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DESIGN OF A COFFEE POWDER DISPENSER

with Muova

School of Technology
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Kone- ja tuotantotekniikka

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Työn aiheena on suunnitella yhteistyössä Muovan kanssa sähköinen kahviannostelija, jolla saadaan aina yksi annos kahvijauhetta yhdellä painalluksella.

Kahvijauhetta annostellaan usein käsin ruokalusikalla ilman tarkkuutta ja mukavuutta. Tässä opinnäytetyössä suunniteltavalla kahviannostelijalla saadaan haluttu määrä kahvia vaivattomasti ja tarkasti. Kyseisiä tuotteita käytetään yleisesti kotitalouksissa ja yrityksissä.

Suunnittelun lähtökohtina ovat tarkka annostelu, mukava käyttö, edullinen hinta, kestävä rakenne ja helppo valmistus. Työssä tehtiin konsepti-, systeemi- sekä detaljisuunnittelu käsin piirtäen ja Siemens NX:llä, prototyyppien tulostus 3D-tulostimella, testaus ja parannus. Kokoamisjärjestys oli suunniteltu. Kokoonpanorobotti oli ehdotettu. Lopputuloksena saatiin tuote, joka on tuotantokelpoinen ja täyttää annetut kriteerit.

Avainsanat tuotesuunnittelu, kahviannostelija, sähköinen, kotitalouskäyttö

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ABSTRACT

Author	Liu Xueyun
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The subject of the thesis was to design an electronic coffee powder dispenser in co-operation with Muova. The dispenser always gives one portion of coffee powder on one press upon the button.

Coffee powder is usually dispensed with tablespoons by hand, which is not precise or convenient. With the coffee powder dispenser designed in the thesis, a right amount of coffee can be obtained with ease. The product can be used widely in households or companies.

The objective of the thesis work was to design a product, which is precise in dispensing, easy to use and manufacture, cheap and durable. During the work, conceptual, preliminary and detail designs were performed with hand drawings and Siemens NX10 program. The prototypes were printed out with 3D printers. Then tests and improvements were carried out. The method of assembly was designed. The final result of the thesis is ready for production and it meets all requirements.

Keywords Product design, coffee powder dispenser, electronic, household use

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1 INTRODUCTION

1.1 Introduction to the Company

Design Centre Muova is a research and product development centre, which offers design, research and training services. It cooperates with VAMK. Muova's customers include companies and public organisations. It initiates and implements research and development projects concerning market-based design and creative know-how. Projects are based on the needs of the companies and on Muova's special know-how.

Muova has a strong position as a regional influence. In research projects, it studies and develops different design methods for different fields of operation. The mission is to respond to socially significant challenges and to develop the international competitiveness of companies with the means of design. The concept of design has lately expanded to include, besides traditional product design, also for example service design, strategic design and developing value networks by means of design./1/

The customer of this design of coffee powder dispenser is A. Viianen Oy, which is basically a business consultant company. They created a patent for this electronic coffee powder dispenser.

1.2 Background of the Design

Nowadays, coffee powder is usually dosed with special tablespoons by hand every day. Since this process is troublesome and imprecise, it would be good to have a product to repeat it (many times) every day with precision and convenience for the users.

A. Viianen Oy has a patent for a powdered product dispenser with a chamber for the powdered product, which has a funnel-like lower portion, and a vertically moving cone controls the funnel discharge opening. The cone surface is configured to contact the funnel surface. The powdered product is dispensed by freely falling past the cone edges, through the discharge opening. The amount to be dispensed may be controlled by allowing the funnel to be open for a predetermined time period./2/

However, in the description of this idea, a large amount of choices and possibilities are given, which enable various modifications as to, for example, the source of power, choice of actuator, the mechanism to realize the reciprocating movement, the shape of the conical part and the structure for coffee powder to exit from the product.

The objective of this design work was to make the best solution/ embodiment for the product and to implement it from a very beginning idea to the final product that is ready for mass production.

2 THE ENGINEERING DESIGN PROCESS

The engineering design process is a methodical series of steps that engineers use in creating functional products and processes. In another word, it is a process, in which a concept becomes a product. The process is highly iterative - parts of the process often need to be repeated many times before another can be entered.

“It is a decision making process (often iterative) in which the basic sciences, mathematics, and engineering sciences are applied to convert resources to meet a stated objective.” The basic elements of the design process include objectives establishment and criteria, synthesis, analysis, construction, testing and evaluation./3/

According to a simplified model, the engineering design process can be usually made up of the following stages: requirement analysis, conceptual design, preliminary design, and detail design./4/

- The requirements of design control and instruct the whole product design process. They usually answer the question: why the product is needed. The requirements can include basic items, such as the characteristics, functions and operating parameters - determined by assessing user needs or referring to the laws, regulations, product safety or ergonomics rules. Requirements of design can also include hardware and software characteristics, maintainability, availability, testability, deadlines and cost targets. The result of this process is a requirement list.

- Conceptual design is to produce the basic solution path through the elaboration of a solution principle. It is to identify the outlines of functions. Usually a brainstorming method can be applied to create many design variants. Afterwards, each variant is evaluated by likelihood of error, costs, risks and potential success. In this process, no detail needs to be considered yet. Ideation may be expressed by using a paper drawings or flow charts as the primary method. The conceptual design process answers the question: how the product is going to work.

- Preliminary design works between conceptual and detail design processes. It starts from the principle solution and continues in accordance with technical and economic criteria. It turns the ideation formed during the conceptual design into a sufficient layout for full evaluation. It is to define the integral system configuration, frame or basic structure of the project. The preliminary design process answers the question: what kind of system to ensure the product works as desired. Although during detail design, the parameters of the part may change, the preliminary design is to create the overall framework of the project./5/

- The detail design phase finalises product and operating details, and makes all parts of the product concrete by complete description through 3D modelling, drawings as well as specifications. It completes the embodiment of product with final detailed instructions. Computer-aided design (CAD) programs are usually used to make the detail design process more efficient and precise. They also ease the elaboration of production documents. DFMA (Design for Manufacturability and Design for Assembly), prototyping, testing and improvement also belong to this phase, as they mainly focus on the parameters and characters of the parts. As mentioned above, the parameter design, prototype, test and improvement processes sometimes need to be repeated many times before an ideal product is achieved.

3 PROCESS OF DESIGN

The process of design may be divided into requirement analysis, conceptual design, preliminary design and detail design according to the sequence.

3.1 Requirement Analysis and Conceptual Design

3.1.1 Identification of Requirements

In the beginning of design, we need to know about the market. That will answer the most important questions from the production point of view, such as what do the customers need, what kind of products our competitors provide, how can we provide better products than competitors, who are our target customers for the product. Based on the answers to these questions, we can decide if the design continues.

The process starts with a product requirements list, where feature based classifications, design guidelines (e.g. safety, ergonomics), as well as customer's requirements for the products should be included. At the same time, basic, standard requirements and wishes should be distinct.

The product has to fulfil the basic requirements either way. This might mean basic functionality, entry-level functions, design, or meeting the standards and regulations. Within the standard requirements, there can be more or less significant ones from the aspect of market success. The standards are those needs, along which parameters the product will be better than the competitors' are. While the fulfilment of the wishes is not needed for functionality, not expected from the user side, though could lead to advance in competition, or can have a positive effect on the quality image. /6/

According to the investigation of market and users, the requirements of the coffee powder dispenser were defined and can be seen in Table 1.

Table 1. Requirements list of the coffee powder dispenser.

Basic requirements	Standard requirements	Wishes
Safe	Easy to use	Simple construction
Ergonomic	Economical (market price about 20 €)	Good looking
Materials include steel sheet for the chamber body and plastics for other parts	Light enough to be held in hand for a few minutes during usage	Easy to maintain and clean
Able to dispense coffee powder	Properly sized for desktop and housewives	Black, white and red (button) in colour
	Capacity 500 g of coffee powder	Power supply do not need to be changed frequently
	A reciprocating conical part and funnel for dispensing	Keep the kitchen clean
	Amount of powder dispensed may be controlled	
	Cylinder shaped	
	Easy to manufacture	
	Quick to assemble	

In current markets, there are few coffee powder dispenser available, especially electric ones. Some companies do provide manual pedal-structured dispensers, but these are either expensive or difficult to control the flow of coffee powder. Therefore, in normal households, people measure their coffee powder by hand with a spoon. Problems are the process has to be repeated many times a day and coffee powder may drop and soil desktop during the process.

3.1.2 Ideas, Sketches and Selection

After the identification of requirements and study of competitors' products, as well as understanding of the contents of patent, it was time for ideas. In this process, choices that meet the requirements list were created. Ideas can first be specified by hand drawings or 3D drawings on computers. Then they are compared and evaluated according to needs. Usually more than one ideas should be created, among which the best one will be selected.

As already stated in the patent description, the dispenser should have a chamber (body) for the powdered product (coffee), a funnel portion and a reciprocating conical part.

The focuses of the ideas are:

- For mechanics:
    - Mechanism to realize the reciprocating movement
    - Mechanism for dosing
    - Control of coffee powder flow (mess prevention)
    - Coffee powder lump prevention
    - Protection of actuators from coffee powder
    - Source of power
    - Shape of conical part

- Shape and volume of body chamber
- Weight of the product
- Appearance of product

- For costs:
  - Market price of the product about 20 €, so costs of all components together should be under 12-15 €

Since there was no description in the patent about how the dispenser works all possibilities were considered. In one of the sketches, a small electric motor is applied to drive a rotary rod, which controls the reciprocating activities of the main shaft. Another idea was to apply a mechanism, which doses the amount of coffee powder before it is given out. In another idea, different amount of coffee powder is dispensed, according to the users' choice on a second button.

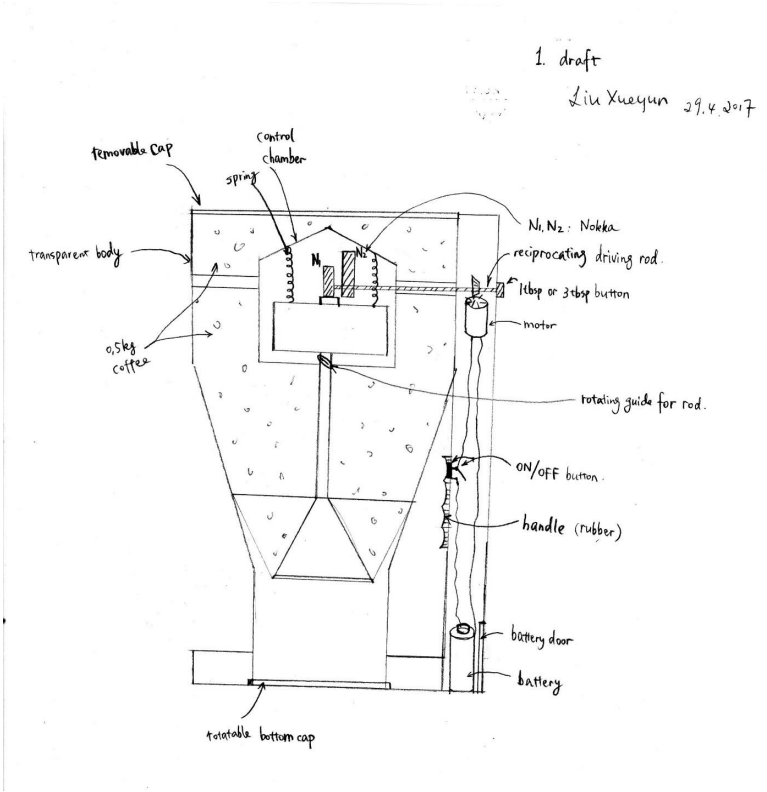

Figure 1. One of the first sketches of the coffee powder dispenser.

After many sketches are ready, evaluations are made according to the requirements list. The product should be simple-structured, precise in dosing, easy to manufacture and assemble, cheap and durable. Finally, an electric model with a solenoid as actuator and an off-delay relay for dosing control was accepted.

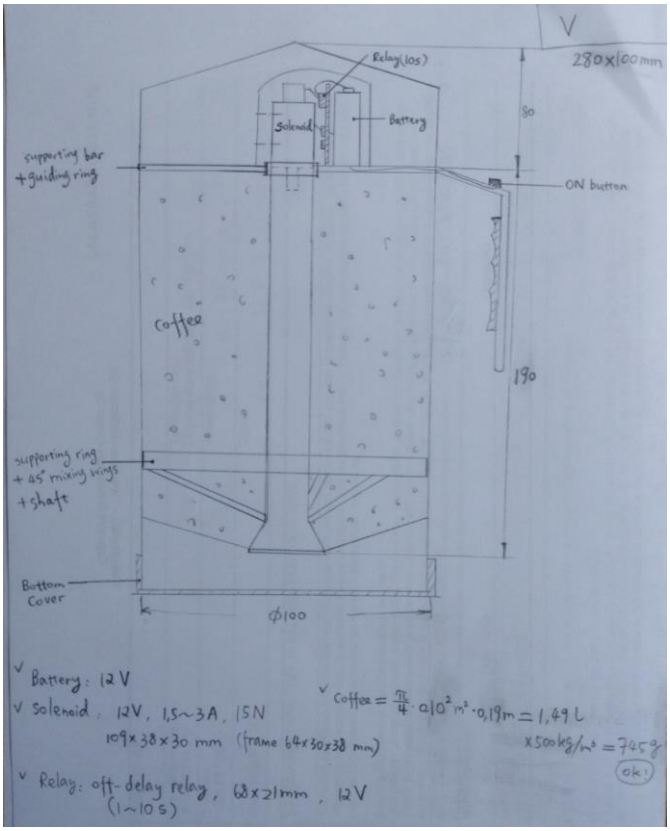

Figure 2. A sketch of the idea that is accepted.

3.2 Preliminary Design

The preliminary design process is about how the product could function logically, and in this process, the overall system configuration was defined. According to the requirements list, the coffee powder dispenser could be composed of body, functional, power and auxiliary parts.

- The body parts are to provide space for coffee powder and they include a body chamber and a funnel. Users add coffee powder to the body chamber and the coffee powder will finally exit the product through the funnel.

- The functional parts are to realize dispensing function. They include an actuator and a main shaft to realize the reciprocating movements, a dosing system to determine the amount of coffee powder to exit the product each time, a control chamber to hold electronic components, another actuator to ensure smooth flow of coffee powder, and a conical part at the end of main shaft to act as a control gate for the flow of coffee powder.

- The power parts are to empower the whole system. They are batteries, battery cases, wirings from batteries to electric components and an ON/OFF button.

- The auxiliary parts are to help the users to operate the product or to help other parts to work properly. They consist of a handle for users to hold on, a top cover, a bottom cover to prevent the coffee powder from polluting desktop, a battery case cover to protect the batteries from coffee powder, a mixing wing to guide the movements of main shaft as well as to prevent possible big lumps, and a secondary funnel to reduce the compression of coffee powder.

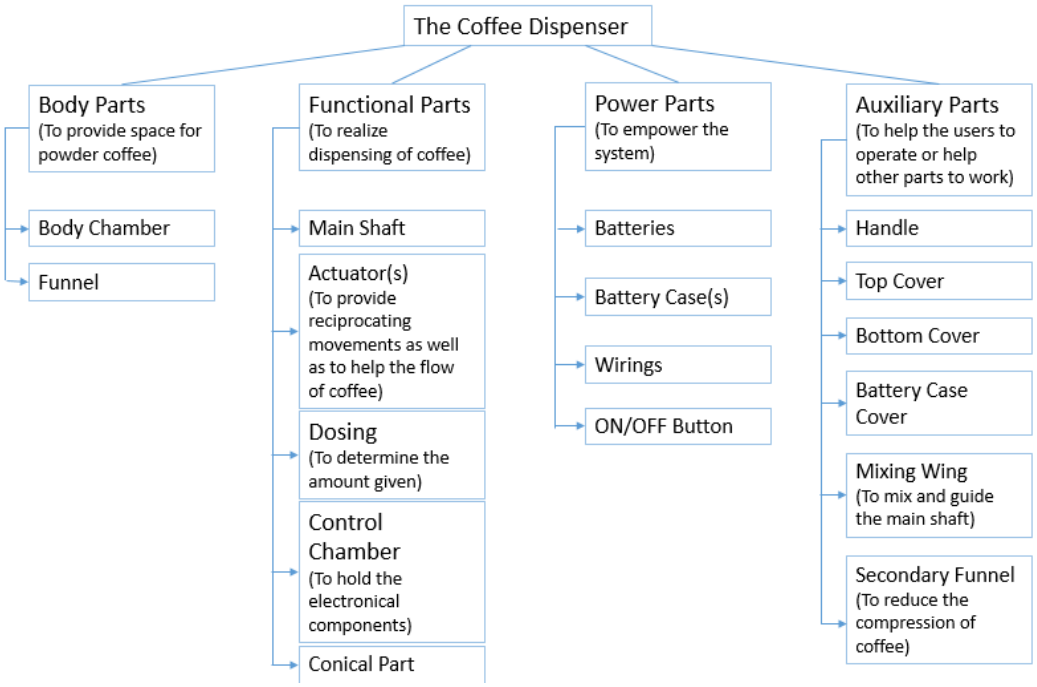

Figure 3. System configuration of the coffee powder dispenser.

3.3 Detail Design

Although during the detail design process, new ideas about how the product could operate better will sometimes still appear, this process is mainly to make all parts of the product concrete. The detail design process further elaborates each aspect of the product. During this process, final details, specifications, tolerances and drawings of the product are taken care of. 3D models as well as drawings of all parts are to be made.

In the detail design process, 3D CAD software (Siemens NX 10) is used as a tool for design. 3D CAD, or three dimensional computer-aided design, is technology for design and technical documentation, which replaces manual drafting with an automated process. Used by architects, engineers, and other professionals, 3D CAD provides an extra dimension to precisely visualize and share designs./7/

3.3.1 Actuators

- Solenoid

The reciprocating movement of the conical part is realized by a solenoid. A solenoid refers to a device that converts energy into linear motion. Compared to electric motors, the solenoid is more straightforward and easier to implement, since no change in direction of movement or rotary speed is needed. Thus, it greatly simplifies the structure and reduces the cost of the product.

Since the most volume of the coffee powder dispenser is dedicated to the body chamber, which holds the coffee powder, there is little room left for actuators. So in this case, a small sized solenoid with only pulling function was chosen. The pushing function is omitted for space saving on the top side.

The solenoid is required to lift 500 g of weight (one standard package of coffee powder) plus possible acceleration upward (1 G). So approximately a lift force of 1 kg is needed. At the same time, considering continuous coffee flow required, a minimum of 6 mm stroke is needed for the solenoid, conical part and main shaft.

According to the figure of relationship between the pulling force, stroke and power provided by the supplier of the solenoid, 18 W of power for the solenoid is required. So if we choose the 12 V model, the current in the circuit should be about 1.5 A (I=P/U). /12/

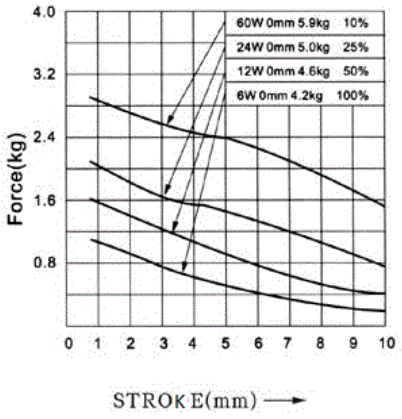

Figure 4. Relationship between force, stroke and power of the solenoid.

Figure 5. Solenoid.

- Vibration motor

There is friction between particles of coffee powder. This friction sometimes leads to a block in the exit flow of coffee powder when the conical part is open. The heavier the coffee powder is in the body chamber, the more friction there is between the coffee particles near the exit ($F_s=\mu_s*N$). /12/

In order to assure the smooth flow and to guarantee the precision of each dosing, a vibration motor was attached to the end of the conical part. It is also to break possible lumps near the exit. It is connected into the same circuit as the solenoid, so that it works only at the same time when the solenoid works. Other possible places to put it were also explored, such as by the funnel or on the battery case cover, but only when it is located on the conical part, it does its work best.

In this coffee powder dispenser, a Ø8x3.4 mm coin micro vibration motor for cell phone was chosen for its small size, lightweight and cheap price. It comes with a stick on back, so that little effort is required for installation.

Figure 6. Vibration motor.

3.3.2 Main Shaft/ Conical Part

The main shaft and conical is designed as one part. It connects to solenoid and controls the flow of coffee powder in cooperation with the funnel part. Its lower edge is to seal the funnel part when it is closed.

Since the force of the solenoid is very critical, the weight of coffee powder on top of the conical part as well as its own weight should be as light as possible. At the same time, the perimeter of the conical part decides the speed of coffee flow, so it should be big enough to guarantee the outflow of coffee powder. While these factors were taken into consideration, the angle of the cone of conical part was designed as 45 degree and the cone was made into hollow to reduce self-weight.

3.3.3 Dosing

The amount of coffee powder dispensed is to be controlled by the open time of the conical. Here an off-delay relay was applied to control this interval. An off-delay relay (retriggerable one shot) switches the output to operate condition and starts the time delay when the power supply and the control signal are applied. It switches the output to release condition after the setting time has elapsed. The length of the interval is adjustable according to need (0-10 s). This solution is simple and cost-efficient.

Another option is to dose the coffee powder already before it comes out of the product, for which a separate chamber to store the measured amount of coffee temporarily and a mechanism to open this chamber to the main body have to be added. Another option is to dose with another actuator (for example, an electric motor), but that adds greatly to the complicity of the structure.

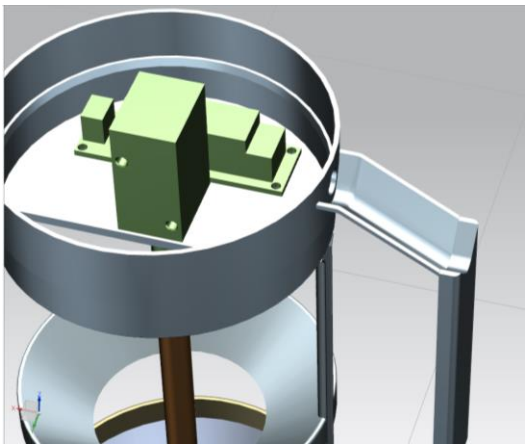

Figure 7. Solenoid and off-delay relay.

3.3.4 Control Chamber

In order to protect the electric components from coffee powder and for easy maintenance, a control chamber for the solenoid and relay was designed. It is located on top of the product so as to be as far away from the coffee as possible. It is basically semicircle-shaped, saving the other half circle as an opening through which users can pour their coffee powder into the body chamber.

The solenoid, off-delay relay and wires are collected into the control chamber. Since the solenoid, which connects to the main shaft, has to be located in the middle of the body chamber, the straight wall of the control chamber is 19 mm over the middle point, which is half of the length of solenoid.

An opening on top of the control chamber was made (with a removable cover), so as to simplify the possible maintenances of inside components.

The control chamber was made into one assembly together with the handle and ON/OFF button. This structure ensures easy installation, wiring and maintenance.

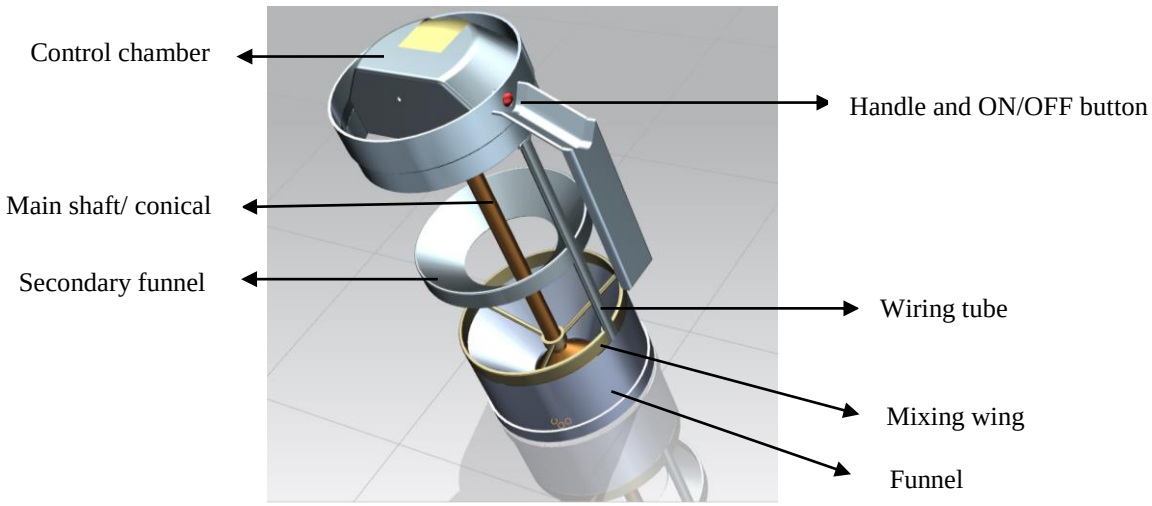

Figure 8. Inside structure of the coffee powder dispenser.

3.3.5 Batteries

Since the voltage requirement of the solenoid is 12 V and power should be 18 W, choices for the power source are: 2 pcs of 6 V small batteries, 8 pcs of 1.5 V AAA batteries, a 12 V 1.5 A power bank or an adaptor from 220 V AC into 12 V DC.

Through tests, it was found out that 6 V small batteries could not provide enough current (1.5 A) for the system need. 12 V power bank costs more than the product can afford. The adaptor needs to be plugged to a socket during usage, which is not so appreciated by users. So these three solutions were denied. Although it sounds like a lot of batteries, the 8 pcs normal AAA batteries solution was decided on. The reasons are easy and cheap to obtain, long-lasting, proper current (up to 1.5 A), relatively light and no need for connection to the socket during usage.

3.3.6 Battery Case

The space for batteries is small in the product and the centre of gravity limits the location of batteries, so they are put in four cases on one common base beneath

and around the funnel. Holes had to be made into the base as well as the four cases in order to fit the shape of the funnel. Brackets for series connections between two batteries within a group, as well as holes for wirings between four groups of batteries were added.

Users are able to unload the whole battery case from the common base, so that they may change the batteries conveniently without turning the whole product upside-down. Since the battery case is just next to the exit of coffee, a cover was also designed to prevent possible soiling. A small notch was added to the edge of the battery case cover to fit the user's finger, so that he could open the cover easily.

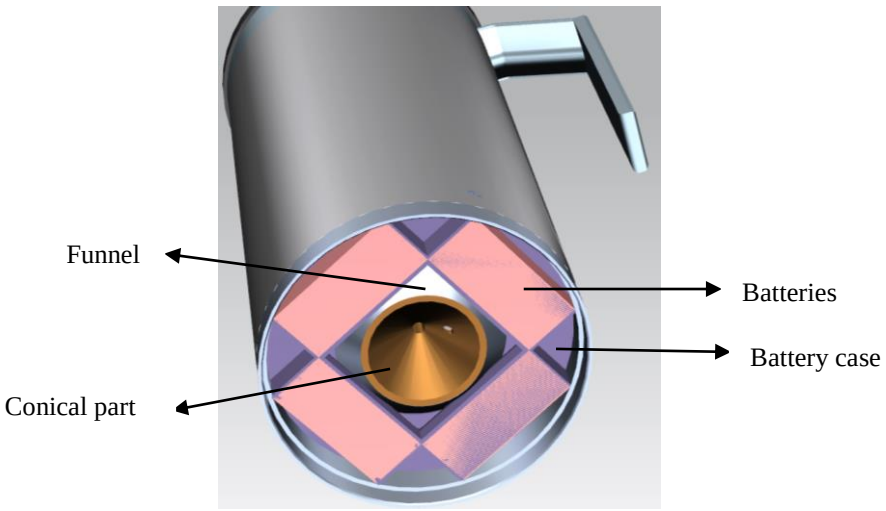

Figure 9. Battery case and bottom of the conical.

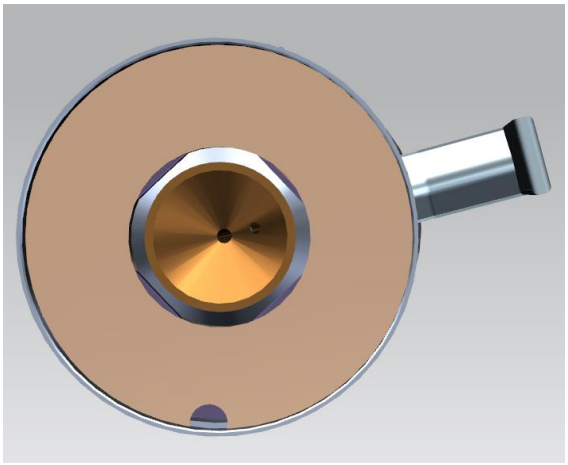

Figure 10. Battery case cover.

3.3.7 Wiring Details

Since this product is used for dosing coffee powder (food), no obvious wire is expected to be visible to the users. In addition, because of the property of the powder material, all structures have to be closed, so that the coffee powder will not cause any problems to the work of the product nor will it pollute the lovely desktops of the users.

Although the wirings between the solenoid and relay can be held in the control chamber, a plenty of wiring details still need to be taken care of.

Since the batteries are located on the bottom of the structure, while the actuators and ON/OFF button are in different parts of the product, a wiring tube was attached to the wall of the body chamber and extends all through the body. Small holes that fit the sizes of wires were made into conical part (for vibration motor), control chamber (for solenoid and relay) and battery case (for batteries). A short connecting tube from control chamber to ON/OFF button was used to conceal obvious wires.

The battery case is expected to be easily detachable, so that the user can change batteries without turning the whole product over. To implement this, a detachable wire connector and its notch were arranged.

3.3.8 Body Chamber

The body chamber is the place where coffee powder is stored. It is made of steel sheet. To please the users, the height and width of the body (including handle) was made into as close to golden ratio (1:1.618) as possible.

At the same time, the cost should be taken into consideration. According to the size of the steel sheet, the diameter of the body could be up to 105 mm. In addition, the volume of coffee powder was considered. If one package of coffee, that is 500 g, takes about 1.4 l space (as we measured in lab), at least 1.7 l of free space should be arranged inside the body chamber. For these reasons, the body chamber was designed into a cylinder with 105 mm diameter and 205 mm height. $V= (\pi/4)*D^2*h= 3.14/4*1.05^2*2.05\ dm^3= 1.77$ l. /12/

3.3.9 Funnel Part

The funnel part is to control the flow of the coffee powder. The coffee powder exits the product through the gap between funnel and conical part. It is located on the bottom of the product. To guide the coffee flow and to prevent it from being accumulated, the funnel was designed into a bevel angle. At the same time, in order to assure there is enough coffee powder around the conical part and wait to exit, the angle could not be too big (to the bottom line of the body chamber).

Another consideration was the space for batteries. Since batteries are not possible to be put together with the actuator in the control chamber due to the weight (centre of gravity of the whole product) and size, they are held in the free space beneath the funnel part. Eight batteries are divided into four groups and put around the opening of the funnel. Enough space around there should be assured. So the angle of the funnel part to the bottom line of the body chamber was designed as 50.5 degree now.

3.3.10 Secondary Funnel

Coffee powder easily is compressed under its own weight. Especially when the body chamber is full of 500 g coffee powder, the powder is compressed and stagnates. As a result, it can no longer exit from the funnel smoothly and normally.

To prevent this from affecting the function of the product, a secondary funnel was added to the middle of the body chamber, which is to carry up to 30 % of the weight of coffee, and as a result, to keep the coffee powder near the exit fluffy and flowing smoothly. So that the secondary funnel does not affect the open of conical part, a hole of Ø56 was added in the middle.

3.3.11 Lump Prevention

Coffee powder is easily lumped together, so a mixing wing was designed to prevent this problem. The mixing wing was attached to the wall of the body chamber. To reduce the burden on the solenoid, it does not move with the reciprocating movement of the shaft. Though it is stationary, when the coffee lump passes, it is able to cut big lumps. It also acts as a guide for the direction of movement for the main shaft from the lower end (upper end is guided by a part of the control chamber).

3.3.12 Handle

The handle was made into one piece together with the control chamber to reduce the total number of the parts. It is required to be comfortable to hold to, nice looking and firm enough to support the weight of the product that is full of coffee powder. Therefore, the holding part was designed as thick and rounded to fit the shape of hand, while the supporting (lateral) part is thin and in a “V” shape, as the “V” shaped material is stiffer (less likely to bend) under pressure.

3.3.13 Weight

Since mainly used in households, the weight of the product was considered. It is now no more than 800 g with the body full of 500 g coffee powder and all eight pieces of batteries installed.

3.3.14 Appearance

The appearance of the whole product is important for consumers, so it should be simple and lovely. The structure of the product is to be made as simple as possible. Chamfers and fillets were added not only for product safety reason, but also to please users. The curves of the chambers were designed into smooth and pleasant looking. Connections and wires were also simplified and hidden from the view as much as possible. The ON/OFF operation button in red colour on top of the handle is very noticeable and easy to operate.

3.3.15 DFMA

DFMA consists of two concepts: DFM and DFA. DFM, Design for Manufacturability, is the practice of designing products in such a way that they are easy to manufacture. It includes all the methods and arrangements that simplify product constructions and lower manufacturing costs. DFA, Design for Assembly, is a process by which products are designed with ease of assembly in mind. /8/

Keeping DFMA in mind, focuses in design are mainly put on reducing parts number, using standard commercially available components, simplification of geometry, elimination of over-constrains, top-down layered assembly, making parts independently replaceable and module structure.

- By reduction in parts number, assembly costs are lowered and the product will be more reliable. It may be applied to parts that are made of the same material and no displacement from each other. In this case, the control chamber and handle are of the same material (plastics) and there is no displacement between them, so they were made into one piece. However, during the assembly, it was discovered that it is difficult to tighten the screws and connect wires inside the control chamber through the opening on top. As a solution, the control chamber was then made into two parts- the top and bottom parts, with the bottom part connecting to the handle.

- By use of standard commercially available parts, design time and inventory control can be reduced. In this product, the solenoid, relay, batteries and

all the screws are commercial parts. They can be purchased directly from shops or online.

- By simplifying the geometry of the parts and elimination of over constraints, unnecessary features are avoided, less processing or sortation are needed, and production time can be reduced.

- Top-down layered assembly is the fastest and thus the most cost-effective. In the design process, fillets and chamfers were added to the edges of parts that need to be plugged or placed into other parts to ensure easy assembly. Thus the assembly of the whole product is in one direction and top-down layered: top cover - control chamber top - solenoid and relay - control chamber bottom with handle and ON/OFF button - body chamber with wiring tube - secondary funnel - mixing wing - main shaft with conical part and vibration motor – funnel - battery case and batteries - battery case cover - bottom cover.

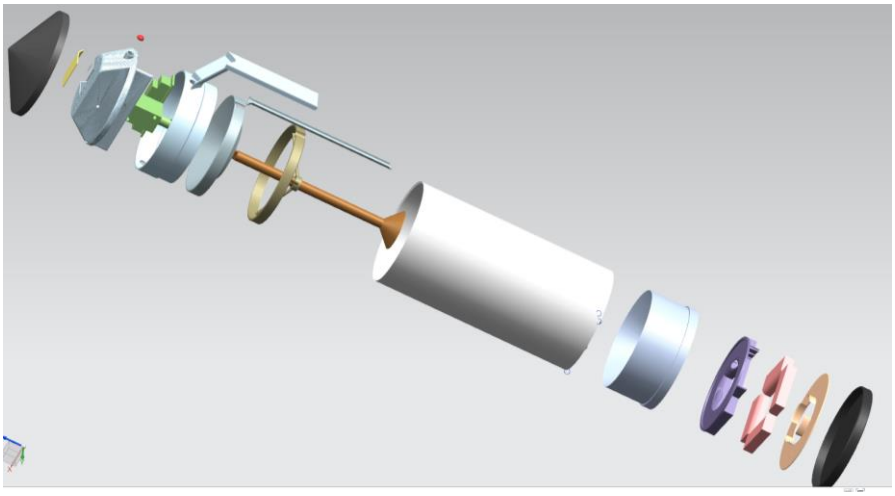

Figure 11. Assembly of the coffee powder dispenser.

- Replaceable parts and modular structure will facilitate maintenances and repairs. In addition, inventory requirements are reduced. The final assembly time is minimized. In the product, the battery case, AAA batteries and

battery case cover form a power supply module. It has a relatively individual function and could be taken off and replaced as a whole.

3.3.16 Tolerance

Tolerance is the permissible limits of variation in a dimension. Although this coffee powder dispenser is not such an extremely precise industrial product, it still has some points where attention needs to be paid to tolerance focuses.

Since there is a strict relationship between the power, stroke and pulling force of the solenoid, the stroke of the main shaft has to be made precise. Considering the ability of the solenoid and amount of coffee powder needed to exit on each operation, the stroke of the main shaft was decided. And that also decided the height of body chamber and the length of main shaft. The tolerance of the stroke is ±0.5 mm.

The control chamber is narrow. It should be just enough to hold the solenoid and relay. The solenoid has to be attached by screws to the wall of the control chamber and relay attached to the bottom. Therefore, the dimensions and geometries of the control chamber needed to be carefully designed. The tolerances are set to -1mm - 0 mm.

Tolerances are also set to the parts that guide the movement of the main shaft, such as the inner sides of the holes in the control chamber bottom and mixing wing. Since the main shaft moves along the direction of the holes, their diameter should be +0.5 mm bigger than that of the main shaft. However, to prevent the coffee powder from getting stuck between them, the difference in diameters should not be over 1 mm. The tolerances of the inner surfaces of the holes in the control chamber bottom and mixing wing are +0.5 mm - +1 mm.

The wiring holes for vibration motor in the conical part, as well as the bottom edge of it need tolerance of ±0.5 mm, so that they are tight enough to prevent coffee powder from exiting from undesirable points.

The battery case under the funnel is delicate due to the small space and relatively intricate structure. The tolerance of ±0.5 mm is applied.

3.3.17 3D Modeling and Drafting

When starting the designing of a product, geometries and dimensions are not yet fully decided. Gradually, the design becomes clearer and different parts get their shapes. Their dimensions affect each other and in an assembly model, their compatibility can be further checked./9/

In 3D modeling of this design, the Siemens NX 10 program was used and a top-down method was applied, which means 3D model was established from assembly level downward to component level. Key aspects, such as dimensions, geometries or locations are defined in the control model (in assembly)./9/ The advantage of top-down design is that much less rework will be needed when changes in the design occur.

The diameter of the body chamber, the height of the product, the thickness of the walls, the full stroke of the main shaft, as well as the stroke of the solenoid were set as parameters in the control model. An expression about how the full stroke of the main shaft decides the length of it was made. Then a sketch of assembly was drawn, which is the most important sketch in this 3D modeling process. It contains the information of relationships between different parts. It is always wave-link copied to all the components when they are established. Then individual components get their shapes by extruding or rotating different shapes and lines. Holes were drilled and threads, fillets, chamfers and other geometries were added gradually.

Standard engineering drawings may be produced and maintained directly from the 3D model or assembly part. Drawings created in the drafting application in NX are fully associative to the model and any changes made to the model are automatically reflected in the drawing./9/ Dimensions, tolerances, materials etc. are noted in the drawings. Finally, an assembly draft with an explosive view of the product

was made, in which all the relationships between different parts and their positions are demonstrated.

3.3.18 Prototype (Components Purchase and 3D Printing)

The prototype is one of the most important steps in the design process. It is a simulation or sample version of a final product, which is used for testing prior to the launch. The goal of a prototype is to test products (and product ideas) before sinking much time and money into the final product. Prototyping is essential for resolving usability issues before launch. It can also reveal areas that need improvements. /11/ Once a physical draft of product idea is available, more tests can be carried out and needs for improvement to the initial work can be more obvious.

The prototype is not to be made only once or twice, but can be any version of the product that is able to be used for testing.

Thanks to the 3D laboratory in Technobothnia, prototypes of the product are able to be printed out without delay. The PRT files of NX were converted to STL (stereolithography) files, which describe only the surface geometry of a three-dimensional object without any representation of color, texture or other common CAD model attributes./10/ Afterwards, a 3D print program was used to define parameters such as the thickness of wall, infill percentage, height of layers, printing speed, support, brim, skirt, etc. The STL file was sliced and sent to print. Printers Dimension, Object, Ultimaker, Wanhao, Maker One were used to print different parts according to needs and conditions. Printing processes varied 4-12 hours depending on the printer and shape of the parts. When the prints were ready, they were removed from the printing bed. Supports and skirts were removed and finishing work needed to be performed.

Figure 12. 3D printer (Dimension) in Technobothnia.

While most complex parts of the product were printed on 3D printers, the body chamber was made of plastic films by hand. One of the reasons is that it is difficult for 3D printers to print smooth shell structure. The other reason is the need for reduction in printing cost. It turned out to be quite a successful way, except the plastic films were not stiff enough to keep their shapes. To help with the problem, a ring made of aluminum was added to the top provide more support.

Electronic components were mainly purchased online from China due to the higher price-performance ratio. Since Chinese have developed mature systems of online shopping (such as Alibaba, Aliexpress and Made-in-China etc.), it is not difficult to find the components needed. However, it was important to take into account the period and costs of delivery.

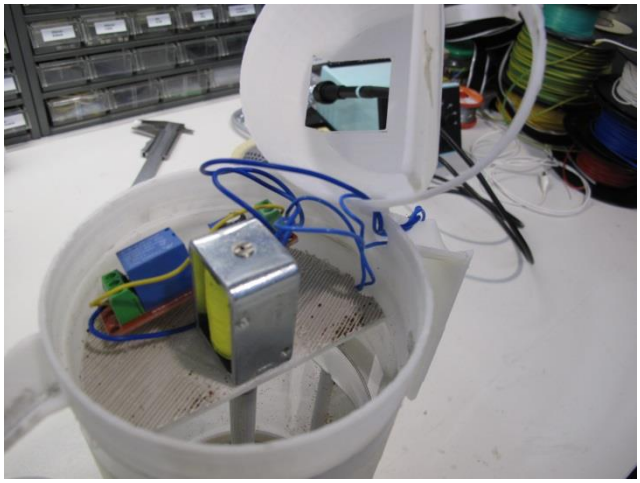

Figure 13. Purchased components installed in the prototype.

3.3.19 Assembly of Prototype

The assembly is top-down layered. The sequences are top cover - control chamber top - solenoid and relay - control chamber bottom with handle and ON/OFF button - body chamber with wiring tube - secondary funnel - mixing wing - main shaft with conical part and vibration motor – funnel - battery case and batteries - battery case cover - bottom cover.

Figure 14. Assembled prototype of the product

3.3.20 Tests and improvements

While the prototype of the product was assembled ready, batteries were installed and a whole package (500 g Paulig Juhla Mokka) of coffee powder was filled into the product. Tests about if it works as expected were performed.

Different parameters were tested: stroke of the main shaft, power of the batteries, volume of the body chamber, delay period of the off-delay relay, functions of vibration motor and secondary funnel, and the amount of coffee powder obtained on each operation.

As mentioned, designing, prototype, test and improvement are steps in a circular process. They are not to be carried out only once. Instead, prototypes are to be made to any version of product that can be tested. Problems and improvement ideas are to be found. Then the design of the next version starts.

4 ASSEMBLY AND MAINTENANCE

4.1 Suggestions on Assembly by Robots

Nowadays robots are widely used in assembly, as they are able to reduce assembly time, increase production speed and improve quality. They can replace human operators in dirty, dangerous and dull jobs to reduce repetitive strain and accidental injuries.

Since this is a light and small sized coffee powder dispenser, a small robot arm is required to carry out the assembly work. For example, Universal Robots UR3 – Small Collaborative Robot for 3 kg payload, that has a 500 mm work radius.

Figure 15. Universal Robots UR3 robot arm.

So that the robot can be successful in performing all the assembly work with one pair of small grippers, the screw connection between the solenoid and the control chamber wall, as well as that between off-delay relay and the control chamber bottom need to be switched to snap fits that are self-fastening. Proper conveyors that cooperate seamlessly with the robot need to be planned.

4.2 Maintenance

The coffee powder dispenser is designed as easy to maintain and repair. The power supply module is detachable, so that the battery change takes no more than 3 minutes. Since the total structure of the product is simple, components such as actuators and relay are easy to change.

5 FINAL RESULT

As the result of this project, a coffee powder dispenser, which meets the requirements of the customer, was obtained. The product is made up of body parts, functional parts, power parts and auxiliary parts. It is able to dispense 1 tbsp. of coffee powder on each operation and the amount is adjustable. It is inexpensive, ergonomic, nice, simple and light. It is able to hold a whole package of 500 g coffee powder. Moreover, it is easy to manufacture and assemble.

The design process started with requirement analysis. Through conceptual, preliminary and detail design, a pure idea of a coffee powder dispenser was turned into a production-ready result, with each part of the product clearly defined and the whole prototype tested. With functionality, simplicity and thrift in mind, limits were set to the development of parts and selection of purchased components.

The body parts forms the outline of the coffee powder dispenser. In accordance to the requirements list, the body chamber is now able to hold 500 g coffee powder. For dimensions of the body chamber, consideration was given to the sizes of the steel sheet used to make the cylinder. The diameter of the body chamber is dependent on the maximum width of the steel sheet. A funnel is connected to the body chamber. It guides the flow of coffee powder.

The dosing function of the product was implemented by cooperation of the funnel and a conical part that is connected to a reciprocating main shaft. The funnel and conical parts were designed so that they fit each other and are able to ensure the out coming flow of the coffee powder. To implement that, the diameters and angles of the ends of both parts are chosen with care. The main shaft is controlled by a solenoid. When the solenoid pulls the main shaft upward, the conical part reaches its upper position and coffee powder exits from the product through the gap between the conical and funnel parts. The stroke of the main shaft is a key factor to determine the flow of the coffee powder. At the same time, it is dependent on the ability of the solenoid. The length of the main shaft was calculated from the full stroke of it. In order to reduce burden on the solenoid, the main shaft and conical are made into hollow. The open time span of the solenoid is controlled by an

off-delay relay, which turns on the circuit and starts timing as soon as the ON/OFF button is pressed, and turns it off after preset duration of time. The solenoid and the relay are placed into a control chamber to protect from coffee powder. To speed up the coffee flow, a vibration motor is applied at the end of the conical part. It is also to break possible lumps near the exit.

The actuators are empowered by the power parts. Eight pieces of 1.5 V AAA batteries provide the product with 12 V voltage and up to 1.5 A current. They are arranged into four common-based battery cases and put beneath/around the funnel. In this way, no additional space is needed and users can replace batteries with ease. Wiring details are also taken care of. A tube that connects the batteries beneath the funnel and the control chamber on top is designed to carry the wires. Holes for wiring are added. The ON/OFF button is made into red color for easy operation.

The auxiliary parts are to help the product to operate better. A secondary funnel was designed to avoid the compression of the coffee powder under its own weight. This helps the coffee to exit smoothly even at its maximum volume. A mixing wing is to guide the movement of the main shaft from the lower end (upper end is guided by a part of the control chamber) and to break big coffee lumps when they go past it. The handle is combined with the control chamber to reduce total number of the parts. It is shaped as thick and rounded for comfortable holding. While its lateral bar takes on a thin “V” shape to better support the weight of the product with coffee powder. To protect batteries from coffee powder, a battery case cover was designed to be the right size to stay in place, and at the same time, easy to take off by users when necessary. The top and bottom covers of the product enclose the space. They can prevent coffee powder from scattering and keep off moisture.

During the design process, DFMA idea was always kept in mind. It simplifies product constructions and lowers manufacturing costs. It was implemented by reducing parts number, use of commercial parts, simplifying geometries, elimination of over-constraints, module structure and top-down layered assembly method.

After careful 3D models of all parts were made in the Siemens NX 10 program, the prototypes were printed out with 3D printers in Technobothnia, and then were assembled and tested. This designing, prototype, test and improvement circle was performed several times. Problems were noticed and ways of improvements were figured out, until a final satisfying version is decided on.

Suggestions on assembly by robots were also put forward. A properly small sized and uncostly robot arm is able to perform the task. The assembly is top-down layered and a few improvements in the structure of the product were proposed to assure success of the assembly by robots.

Thanks to its simple and modulated structure, the product is easy to maintain and repair.

Cooperation and communication with the customer were important during the whole design process. When a confusion or uncertain situation arose, to discuss with the customer and accept his advice was a wise and quick way.

Figure 16. An outlook of the coffee powder dispenser.

6 DEVELOPMENT PROPOSALS

The coffee powder dispenser is working on the power supplied by eight pieces of 1.5 V AAA batteries. However, the batteries are not able to provide a sustainable 12 V voltage and 1.5-A current for a long time. As a result, the users will have to change the batteries fairly often. A possible solution is to apply one or several pieces of rechargeable batteries, which can be charged while the product is in a stand-by condition. Attention should be paid that ten pieces of 1.2 V AAA re-chargeable batteries cannot be applied here, due to the big space required and the small current available. A powerbank may be a solution if any cheap version could be found.

As the current version of the coffee powder dispenser takes five seconds for one operation to get 1 tbsp. of coffee powder, it feels a bit long for families that need to prepare more than 5 cups of coffee at one time (thus at least half a minute is needed to wait for the product to work). The solution will be to switch to a more powerful solenoid with a bigger stroke. As a result, the conical part can be open 10-12 mm upward. Coffee powder can exit from the product more quickly.

At the end of the design, I started exploring how to make the storage and transportation of the product easier. Since the body chamber of the coffee powder dispenser is empty, all body chamber parts may be kept together. If they are made into circular truncated cone shapes, they may stack over each other. Thus, a lot of space is saved. Less effort and cost will be needed in the storage and transportation.

7 CONCLUSIONS AND DISCUSSIONS

This design process of a coffee powder dispenser is a good representation for all practical design processes. It starts with understanding of customer's requirements. Then it continues with developing possible solutions. After the best solution is selected, it is developed systematically, and afterwards, into all details. Prototype, test and improvement processes need to be repeated several times until a final satisfying design is obtained.

During the design process, knowledge of all fields studied in school is applied with flexibilities. Especially knowledge of project management, 3D design project, 3D modeling and product lifecycle management, mechanical drawing, construction technology, machine elements, materials, automation technology, statics, robotized assembly, additive manufacture (3D print), cost accounting, technology English etc. is widely used here.

A product design process can last long, when different problems occur from time to time and need to be solved. Sometimes, in order to solve a problem, a part of the previous design needs to be modified thoroughly or a totally new part needs to be added. Especially, if problems inevitably lead to contradictory solutions (for example, functionality, precision, productivity, inexpensiveness), compromises need to be made according to the importance of solutions.

The communication between the designer and customer is very important. Usually at the start of the design, the customer only has a pure idea about what kind of product he is expecting. With the development of design, the product is becoming more and more concrete. Details need to be confirmed based on confirmed requirements. The customer could also give valuable suggestions as to how the product is expected to work, thus saving much time for the designer.

Due to the characteristics of design processes, it is important to keep the project schedule in mind. Different processes of the design should be carried out accordingly. Especially, prototype, test and improvement processes are to be repeated many times, thus it will take a long time before a final design is reached. Alt-

hough it may seem already close by when the first version of prototype is assembled, the final satisfying design is, however, not to come until many tests and improvements are implemented. What makes the schedule important is the fact that it is the key to control the delivery time and duration of the whole design process.

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VAASAN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES

Minutes of the Meeting 20170425

Time: 10:30-11:00, 25.4.2017 (Tu)

Attendants: Tommi, Janne, Liu, Juha

Place: Room A3002, VAMK

- The patent documents of the "dispenser for a powdered product" (short as "coffee powder dispenser" or "product" below) are demonstrated.

- Main features and requirements of the product are discussed:
  - A **chamber** for coffee
  - A **funnel portion** that leads coffee to the dispense part
  - An **electric actuator** to cause the coffee to fall
  - A **conical member** that moves **mainly vertically** to dose coffee
  - The conical member can also **rotate** up to 30 degree horizontally
  - **Time period** (independent on how long the button is pressed) for raising the conical member
  - A **cover** for the whole chamber
  - A **sealing** ring to seal the contact between funnel and conical member
  - The coffee powder dispenser is a hand-held device, so it needs to be **light** and in accordance to **safety** and **ergonomics** standards
  - The product should be about **20 cm in diameter** and 30 cm tall
  - The product is made of PE? And the manufacture cost should be **under 20 €** (PE price is about 0,5 €/ kg and pay for the worker should be about 24 €/ h).

- Schedule of the project is discussed:
  - Starts from now
  - The design part should be ready by 15.9.2017

- Prototype will be made in 12.2017
- Next meeting will be in 8.2017.

- The way of communication is defined as through emails.

- Liu's responsibility is to design the mechanism for the coffee powder dispenser, to make sure it works properly according to the requirements. Liu will receive .stp files in emails from Tommi and Janne for the appearance of the product and then integrate them into the design.

VAASAN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES

Minutes of the Meeting 20170823

Time: 9:00-10:30, 23.8.2017 (Ke)

Attendants: Tommi, Janne, Liu, Juha

Place: Muova

- The latest design of the product is demonstrated and discussed.
  - The main structure of solenoid + relay is confirmed
  - Solenoid and relay are to be drawn and put into the 3D model (so that the 3D model can show all the details)
  - Necessity of bottom cover is to be decided
  - Top cover and handle is to be re-designed into the shape defined by Muova
  - On-off button is to be put together with top cover
  - Middle board is to be integrated with handle as one part
  - Middle board is to be sunk a bit into the body to reduce the height of top cover
  - The measures of the main body is to be modified to hold the coffee volume as well as to leave space for the sunk components

- The materials and production way of the product are demonstrated.
  - Light steel body can be produced at a low cost
  - The new way to seal steel body with the plastic parts

- The out-sourced components (solenoid and relays) are demonstrated.
  - 2 solenoids and 3 relays are bought and delivered from China
  - Components, invoices and documents from Customs are shown

- Schedule:
    - The modified measures of the product will be provided by Muova soon
    - A meeting with the customer will be held in the middle of September
    - Modified 3D model are to be shown in the meeting
    - After the confirmation from customer, the model can be 3D printed

VAASAN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES

Minutes of the meeting 8.9.2017

Time: 14:00-15:30, 8.9.2017 (Friday)

Attendants: Ari Viianen, Tommi, Janne, Juha, Liu

- The structure and each part of the product was introduced to customer and customer was satisfied with the design on the whole.
- The On-Off switch is suggested to move to the top of handle for easier usage.
- The angle of mixing wings needs to be changed to reduce pressure on it.
- Seals on the top cover as well as on the bottom of the funnel part are to be added to maintain the quality of the coffee inside.
- Chamfers are to be added to parts for easier assembly.
- The components (solenoids, relays and batteries) are to be tested in Technobothnia as soon as possible.
- Customer wishes the batteries could last for one month.
- After the 3D model is revised and checked, it could be sent to 3D print.
- Next meeting will be held when 3D model is printed and tested.

Minutes of meeting 21.2.2018

Time: 10:00-11:15, 21.2.2018

Place: Technobothnia

Attendants: Ari, Liu

1. The current design, prototype and function of the product are demonstrated.

2. The problems are put forward:
- It takes 7-8 s to complete one operation that provides 1 Tbsp. of coffee powder, while the customer wish to shorten the time span
- When the product is full with 500 g of coffee powder, it is difficult to get the same amount of coffee out on one operation (less) due to the compression of the powder
- The current vibration motor uses 3 V power
- Currently we use 12 V, 1,5 A electricity from Technobothnia.

3. To do list:
- To search for a bigger solenoid with a stroke of 15 mm (Ari)
- To make a secondary funnel to put in the middle of the product to carry part of the weight of coffee powder (Liu)
- To find a 12 V vibration motor and proper power supply (Ari).

Liu Xueyun

Design of a Coffee Dispenser

Project Plan

Tekniikan
12.2017

LIST OF CONTENTS

Target

The target of the thesis is to design an electronic coffee dispenser for Muova, which can always give one portion of coffee powder on one press upon the ON/OFF button.

Coffee powder is usually dispensed with tablespoons by hand, which is not precise or convenient. With the coffee dispenser designed in this thesis, right amount of coffee could be obtained with ease. The product can be used widely in households or companies.

The objective of the thesis work is to design a product, which is precise in dispensing, easy to use and manufacture, cheap and durable. During the work, concept, system and detail designs are to be performed with hand drawing and Siemens NX. Prototypes are to be printed out with 3D printers. Then tests and improvements are to be carried out. Assembly is to be designed. Final result of the thesis work is to be ready for production and meet all requirements.

During the process of the project, all the knowledge studied in VAMK is to be used with flexibility under the instruction of teachers and customers.

Organization and stakeholder

The instructor of the project is Juha Hantula from VAMK. Teachers from Technobothnia Arto Hänninen and Osku Hirvonen also help with the electronic connection and 3D printing. Tommi Siljämäki and Janne Pekkala from Muova provide brief suggestions on the shape and costs of the product. The customer is A. Viianen Oy, the representative of which is Ari Viianen.

Plan of resources

- The actuators and relays are to be purchased from China by Liu
- Additional actuators (if needed) are to be provided by Ari
- 3D printers and its filaments are to be provided by 3D lab of Technobothnia
- Other materials and all tools needed for prototypes are to be found from Technobothnia
- Batteries (if not available from Technobothnia) and coffee powder is to be purchased from supermarkets by Liu
- All relative teachers provide their help to the project when they have time.

Schedule

Phase	Schedule
Start of the Project	25.4.2017
To study patent files and to understand the way of function of the product	**4.2017**
Identification of requirements (to make the list of requirements)	5.2017
To study the competitors, get ideas, make sketches of each ideas, and idea selection	**5.-7.2017**
System design of the product and make 3D models	8.-9.2017
Detail design of the product	10.-11.2017
Prototype, tests and improvements in the design, design of assembly	**12.2017-3.2018**
Drawings of all the components, to write reports	4.2018
Thesis presentation	**4.-5.2018**

Plan of project tracking

Tracking of the project is mainly by emails. When an aspect needs to be confirmed, a requirement not met, or anything difficult or vague occurs, emails should be sent to all relative parties.

Face-to-face meetings will be held:

- At the beginning of the project (to explain the targets and requirements)
- When initial 3D models are finished (to check the rationality)
- When prototype is made (to check functionality)
- When anything needs to be presented to the customers.

Analysis of Risks

In the analysis of risks, the project plan is analyzed systematically and risks are identified. This project is complicated because it starts from a pure idea and expected to end with a mass productive product. The characteristics of powder coffee also make the result complicated. The project itself does not have a made-ahead budget, but the cost of the coffee dispenser should be no more than 20 euros, so no expensive parts will be allowed.

In order to put the risks into control, good planning, communication skills with all parts and careful work are required.

End of project

- Confirm from the customer

Customers confirm the results of the project meet their requirements.

- Check of project scope

All the requirements in the project scope are fulfilled as what they are expected.

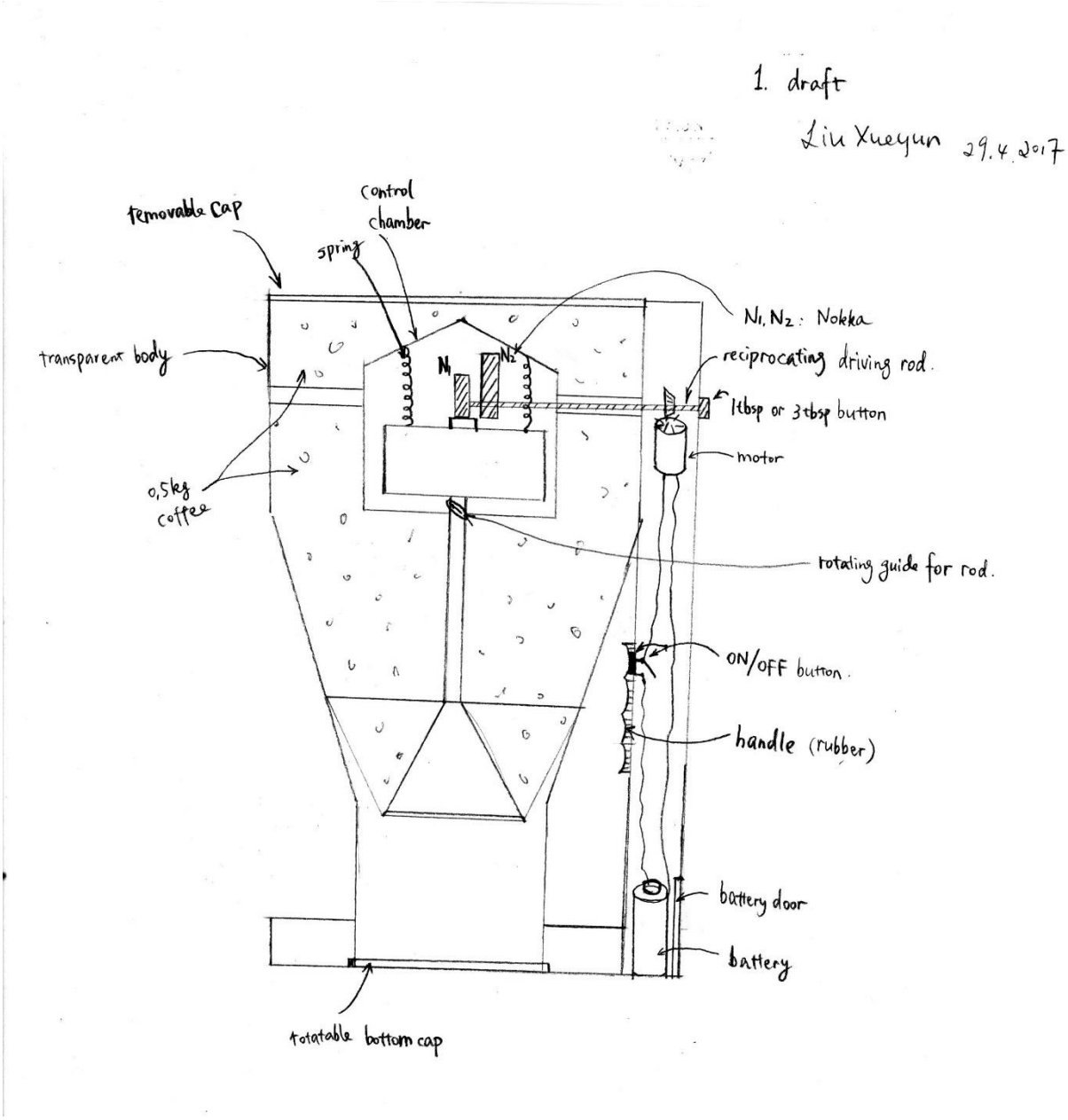
- Documentation

When result is sent to the customers and school (VAMK), relative project documents should be made and collected. The documents ensure that projects in the future will be more successful.

Sketches of products in different phases

Draft 1 Liu Xueyun

29.4.2017

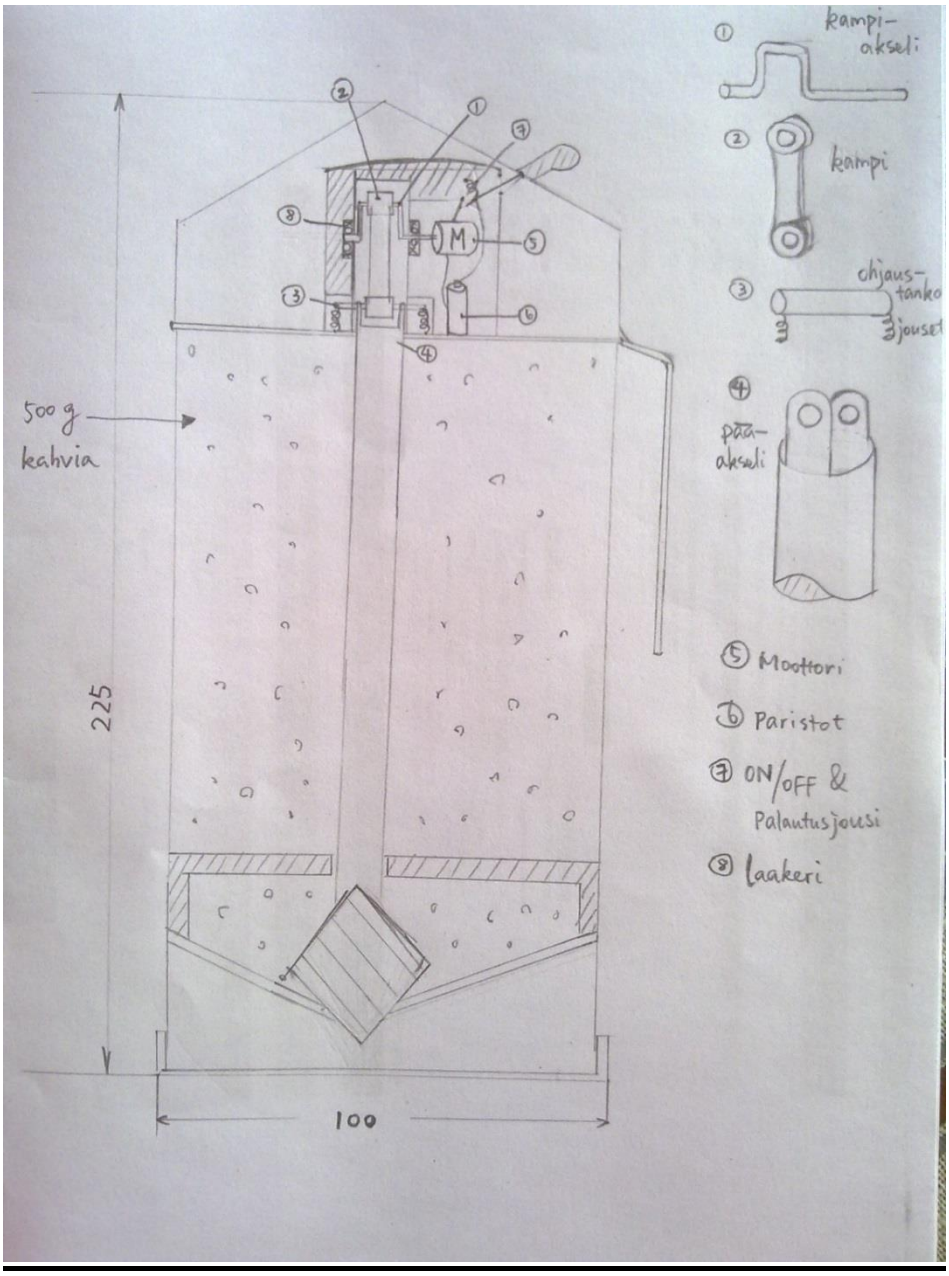


- **A control chamber** is added, so that the weight of coffee will not trigger undesirable movements of the conical member. Also, possible coffee entry into the conical is avoided.

- The movement of the conical member is controlled by a **camshaft**, which has **two noses (N1 and N2)**. And the return movement of conical is managed by two **springs**.
- N1 and N2 are different in shape, so that different volumes of coffee output will be realized (1 Tbsp. and 3 Tbsp. maybe?). There is an **output volume button** on the handle to choose which output volume is needed.
- N1, N2 and output volume button are connected by a **reciprocating driving rod**, which has two functions: to decide which nose works and to relay the drive from the motor to the noses. I realize the hump on the conical member that contacts noses should be have been made higher, or that upper part of the conical member could be made into rectangle, so that the possible contact with the idle nose could be avoided.
- The body of the product should be transparent, so that user can see how much coffee left.
- A small **electric motor** empowered by a **battery** is used to drive the system and a **bevel gear** is used to change the rotation direction into horizontal.
- The current is controlled by an **ON/OFF button** which is embedded into the **rubber handle**, so that user can easily trigger it.
- A **rotating guide for rod** is designed, so that when the conical member goes downward, it will rotate a little instead of straight vertically, which is supposed to reduce the gathering of coffee.
- The **battery door** is designed for exchange of the battery.
- A **rotatable bottom cap** is added, to avoid the possible small leak of coffee onto table. The bottom cap should be on the same level as bottom, so a **pocket** into the bottom is needed to place the cap.

Draft 2

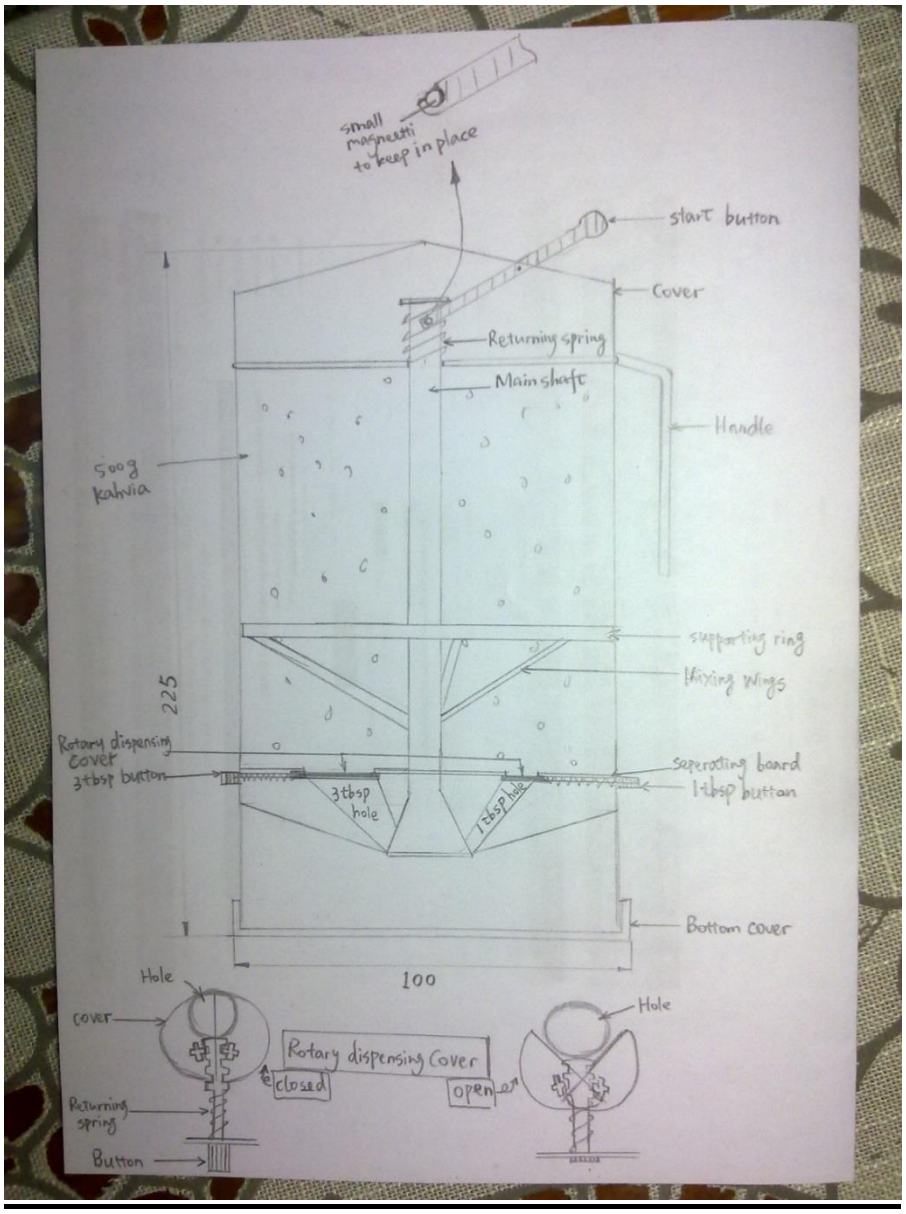
9.5.2017



- A camshaft driven by a small motor
- The motor is powered by batteries
- Primary shaft gets connected to the camshaft through a crank
- Restoration of primary shaft with springs on both sides

Draft 3

19.5.2017

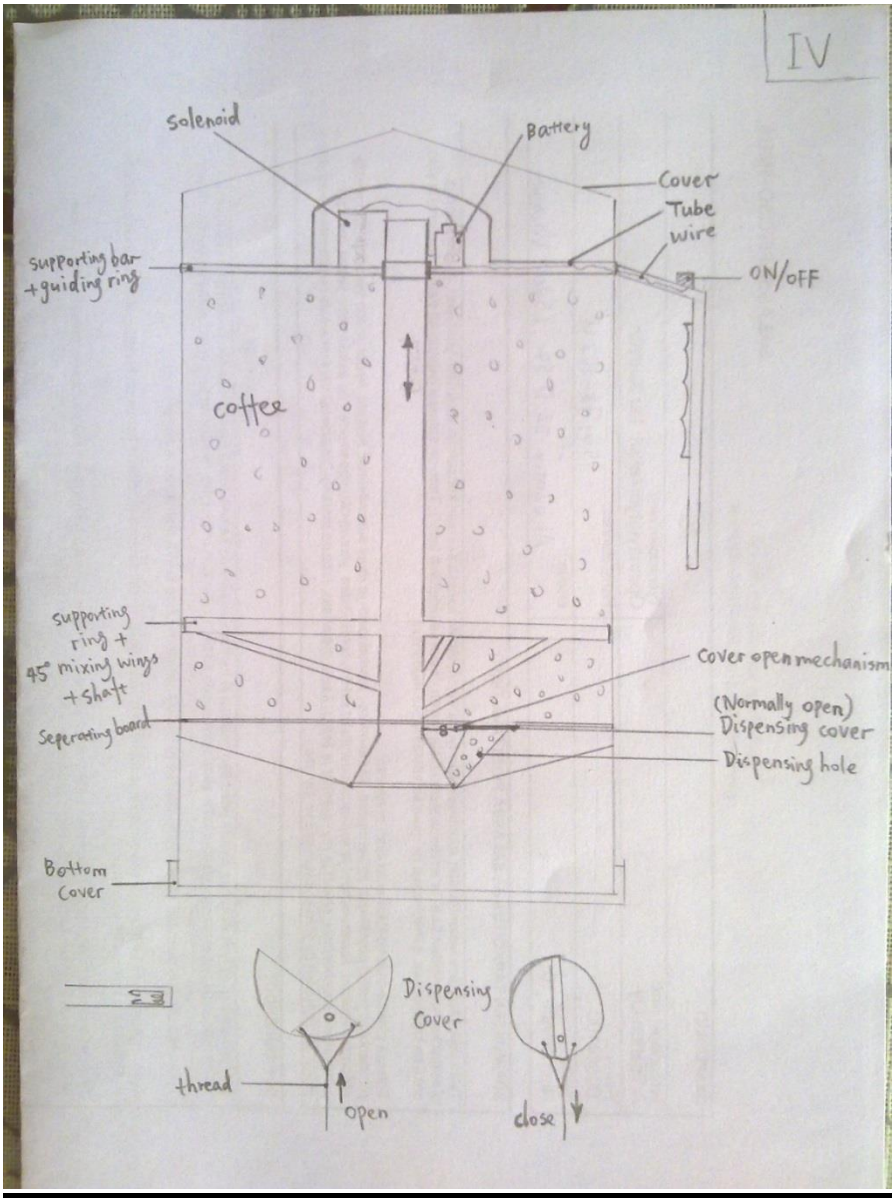


- Dosing is accomplished in a separate part
- Different amounts (1 Tbsp. and 3 Tbsp.) are available, that will be suitable for one person or three persons to drink
- When start button is pressed, the amount that is already dispensed will drop from the product
- The dispensing parts have their own buttons, so that users will need to press the dispensing amount button(s) before pressing the start button

- Rotary dispensing covers are opened by pressing the amount buttons and closed with returning springs
- Primary shaft is controlled by the start button to move upward
- There is a small magnetic piece to allow the detachment of the start button from the primary shaft, so as to allow users to open the cover
- Mixing wings (which will mix the coffee and prevent coffee from getting in one position or agglomeration), supporting ring (which will ensure the primary shaft to go in the right direction) are combined together with the primary shaft

Draft 4

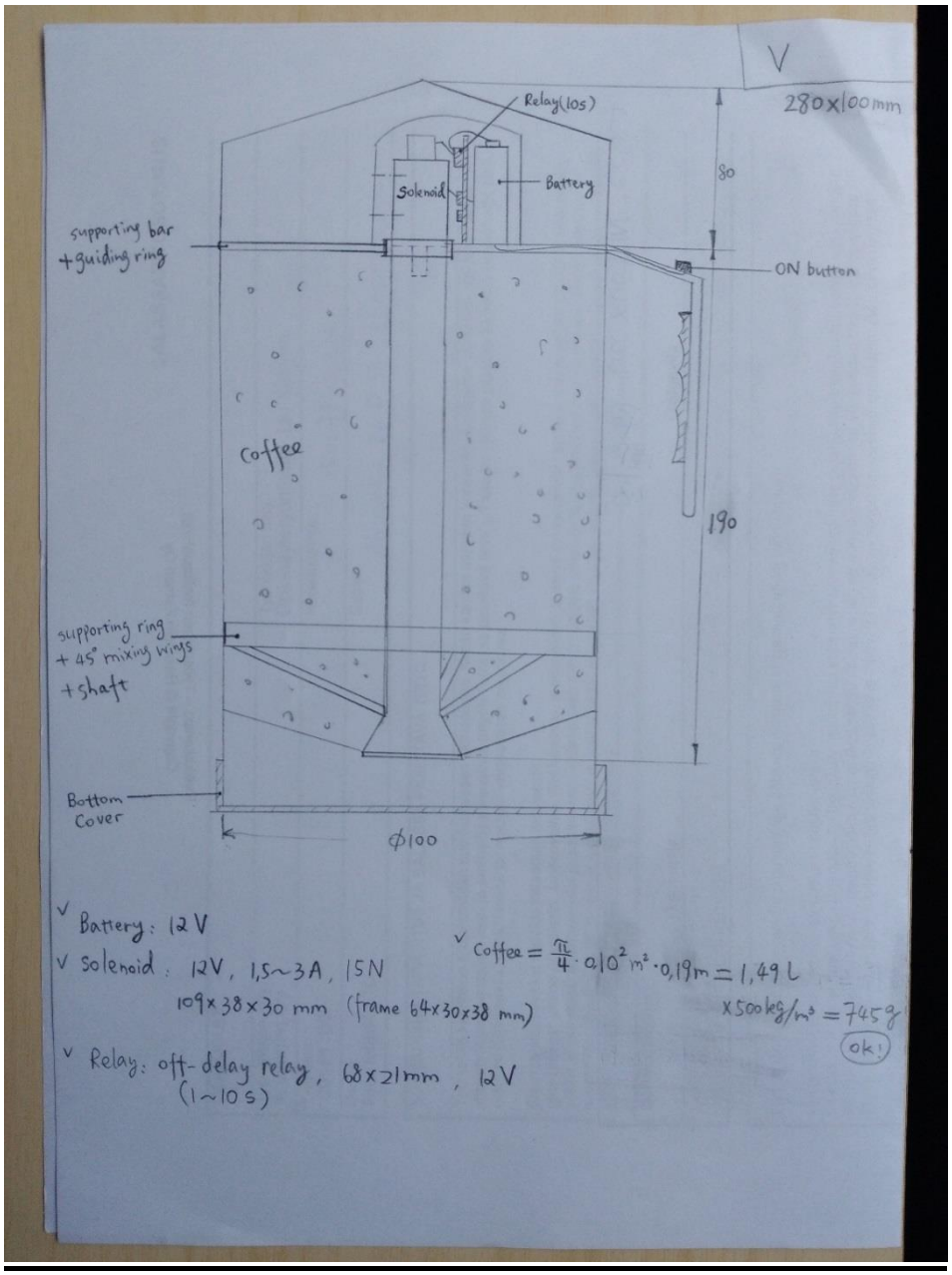
27.5.2017



- Solenoid + battery system is adopted to simplify the whole product
- Separated dosing system is kept, with only one amount available
- Dispensing cover is simplified
- Supporting bar + guiding ring is added to the top of the primary shaft, so as to ensure the shaft goes in the right direction

Draft 5

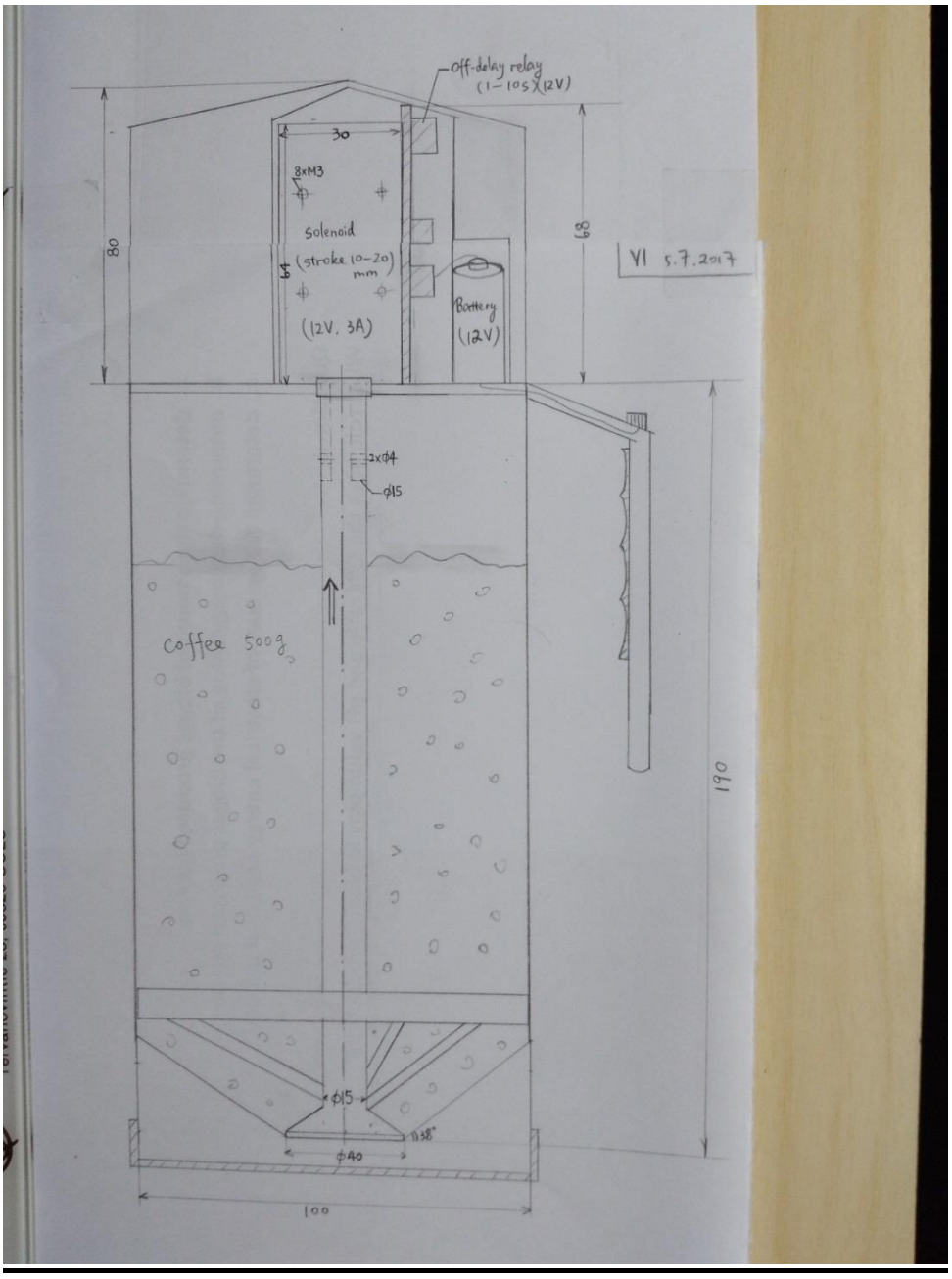
2.7.2017



- An off-delay relay is added, which can control the solenoid to work for a specified span of time (0-10 seconds)
- The dosing system is no longer needed due to the function of relay
- Dimensions of the product is φ100 mm * (190+80) mm
- Volume of coffee is checked. Parameters of solenoid and relay are preliminarily checked.

Draft 6

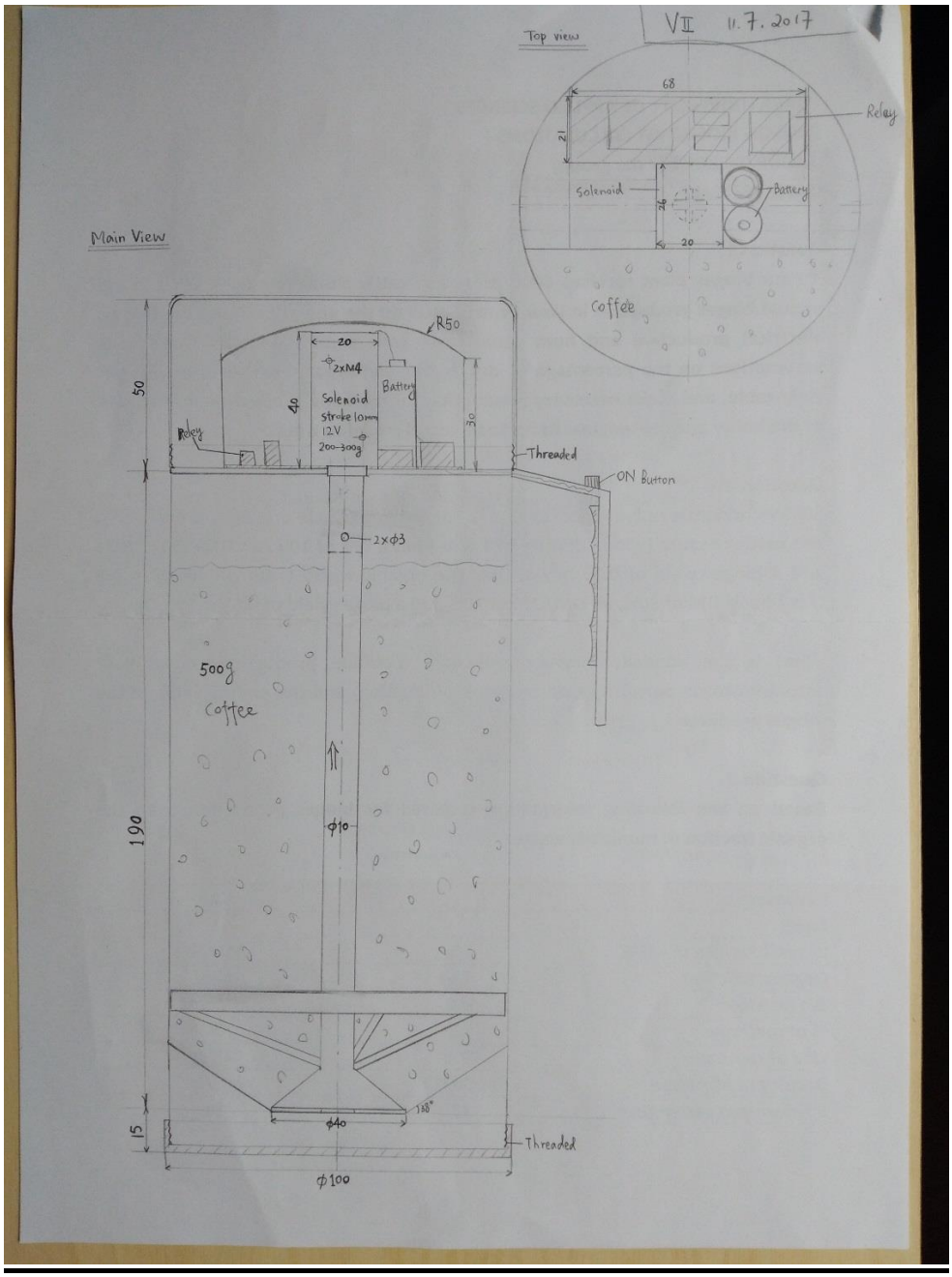
5.7.2017



- Dimensions and main parameters of different parts are more closely studied
- Solenoid to pull the primary shaft upwards due to the bigger pulling strength

Draft 7

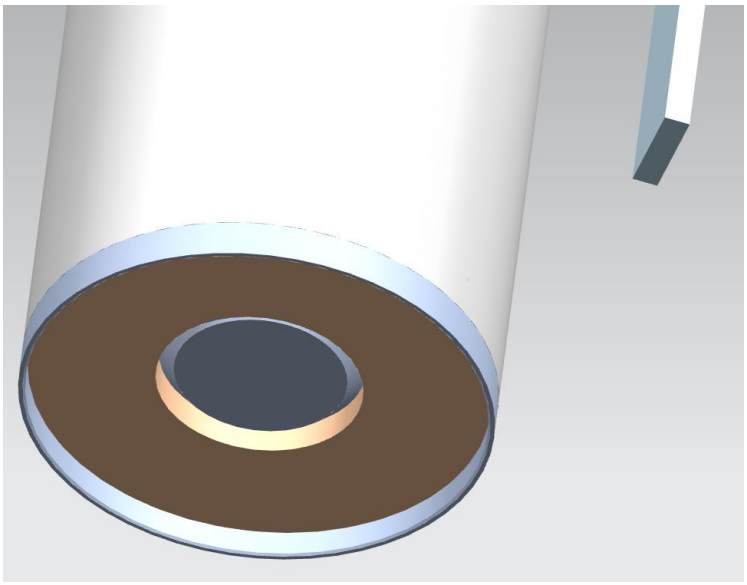
12.7.2017

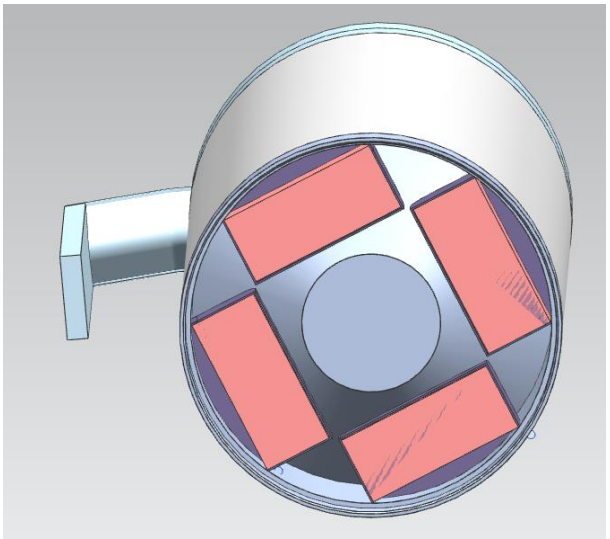


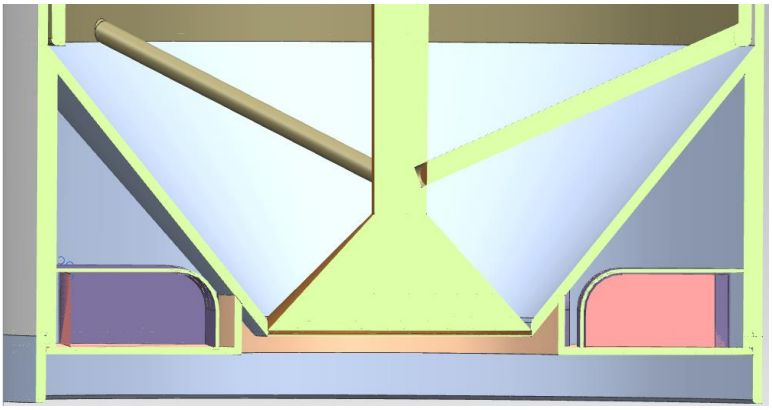
- A smaller solenoid is adopted to reduce the size of the top cover and to maintain the product in proportion, but the solenoid is less powerful
- Off-delay relay is put horizontally to reduce the height of the top cover
- Two batteries (12 V) in parallel connection are put in a separate chamber for easy replacement

Draft 8

2.10.2017





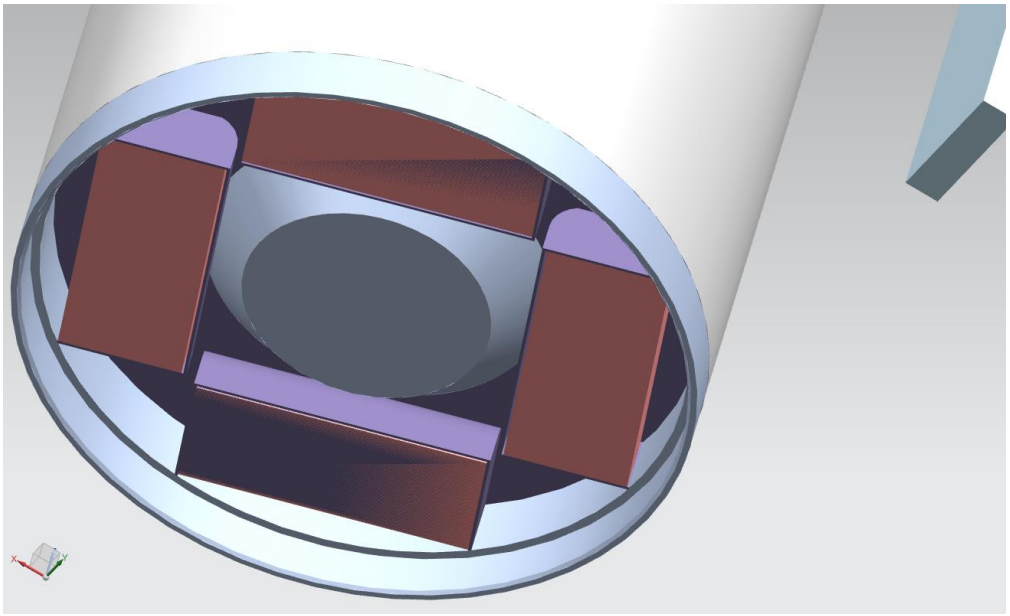


- 8 pcs of AAA batteries are needed. The size of each is Ø10*44 mm. It is difficult to fit them into the top part due to the 44 mm height.
- 8 pcs of batteries are now located on the bottom of the product (around the funnel exit). A cover is added to protect the batteries from dropping coffee. The distance between the edge of the battery cover to the edge of conical part is 4 mm.
- The batteries are arranged so that they surround the exit. Each pink square (group) stands for 2 normal AAA batteries (2*1,5 V). There are altogether 4 groups, which are put in series and make 12 V for the consuming components. The violet parts are the battery cases, which may be integrated into funnel.
- The outfit of the product is otherwise kept the same as before.

V2

3.10.2017

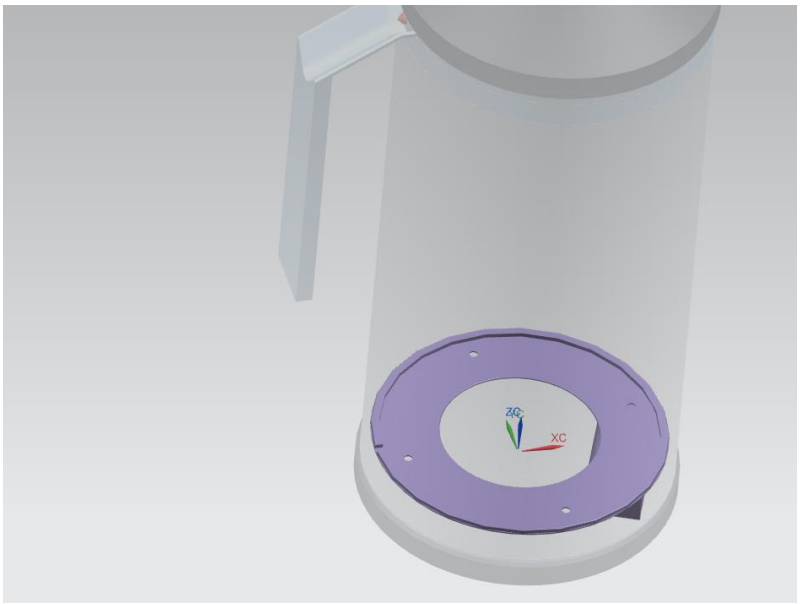
- Now the battery case is made into one piece with 4 compartments, so that the user can easily take the piece off the product and change batteries when needed.



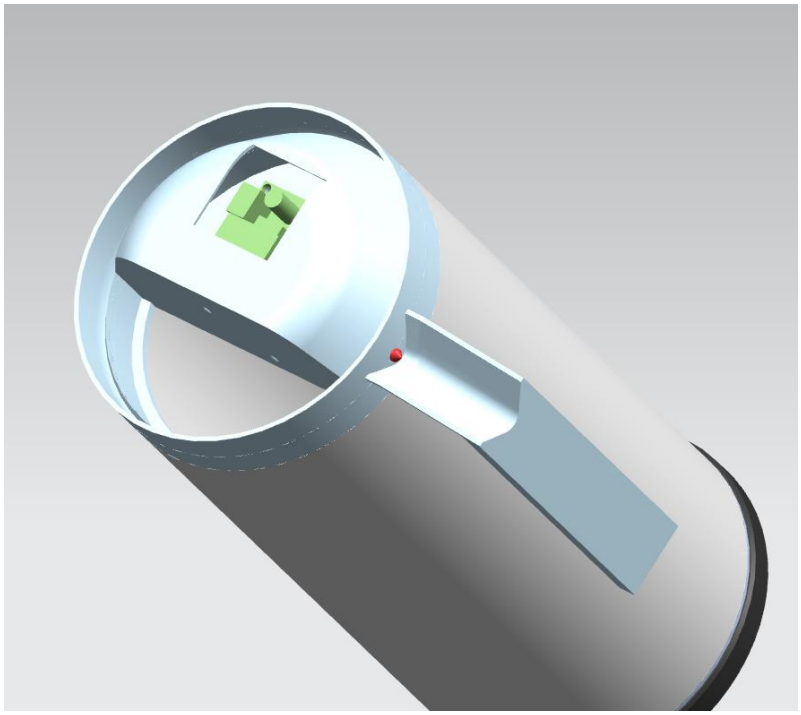
- Holes for wires are made, so that minor wires (which go between batteries) actually go on top of the battery case (under the funnel).

When the user takes the battery case out, the minor wires (between battery compartments) come out together with it, so we should make these minor wires short enough so that they will not look ugly.

- The connection between the minor wires and the main wire (which goes to the top) could be a detachable connector that works only when the battery case is put in its place. For that reason, a notch (lovi) is made in the proper place into the battery case board.



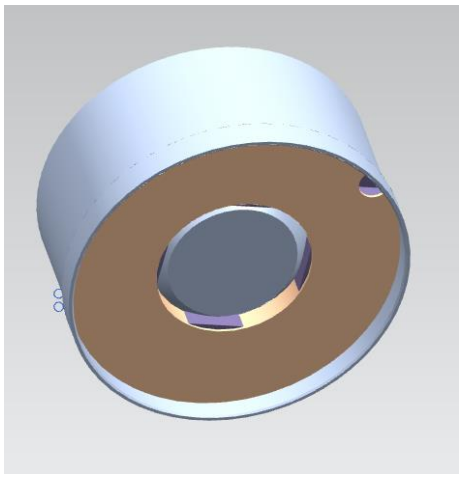
- Also, in the top board, the original battery chamber is deleted. But the hole as well as the original battery cover is kept. Now they are used for installation of relay and solenoid.



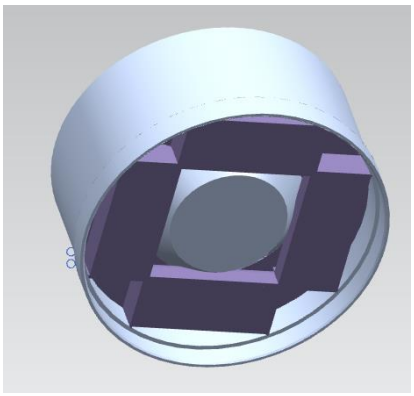
V3

10.10.2017

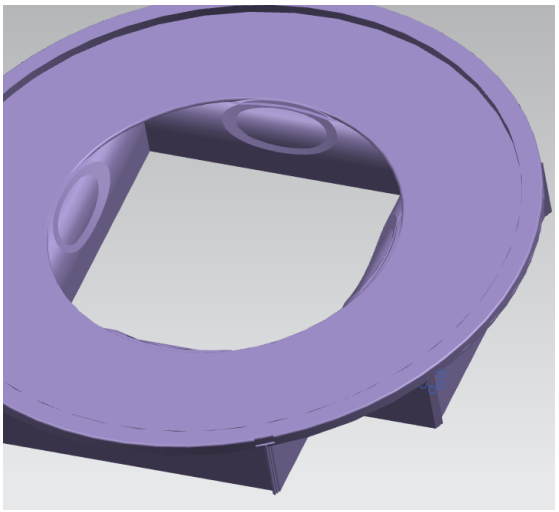
Since the main diameter of product is decreased, the battery case in the bottom now seems a bit different, as the batteries are put closer to the center.



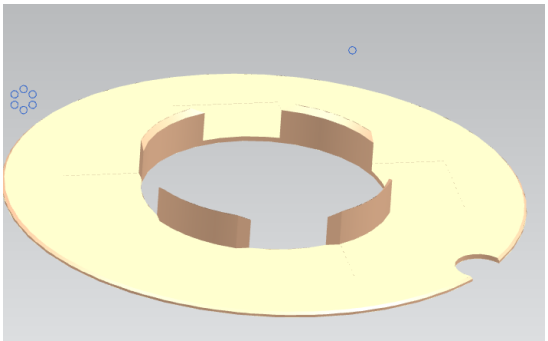
The batteries are put as close to the wall as possible.



Some oval shaped holes are made into the battery cases, to allow them closer to the funnel without affecting the batteries.



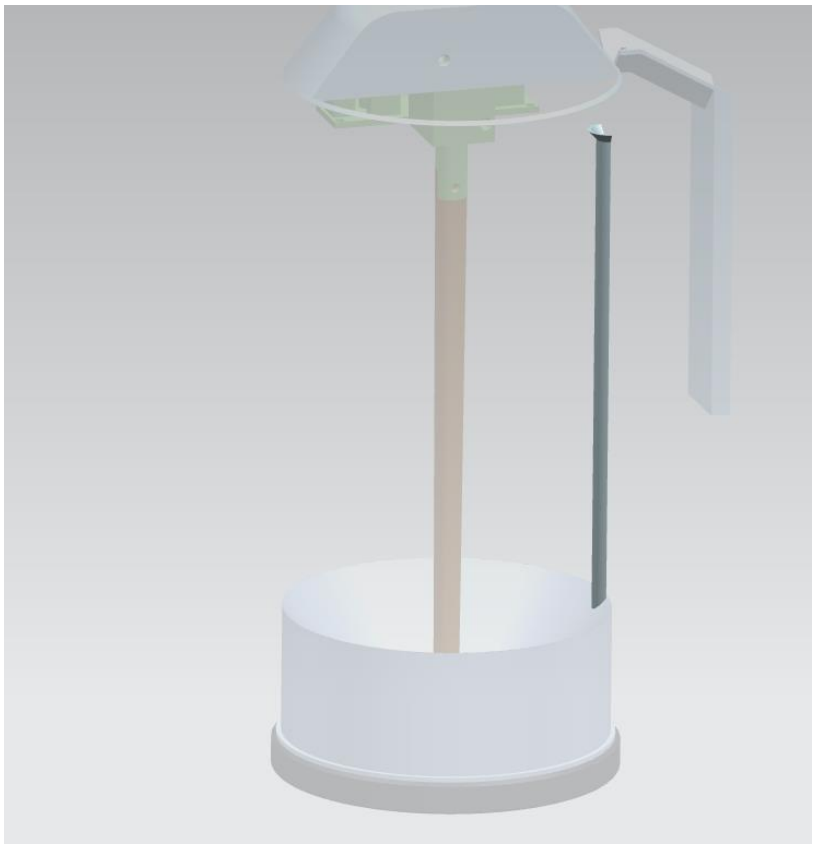
Also, holes are needed for the battery cover to allow the battery case to stick out a little. That hole on the edge of the board is for user to open the cover part.



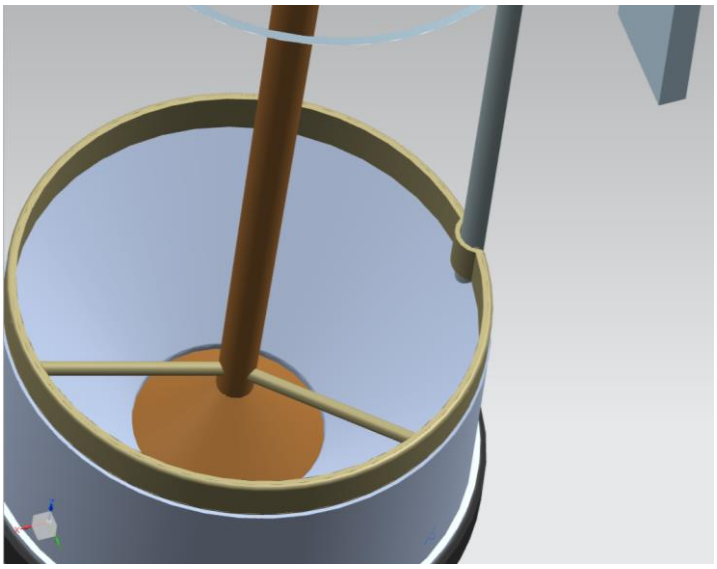
V4

11.10.2017

For the wiring from batteries on the bottom to components on the top, a pipe is designed. The pipe is put in the main body of the product and it is adhered to the body wall. On the bottom, it is seamlessly neighbored to the funnel part.



Accordingly a notch is added to the mixing wing.

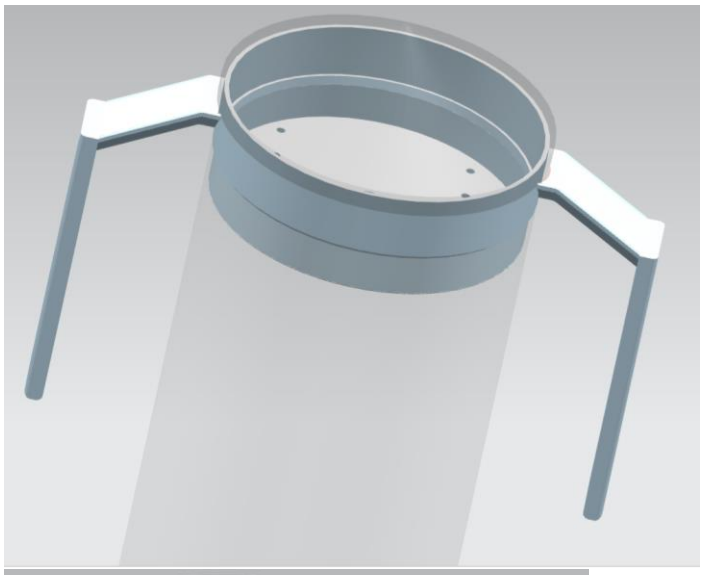


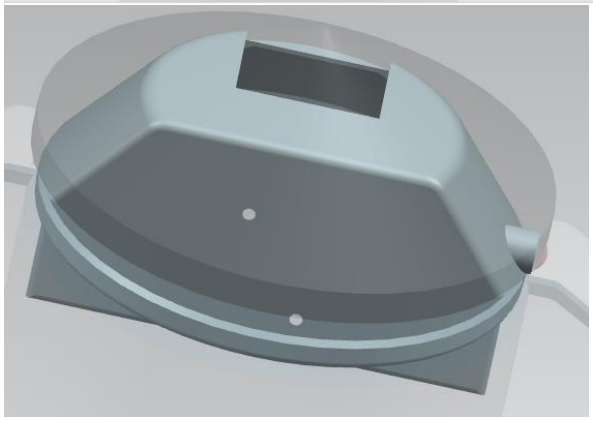
This pipe does not affect the outlook of the product, neither does it affect any main functions. However, it does make assembly a bit more difficult.

Draft 9

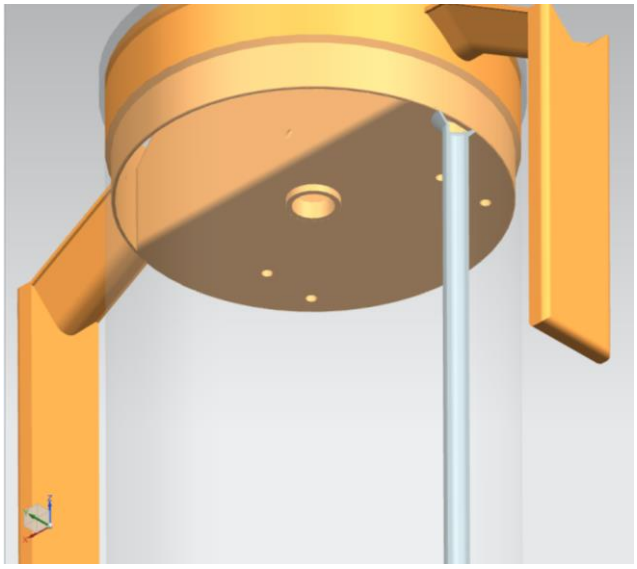
7.12.2017

- After the print out and assembly of the prototype, I find it is very difficult to put the components and wires into and through the top board. According to DFMA, the original top board is split into two parts, a board with the handle (which is called handle now) and a shell (which is called topboard now). In this way, the components and wires can be installed ready before the shell is put.

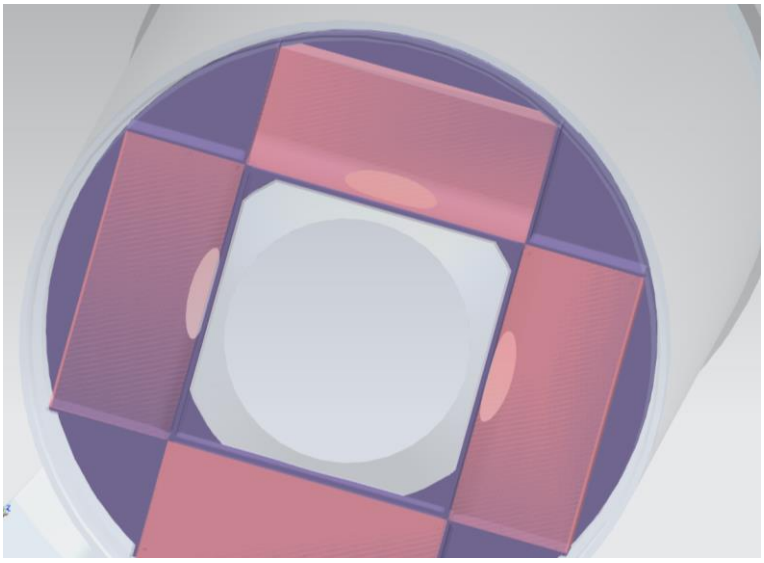




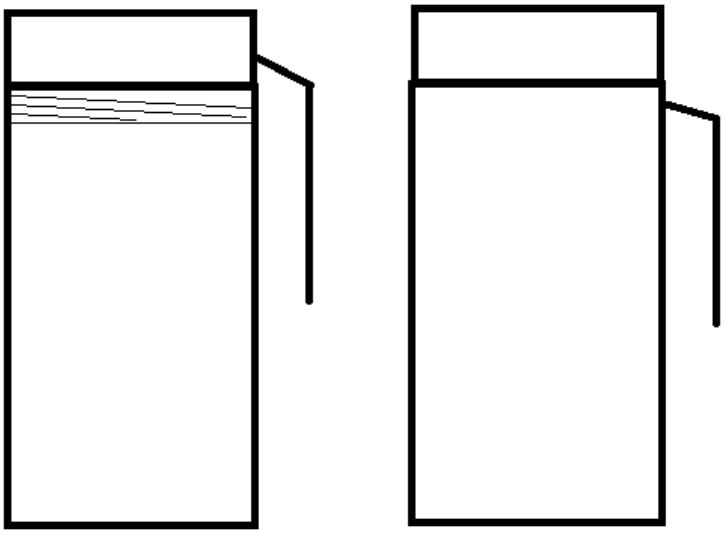
- Depending on the interface type between top board and wiring tube (whether the top board and handle need to be detachable from the body), the design needs to be changed accordingly (so that it could hold the node).



- The thickness of the battery case is revised, because in the previous design it was too thin. However it could not be made into too thick either, due to the limited space.



- There is a question: Considering the weight of the product+ coffee, thread is needed into the top part of the body. Could we have thread into the sheet material? Or do we just weld the body and top board together (that will make the top board unable to detach)? Or is it better to make the handle with the body (that will hold the weight better)?



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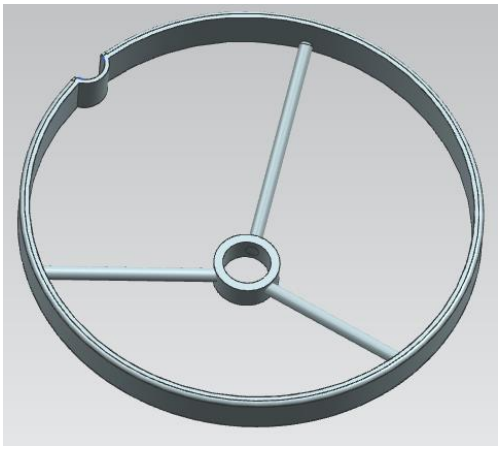
Design 10

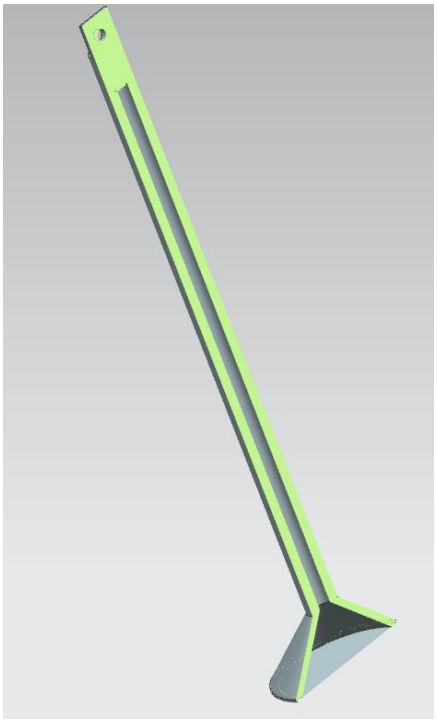
Liu Xueyun 13.2.2018

According to discussion with Ari, the following revises have been made to the product:

1. Mixing wing will no longer have the mixing function (besides when coffee powder passes the leaning bars, there will be some forces), so the diameter of the outer ring is enlarged, so that it would be glued to the wall of the body part. A small ring is added, so that it will guide the movements of the shaft.



2. A hole+tube is added to the shaft to hold the vibration motor and its wires. The bottom end of the shaft is open so that the installation of the vibration could be managed. The tube for wire extends till a few mm below the connection of solenoid, where then should be a hole to let the wire out of the shaft and into the top part of the dispenser.



3. A better solution for longer life batteries is to be found.
4. The body is made into 3,5 mm taller so that a proper stroke is achieved and 500g of content could be held.
5. The new mixing wing and shaft are being printed. While since I could not buy the battery or 12V vibration motor, the product will be tested on the power supply 12 V, 1,5 A from Technobothnia and the current 3V vibration.

Drafts of assembly and all parts of the coffee powder dispenser

(Appendices removed for patent reasons)