdy and durable plastic. It has a density of 0.25–0.36 g/cm^3 and a Rockwell hardness of 97–115 ("Typical Properties ABS"). Also, it has a tensile strength of 4940–7420 psi and a tensile modulus of 246000–410000 psi ("Typical Properties ABS"). All of these factors contribute to the strength of the material, making it a suitable candidate for an outer housing, which will experience a lot of wear and tear. Finally, ABS is a mid-to-low priced plastic material ("Material Selection Guide").

ABS Production and Forming

There are two stages in making this part out of ABS. The first stage is where the ABS is actually made by mixing various plastic and rubber chemicals known as the continuous mass technique. The second stage involves shaping the ABS material into the desired part. There are two primary methods of forming ABS, which are extrusion and injection molding. Injection molding is used primarily for making 3-dimensional parts and is most likely the process used to manufacture the housing for the juicer.

The continuous mass technique begins with making a rubber styrene dissolution. Acrylonitrile, peroxide and other chemicals are then added to this dissolution where a reaction occurs that is initiated by the peroxide. During this polymerization phase, the reaction is monitored and controlled to maximize polymer quality and production rate. After polymerization, there is a devolatilisation step, which removes excess additives and impurities and then recycles them back into the process. Finally, the ABS material is turned into pellets, which can easily be melted and shaped ("ABS").

Injection molding, more specifically thermoplastic injection molding, is the process of molding ABS into a particular shape. The process begins with melting pellets of ABS in a heated barrel and screw mechanism. The molten plastic is then fed into a mold and clamped shut. The plastic is then cooled over time by water lines that run through the mold. After it has cooled, the shaped ABS part is removed from the mold ("Thermoplastic Injection Molding").

ABS Functionality in Juicer

ABS was chosen as the material for the housing of the juicer for a number of reasons, including its durability, insulating qualities, and attractive qualities. ABS is a strong material and it is important that the outside of the juicer be durable and able to withstand getting dropped or bumped. Likewise, the casing is supposed to enclose an electric motor so it must provide insulation and protect the user from electricity and heat radiation. Since the part is on the outside of the product, it is important that it looks attractive and is smooth and glossy, making ABS a perfect candidate. Finally, the material also must be cheap and ABS offers a good balance between price and functionality in these aspects.

As far as looking for new materials to replace ABS, there is no substantially better option to ABS. Price is a large factor that needs to be considered in choosing a different product. One possible replacement would be either medium-or high-density polyethylene because it is cheaper than ABS. However, polyethylene is shown to be significantly softer than ABS as shown in Figure 25 and may not be able to handle the impact of being dropped or bumped well ("Material Selection Guide"). Also, polyethylene would not have the same attractive qualities of ABS. Because of these potential problems, there is not really a suitable replacement to ABS, although there is potentially room to improve on this part by adding polyurethane foam to the inside of this part to absorb sound ("Insulating Material List"). Noise was one of the complaints about the juicer and materials play a big role in absorbing sound or amplifying sound. This addition of foam could help reduce the amount of sound input and make up for the ineffectiveness of ABS when it comes to sound damping.

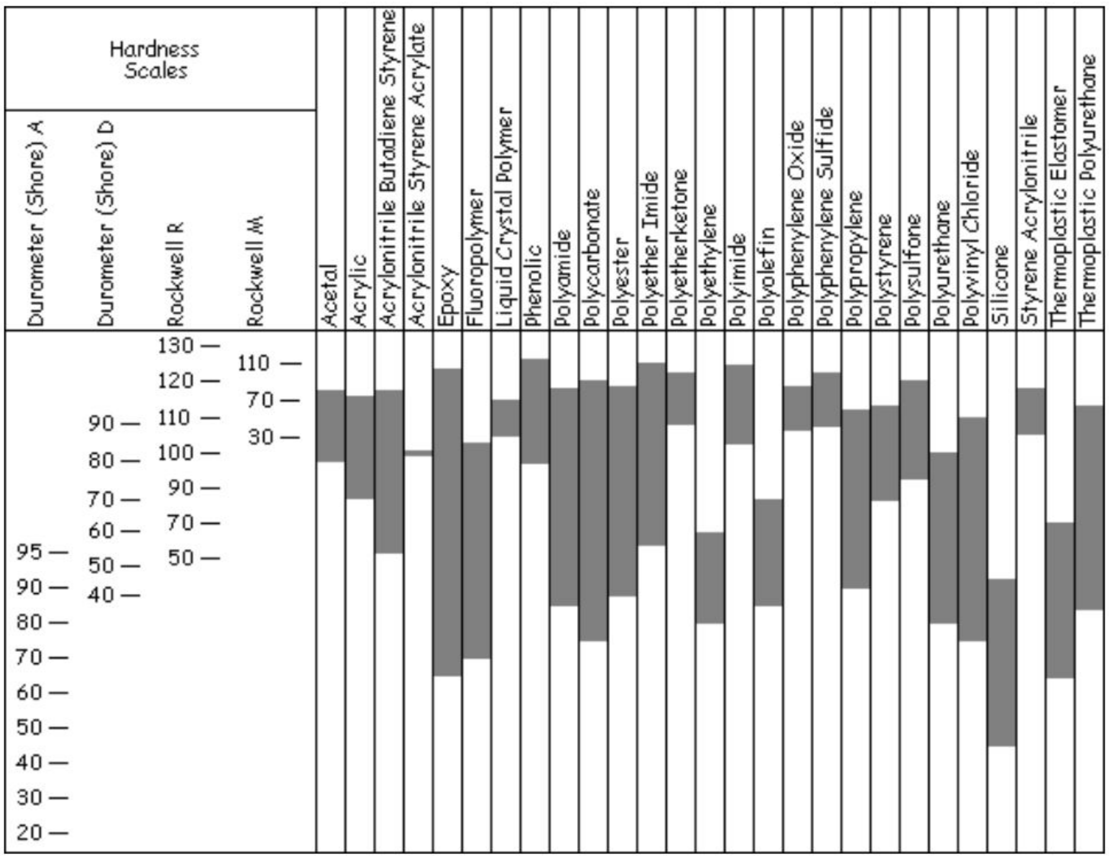


Figure 28. Rockwell Hardness Chart ("Hardness Conversion Chart")

Redesign

Lever

According to the usability tests, one of the major flaws of the juicer was that the user experienced too much vibration. In order to use the product, one has to constantly push down on the fruit with his hand. Another complaint was that it was too tiring to use. Juicing two cups of juice took anywhere from seven to eight minutes, and having to press down on the fruit required a lot of work. In order to fix the issue a top that has a circular shape with a lever will be attached on the base of the cone.

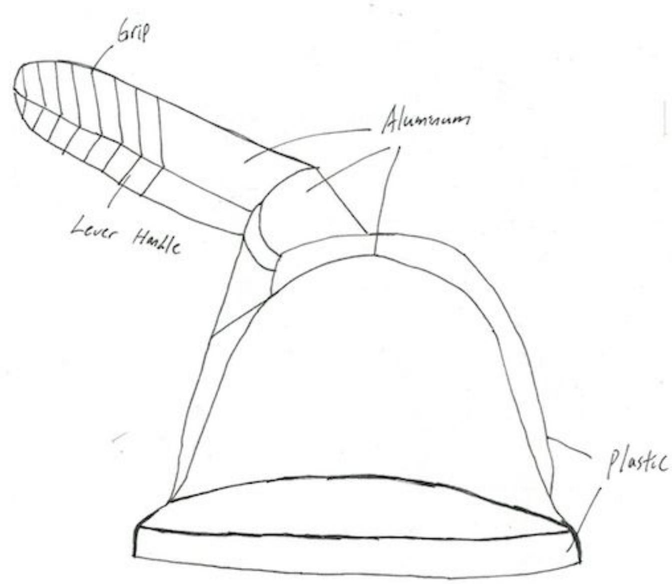


Figure 29. Lever Top ("Source: James Choi")

Even though about the same amount of force will be required, there are multiple ways to apply the force. One can push down on the handle with both hands or even use their arms if s/he is unable to use his/her hands. Since the user has many options to apply the force, there will not be pressure concentrated on just one set of muscles. In the long run, this will increase the customer base because it is not only less tiring to use, but it also has a handle long enough for even children to use.

With this redesign, the user will also experience less vibration. The original design of the juicer let the vibration of the cone to be transferred directly to the user's hand through the fruit. On the other hand, the redesign forces the vibration to travel through the top cover and the handle before reaching the user's hand. In result, most of the vibration will not reach the user's hand.

In addition to the user-friendly aspect of the redesign, the product will also be safer to use. Since no direct contact will be made to either the juice or the cone at any point of juicing, the chance of injury will be decreased. Even though the original design was not seriously dangerous, there was enough space between the cone and base where hair could get stuck. With the top covered, the cone will be sealed during use, which will prevent the user's hair or fingers from getting stuck. Moreover, no juice will be splashed out of the cone due to the top cover.

The material of the redesign will be aluminum. Not only will aluminum be stable to use, but it will also be light enough for a variety of customers to use. Lifting the lever and cleaning the product will not be an issue even for those who are not as strong. There is an abundant amount of aluminum to purchase in the U.S., from both large manufacturers, and small, individual manufacturers found online will be used. Some of the trustworthy manufacturers found were Speedy Metals and Industrial Metal Supply Co. Since only a small amount of aluminum is used for each product, the difference in cost between using aluminum or regular steel will not be significant. Moreover, the redesigned portion of the product will be environmental friendly since recycling aluminum only requires 5% of the energy to make new aluminum.

Speed Control

Another prominent issue we observed was that the juicer's bowl accumulated so much pulp that juice became trapped in the bowl and stopped flowing. We intend to redesign the pulp management system by adding a variable speed control to the juicer. At slower speeds, pulp buildup will be reduced. The addition of slow, medium, and high speed settings will allow the user several options: to make a cup of orange juice (a situation in which the pulp build-up is minimal, regardless of speed) at a fast setting, or to fill a large pitcher (a situation in which the pulp build-up will significantly impact the juicing process, especially at a high speed) at a slower rate.

The speed control mechanism will consist of a rectifier to convert from AC current to DC current, which will then go through a variable resistor to a motor controller (Fig. X). The variable resistor will be controlled by an external dial, and will limit the current flow to the controller, which will limit the motor's speed.

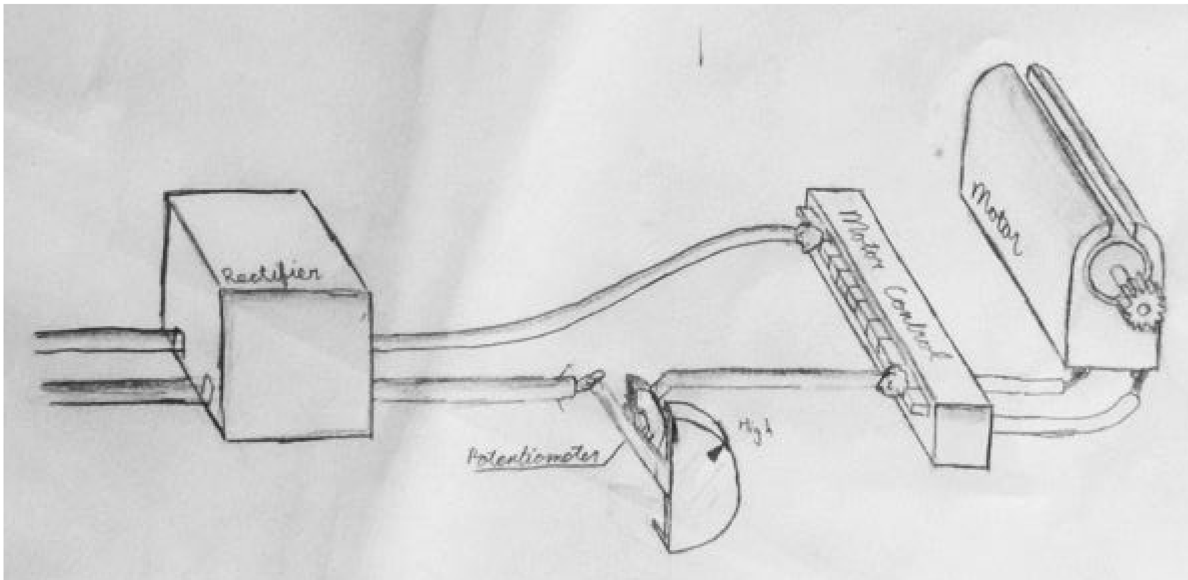


Figure 30. Speed Control Drawing.

The rectifier, potentiometer (variable resistor), and motor controller will consist of the Bridge Rectifier Kit from W. Grainger (Item #46J246), a Digikey rotary potentiometer (Digikey #91R1A-R22-A22L-ND), and a BEI motor controller (Model #84855101). Each of these parts, from the rectifier, to the motor controller, were selected because they provide good functionality for a given cost. They they will increase the per unit cost of the juicer by about $5-7.

Insulation

One of the largest complaints by the test subjects from our usability tests was that the juicer was too noisy. The juicer produced a sound of 90 decibels from 3 feet away, which has the potential to cause hearing loss. The original design of the juicer involved using an ABS plastic housing. ABS, however, has no damping qualities, which allows the noise from the motor and gearing to amplify throughout the housing and then be emitted out from the juicer. The proposed redesign to fix the problem of noise is to line the housing with polyurethane foam to absorb the sound and reduce vibration.

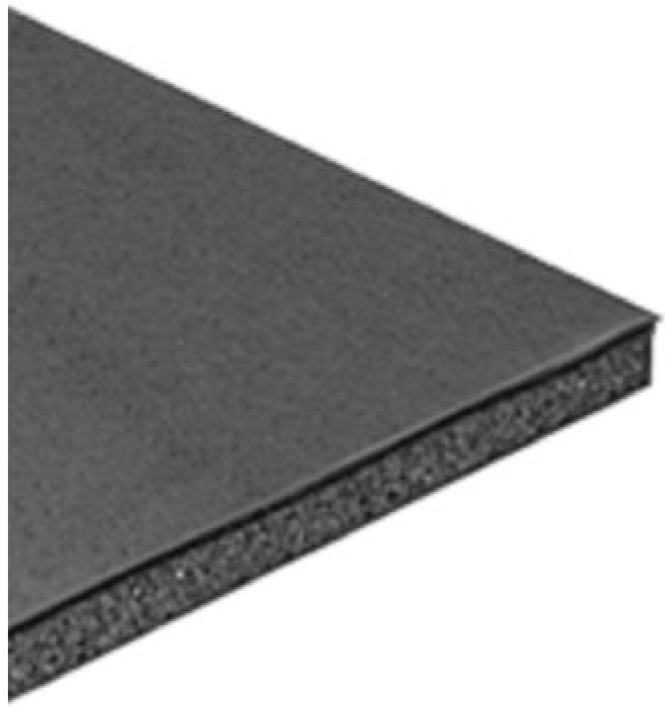


Figure 31. Polyurethane Foam (Source: “Sound Absorber Sheeting”)

Polyurethane foam was chosen for this task because it has good sound absorbing qualities for an affordable price. This foam absorbs 30% of all sound, which will significantly reduce the decibels that this juicer produces. The foam is also very affordable and is sold for $10 a foot at 54” wide and ½” thick. This will come out to be about $3.33 per juicer and this price will go down significantly more if the foam were to be purchased in bulk (“Sound Absorber Sheeting”). Also, polyurethane foam is flexible so it can line the cylindrical walls of the juicer (Figure 31).

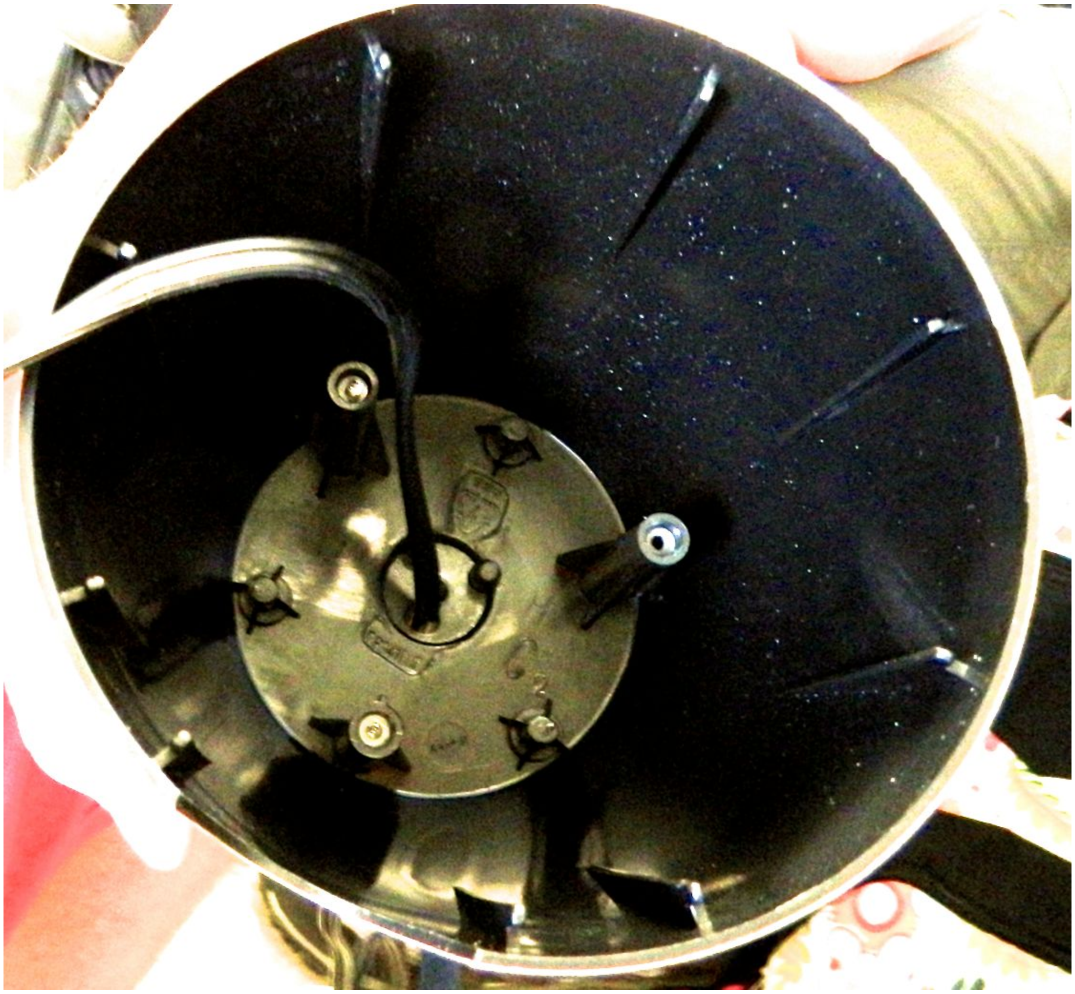


Figure 32. Inside of juicer

This redesign slightly increases the cost of the juicer, but it also fixes the vibration and sound problems that were encountered during the usability tests. With this foam lining, the juicer will be less likely to vibrate and move around on the table. More importantly, it will reduce the sound output of the juicer so that it is within a range that won't cause hearing damage. This lower sound also will make the juicer more practical for juicing oranges in the morning, as before it was loud enough to wake or disrupt people.

Design Team

Our design team consists of 4 UCSB Engineering students, each with a unique background and career focus.

James Choi

James Choi is from San Jose, CA, and is a first year electrical engineering student. He studied mathematics and the sciences at Homestead High School. He is familiar with some common, simple circuits, and is familiar with common word processors and image manipulators. He is also experienced with Java and Matlab programming, and possesses practical experience in soldering automotive electronics.

Iva Icheva

Iva Icheva is a first year mechanical engineering student from Glendale, CA. She graduated from Crescenta Valley High School, where she excelled in the sciences as well in mathematics. She is experienced with Matlab programming, various word processors, and woodworking.

Steven Phillips

Steven Phillips is a first year mechanical engineering student from Simi Valley, CA. He graduated from Los Angeles Baptist High School, where he focused on math and science. He has experience in Matlab and Java programming, and has a lot of experience with woodworking and power tools.

Joseph Villalovos

Joseph Villalovos is a first year mechanical engineering student from Simi Valley, CA. He graduated Santa Susana High School with Certifications in both computer programming and mathematics. He has four years of experience in Python programming, and is moderately familiar with common word processors and advanced image manipulation programs. He is also passingly familiar with common, small electronic circuits, as well as woodworking, metalworking, and soldering.

Correspondence

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19 February 2015

Cuisinart Product Inquiries
150 Milford Rd.
East Windsor, NJ 08520

Dear Sir or Madam:

As an electrical engineering student at the University of California, Santa Barbara, I am currently studying and researching about one of your products as a class project.

I would like to take this time to learn more about the product in the hope of this letter being forwarded to a product manager or engineer. In addition, I would like to know the name and contact information of the product manager or engineer if the information were available.

The product I am researching about is Cuisinart Citrus Juicer, Model No. CCJ-100, Serial No. 00709J. I would like to know more about the history and development of the product. After researching about the juicer, I soon realized that there was not much information available since the product was already about a decade old.

Some of the questions that came up were how long it took to develop the product and how many previous models it took to finalize with this design. Another question was about the general information about the product. Are there any direct patents about this product that were used during development available?

I look forward to a reply or even speaking with you via phone or email. I understand your department is busy with other matters, however, I was wondering if I could get the information as soon as possible due to class constraints. Thank you for your time and attention.

Sincerely,

James Choi

Encl. Instructor Letter

There was no response from the company.

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Appendix

The patents that were studied are attached below

US005193447A

United States Patent [19]

Lucas et al.

[11] Patent Number: 5,193,447

[45] Date of Patent: Mar. 16, 1993

[54] **CITRUS JUICER**

[75] Inventors: **Rafael P. Lucas**, Barcelona; **Jose C. Blasco**, L ospitalet; **Antonio R. Rius**, Manresa/Barcelona, all of Spain

[73] Assignee: **Braun Aktiengesellschaft**, Frankfurt, Fed. Rep. of Germany

[21] Appl. No.: **580,662**

[22] Filed: **Sep. 11, 1990**

[30] **Foreign Application Priority Data**

Sep. 16, 1989 [DE] Fed. Rep. of Germany 3931015
Sep. 16, 1989 [DE] Fed. Rep. of Germany 3931016

[51] **Int. Cl.**[5] **A47J 19/00**
[52] **U.S. Cl.** **99/508**; 99/506
[58] **Field of Search** 99/501, 502, 503, 505, 99/508, 506; 100/213, 132, 111

[56] **References Cited**

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4,378,730 4/1983 Coggiola 99/501

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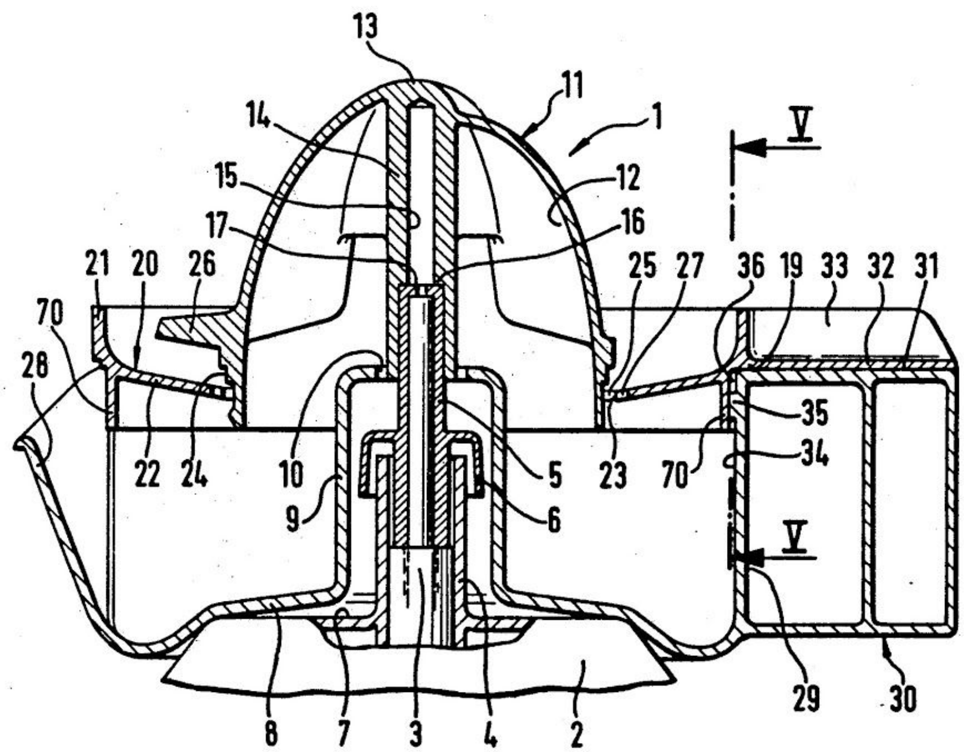
0395450 9/1960 Switzerland 100/132

Primary Examiner—Harvey C. Hornsby
Assistant Examiner—Reginald L. Alexander
Attorney, Agent, or Firm—Fish & Richardson

[57] **ABSTRACT**

This invention relates to a citrus juicer for producing fruit juices. The motor-driven cone (**11**) is surrounded on all sides by a strainer (**20**) having passageways (**27**) under which a bowl for collecting the fruit juice is disposed. As a citrus fruit is squeezed, the resulting juice passes through the passageways of the strainer. The boundary area between the cone (**11**) and the area of the strainer (**20**) surrounding it is configured as an annular gap (**25**) whose cross section of passage is adapted to be increased or decreased by means of an adjusting device. The pulp content in the fruit juice is thereby predetermined.

18 Claims, 5 Drawing Sheets



US006945162B2

(12) **United States Patent**
Areh et al.

(10) **Patent No.: US 6,945,162 B2**
(45) **Date of Patent: Sep. 20, 2005**

(54) **FRUIT JUICER WITH INCREASED JUICE YIELD**

(75) Inventors: **Marko Areh**, Radlje Ob Dravi (SI); **Stanislav Mazej**, Gomilsko (SI); **Michael Steffl**, Marquartstein (DE)

(73) Assignee: **BSH Bosch und Siemens Hausgeraete GmbH**, Munich (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/791,548**

(22) Filed: **Mar. 1, 2004**

(65) **Prior Publication Data**

US 2005/0028683 A1 Feb. 10, 2005

Related U.S. Application Data

(63) Continuation of application No. PCT/EP02/09401, filed on Aug. 22, 2002.

(30) **Foreign Application Priority Data**

Aug. 29, 2001 (DE) 101 42 246

(51) **Int. Cl.**[7] **A47J 19/02**
(52) **U.S. Cl.** **99/506**; 099/508
(58) **Field of Search** 099/495, 501–508, 099/511–513; 100/112, 213; 210/413–415

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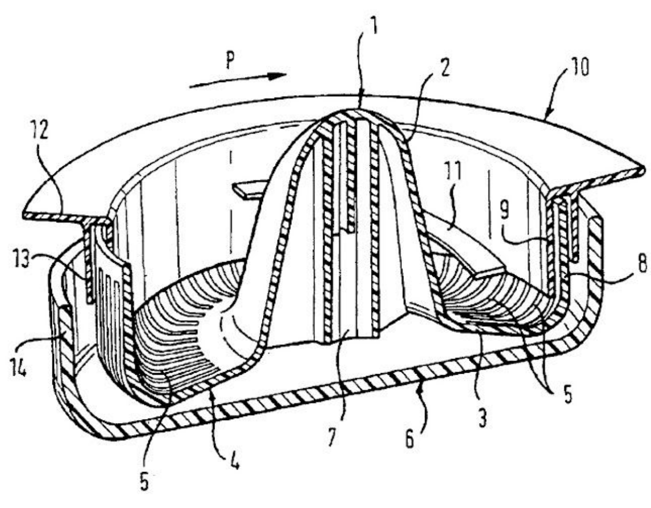
(57) **ABSTRACT**

A fruit juicer has a rotating, upwardly-tapering, centrally-disposed, projecting element, for the pressing of a fruit. The element is surrounded by a collector dish, into which a stationary wall of a fixed annular body extends downwards. A device for compressing the fruit pulp, and thus squeezing additional juice out of the pulp, is formed on the wall. On rotating the collector dish with a motor drive the compression device forces the pulp of the fruit downwards in a generally wedge direction. The additional compression device is one or more blades that are fixed to or formed on the inner side of the projecting wall.

17 Claims, 1 Drawing Sheet



US007871196B2

(12) **United States Patent**
Lin

(10) **Patent No.: US 7,871,196 B2**
(45) **Date of Patent: *Jan. 18, 2011**

(54) **JUICER SAFETY DEVICE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 768 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/839,545**

(22) Filed: **Aug. 16, 2007**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
A47J 43/046 (2006.01)

(52) **U.S. Cl.** **366/206**; 241/37.5

(58) **Field of Classification Search** 366/199, 366/205, 206, 314, 601; 241/37.5, 282.1, 241/282.2; 99/348

See application file for complete search history.

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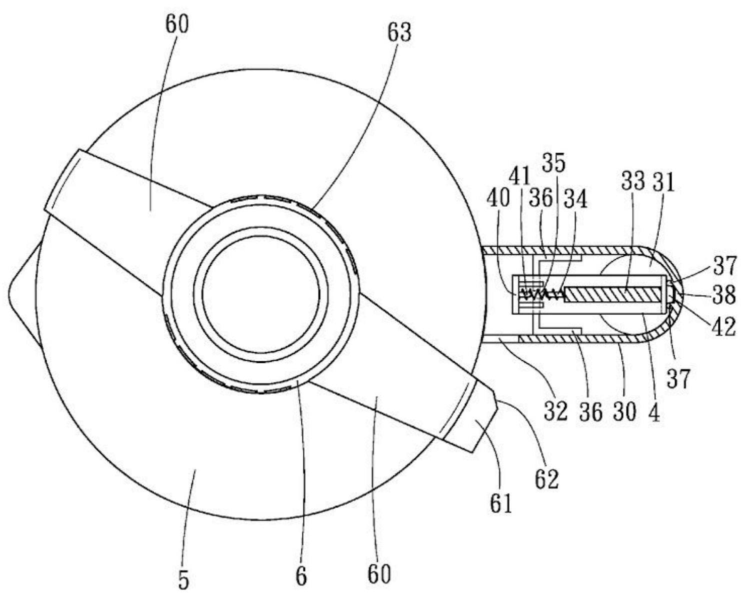
Primary Examiner—David L Sorkin

(57) **ABSTRACT**

A juicer safety device includes a sidearm formed with the container and having a groove in a sidewall, a contact member on an upper surface of a chamber, a spring on the contact member, a position guide member in a sidewall of the chamber, and two projecting ridges with a slide groove between them; a push rod kept in position by the contact member, the position guide member and the two projecting ridges and having a push block with a side shoved by the spring and a guide block in the slide groove; a cap having a rotary member. The cap is closed on the container with the rotary member rotated to let a clamp block insert in the sidearm and push the push rod downwards to move a contact rod of the push rod downwards, touching and turning on a micro switch, which turns on the juicer to operate.

4 Claims, 7 Drawing Sheets



US007117784B2

(12) **United States Patent**
de Groote

(10) **Patent No.: US 7,117,784 B2**
(45) **Date of Patent: Oct. 10, 2006**

(54) **JUICER AND GRATER ASSEMBLY**

(75) Inventor: **Jan-Hendrik de Groote**, Brussels (BE)

(73) Assignee: **Dart Industries Inc.**, Orlando, FL (US)

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(65) **Prior Publication Data**

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A23N 1/00 (2006.01)
A23L 1/00 (2006.01)
A47J 19/02 (2006.01)

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See application file for complete search history.

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Primary Examiner—Timothy F. Simone
(74) *Attorney, Agent, or Firm*—John A. Doninger

(57) **ABSTRACT**

The invention provides a juicer and grater assembly comprising an extractor having a plurality of radially extending tabs integral with a lower portion thereof, a combination grater and strainer having at least a plurality of first apertures and a plurality of second apertures, wherein the extractor is removably secured on the combination grater and strainer in either a first position wherein the plurality of radially extending tabs cover the plurality of first apertures for allowing extracted juice to flow through the plurality of second apertures, or in a second position wherein the plurality of radially extending tabs cover the plurality of second apertures allowing juice and pulp to flow through the plurality of first apertures.

14 Claims, 4 Drawing Sheets