POLITECNICO DI MILANO

School Of Design

Master of Science in Design and Engineering

Redesign a Food Processor Through Usability Optimization

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Abstract

In this thesis, the optimization design of a food processor has been performed. Users prefer to find another solution to process the raw material but not using the food processor machine because of difficulties of using this type of machines. The fundamental question that arises is which are the problems of the existing food processors? To answer this question, the performance of the product has been divided into two phases, which are application phase, and pack away phase. The problems of each phase and the existing proposed solutions to deal with these problems have been discussed.

Studies show that there have been some efforts to optimize the performance of these food processors, in either the application phase or the pack away one. However, none of the proposed solutions include all the defects of this type of products and the user prefer to use single function devices, rather than food processors.

In the next stage, study of the existing food processors; lead to define the level of quality for food processor machine, to redesign it, taking into account the significant factors in the design, such as the working environment of the device, the necessary motor power, and the security system. Considering these factors the preliminary design of the new device is defined.

At the end an innovative design of the food processor has been created, in which a system-space definition, coincident with the common kitchen furniture standards for the accessories of the pack away phase has been considered, to optimize the pack away phase of the performance of the product. Also, with defining a new design for the security system, and the assembling and disassembling of device the manipulation phase of the product has been optimized.

Acknowledgment

I would like to express my deepest gratitude to my supervisor Prof. Francesco Trabucco, who not only helped me thorough different phases of this project, but also taught me the true designer's way of thinking, and Special thanks to Sara Bergamaschi, who as a friend were always willing to help and give her best suggestions. I would like to thank Hisham Kulhanek, for his excellent guidance, during this thesis work.

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Chapter.1

Introduction

After industrial revolution by women employment[i] and also by industrial development, new kitchen tools were produced in order to save housework time.
The first samples of these tools emerged in 1960s and gradually developed and evolved. By technology development and increasing consumption, production of these tools increased and on the other hand, due to urbanism, buildings dimensions became limited and kitchens filled with many useless tools.

Food processors are an ingenious appliance to have in the kitchen. Its main purpose is making meal preparation much easier and faster for the cook or chef. The food processor is equipped with several settings to knead, shred, grind, chop, slice, mix, blend, shave and pulverize numerous types of foods[ii].

1.1. Food processor history

One of the first electric food processors was Starmix, introduced by German company Electrostar in 1946.Although the basic unit resembled a simple blender, numerous accessories were available, including exotic attachments for slicing bread, milk centrifuges and ice cream bowls[iii] (Figure 1-1).

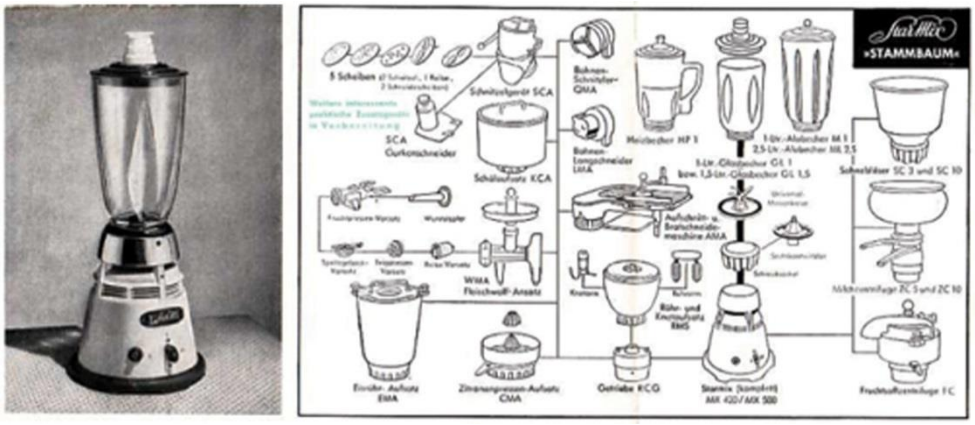

Figure 0-1: Starmix

The food processor was invented by a French catering company salesman in 1960. Pierre Verdon named his invention the Robot-Coupe. By 1971 this machine was renamed to Le Magi-Max. In 1973 Pierre Verdon met an American

inventor; Carl Sonthemier who refined the construction, design and perspective of Pierre's original food processor. The improvements were astonishing and they agreed to create a new name for this appliance that would prepare food in a fraction of the time that manual preparation would take. This new food processor debuted in 1973 and was finally named the Cuisinart[iv] (Figure 1-2).

Figure 0-2: Examiner

1.2. Aesthetic-performance features in food processors

In the design world, one of the applications of products is their aesthetic application. This kind of products is designed well according to aesthetic criterion but maybe they are not practically useful. Nowadays, the practicality is the main reason that food processor is one of the usual device in every kitchen (Figure 1-3).

Figure 0-3: Beauty-usability

However, there are several problems in optimizing of pack away, preparation and instruction steps of food processor that lead users not to use it. Because, by prolonging of preparation steps and complicated instruction, users prefer to solve their problems in any other ways.

1.3. Food processor usage difficulties

After purchasing the product, the product life begins. Some products are providing their services all along their life; some others are in service periodically. For these products the active service time is much less than the inactive time. Food processor machine is categorized in this group of products, and most of it's life time is the duration of its inactive service time **(**Figure 1-4**).**

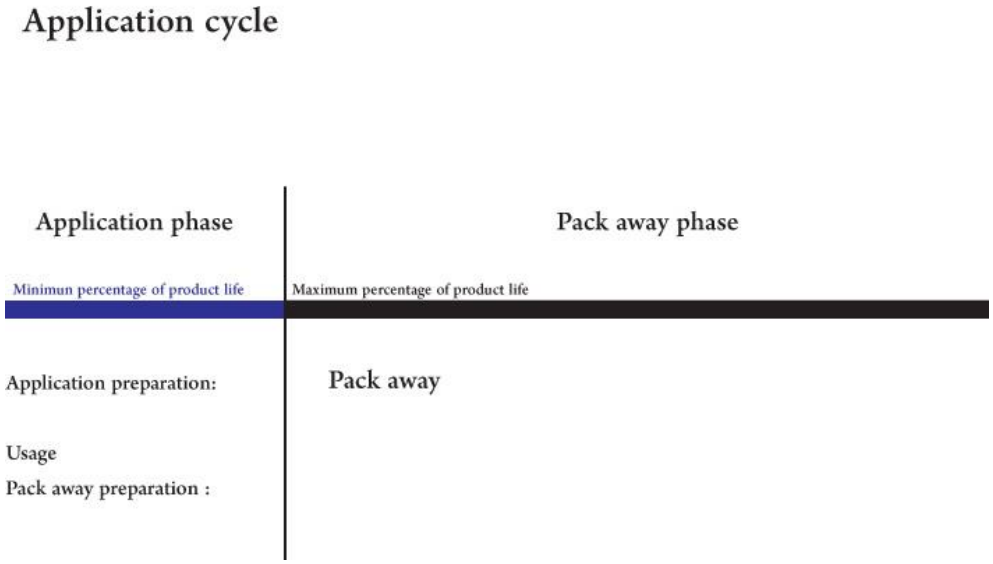

Figure 0-4: Application cycle

1.3.1. Pack away

There are always difficulties in pack away with small kitchen appliance. Because of their multiplicity items, it is not possible to sit them fixed on the table, and they must be moved into a cabinet or another place expect table in the kitchen. Food processors have more serious problem in this matter, because they have different attachments and the later are still remained disorganized.

1.3.1.1. Ways of pack away/usage

- **Sitting on the counter**

Some people use food processor as a daily tool. In this situation, it sat on the counter and it kept there too (Figure 1-5). It seems that the problem is solved but this layout will create some problems as follow:

" Kitchen electrics: blender, food processor, Food Saver etc. In my other Kitchen they sat on the counter unused, collecting dust and taking up valuable space most days of the week. This time around I could see that I could house the kitchen electrics on the back shelf of one of the new cabinets. This solved

the “collecting dust” issue somewhat and freed up a large amount of counter space. You might think this is less efficient because I have to go into a base cabinet to get the item I want to use first. The reality is: I never used the items in the place when they were on the counter. I'd end up moving these items to another section of counter first. Now for the majority of the time I am making far better use of my countertop. When I do need to use these items, it is not much different than it was before”[v].

Figure 0-5: Sitting on the counter

- **Keeping in the cabinet**

The food processor might be kept in cabinets. In this situation, it will be used whenever is needed but the attachments are still disordered and unorganized (Figure 1-6). However, they are organized somehow[vi].

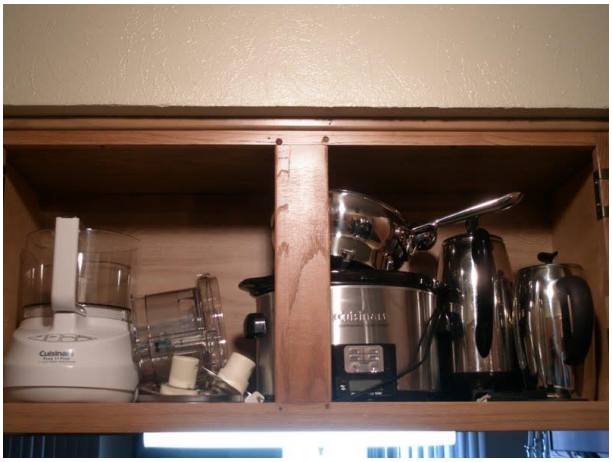

Figure 0-6: Unorganized food processor

This is an example of disorganized attachments (Figure 1-7).

Figure 0-7: User solution for unorganized food processor accessories

They are organized afterwards (Figure 1-8).

Figure 0-8: Organized food processor by user

- **Removable boards**

Another way for keeping the food processor is a removable board. As shown in the picture. With a defined move, it will go into the cabinet. However, the problem of organizing attachments is still there (Figure 1-9).

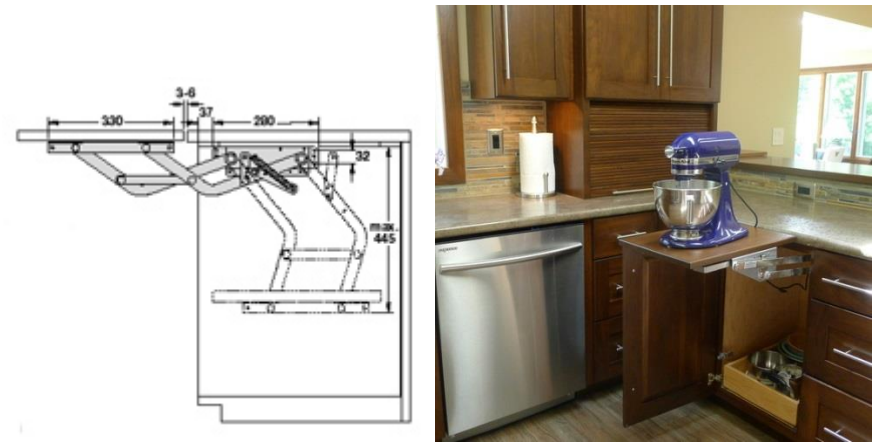

Figure 0-9: Removable boards

It can be seen obvious from the mentioned check outs, the preparation steps of food processor device includes bringing the device from predetermined place (usually we consider cabinets), and firing it up with required accessories.

1.3.1.2. Suggested solutions for organizing accessories

Suggested solutions can be used as a system to organize the accessories or the space to organize the machine.

- **Integrated attachment organizer system**

Some products have some facilities to allocate their attachments in a small space in their own. This decreased a little the difficulties of the problem (Figure 1-10).

Figure 0-10: Integrated attachment organizer

This solution is not complete because as you can see in Figure 1-11, the number of attachments is always exceeded than the allocated space. The food

processors at least have a work bowl with a blinder, a mini choppers, blades and disks.

- **Attachment organizer system**

Another solution is boxes which are merely designed for organizing attachments of the food processors. Such as the following pictures (Figure 1-11)

Figure 0-11: Attachment organizer

These boxes sometimes are offered with the product (Figure 1-12).

Figure 0-12: Attachment organizer

But according to the dimensions of these boxes and the number of attachments (included blender, work bowl, grinder, etc.) there is always problem with organizing product storage. For example, the previous picture (Figure 1-10) is about “Kenwood Multi Pro Excel FP980”; this product has 52 different functions, however, in the allocated box of attachments, there are only blades and disks. In the following picture, it is seen with its attachments (Figure 1-13).

Figure 0-13: Kenwood Multi Pro Excel FP980

- **Belt-in food processors into the cabinet**

Another kind of solution is to hide the technical parts of the machine into the cabinet as shown in the following design. This sample is a kind of a space-system sample to organize the accessories. In this design, there is an innovation in which the user’s energy is the motive force of the machine (Figure 1-14).

Figure 0-14: Pedal powered food processor

Of course, the attachments are organized in its drawers (Figure 1-15).

Figure 0-15: Pedal powered food processor accessories organizer

In other samples the space to organize the equipment's is not considered .just like "Bosch MEK 7000" (Figure 1-16).

Figure 0-16: Bosch MEK 7000

1.3.2. Preparation difficulties

When the food processor is on, it is necessary to comply with safety (in general, when the machine is on, all moving parts are out of reach) in which every single part must be in the correct position in order to enable micro-switches and turn the machine on. In fact, some guides are designed between the main bowls - the body and the main bowl cover – and main bowl for the safety of the machine in order to put the main bowl and the bowl cover in the correct position and hence the machine will be turned on.

As you see in this picture, first step is to put the main bowl in the correct position carefully (this step needs accuracy, because guides of the bowl and the body must be locked in correctly in order to assemble the machine). Second step is also to lock the main bowl cover onto its exact position. At the third step, the main bowl cover must be rotated carefully as well, because the guides are located in an internal part and cannot be seen properly. The user therefore, according to the specific signs on the bowl and the main bowl cover must measure the proper rotation. At the last step, the work bowl with its cover on will be rotated. It also needs accuracy such the previous steps (Figure 1-17).

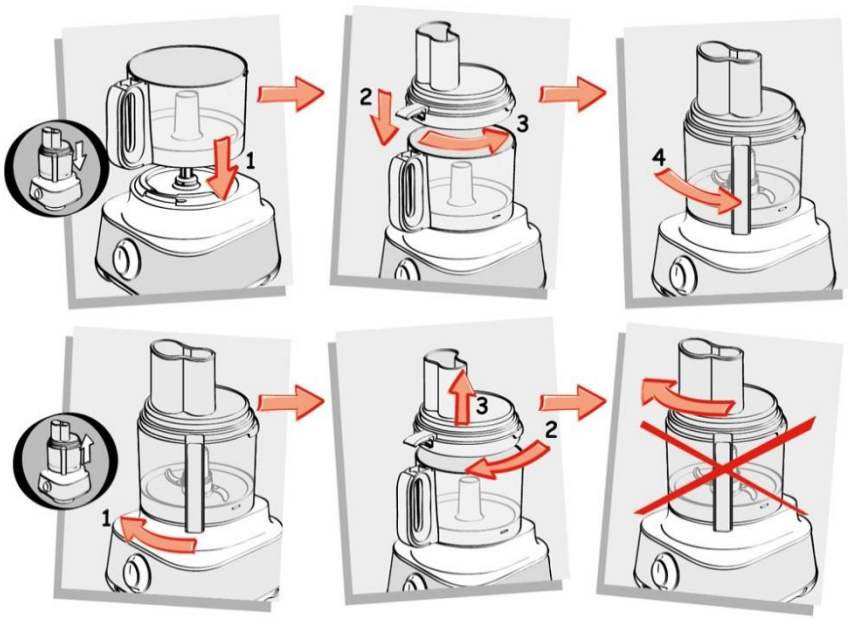

Figure 0-17: Moulinex MASTERCHEF 8000 manual

1.3.2.1. Recent solutions for opening and closing

In some new devices, these new solutions are considered and by closing and fastening modifications, there is no need to pay close attention to the closing process.

For example, in MOULINEX MASTERCHEF 3000, as you can see, the closing procedure is done in three steps, without close attention.

The first step is to position the main bowl properly (because there is no guide rail and no need for rotation, no close attention needed)

The second step is to put the main bowl cover in the correct position using a guide bar attached to it. This step requires close attention but it is easier than positioning the cover in the guides, such as MASTERCHEF 8000.

In the last step, the bowl cover will be pushed down to lock on (Figure 1-16).

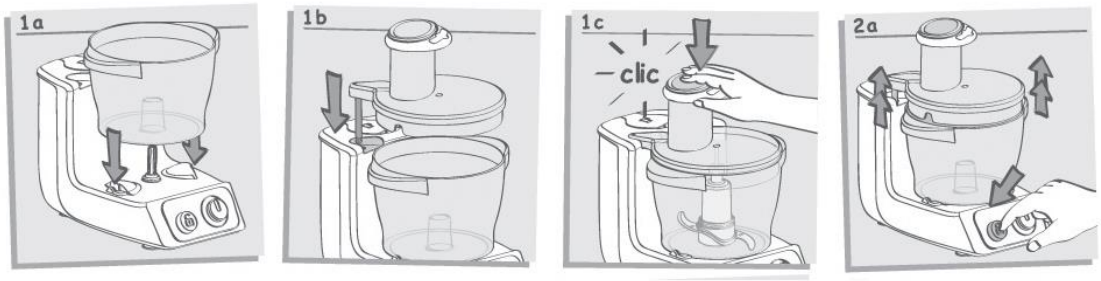

Figure 0-18: Moulinex MASTERCHEF 3000 manual

To open the cover, as you can see, there is only one step, pushing the button.

Chapter.2

Market Analysis

2.1. The single-function devices

As a home appliance, there are many products that do some functions of a food processor. These appliances are included chopper, Citrus Juicer, blender, mixer, mini chopper, meat grinder, coffee grinder, and slicer etc. From the consumer point of view, the main competitor of food processor is the single-function devices. The single-function devices have an engine with a proper speed and power for the mentioned activities. It is obvious that in order to do all those functions a food processor can do, a user needs several single-function devices. Furthermore, it is required to spend more money and occupy more space. Nevertheless, why the single-function devices are the competitor of the food processors?

Here, the preparation steps of both single-function device and a food processor compared with each other.

2.1.1. Advantages of a single-function device at the first step of preparation

The first step of preparation is moving the device from the cabinet and putting it on the table and the advantages of the single function devices are as follow:

A. It weighs less than a food processor

B. It has a smaller size

2.1.2. Advantages of a single-function device at the second step of preparation

Simpler preparation of attachments; As it mentioned before, preparation of food processors have several steps that require close attention, but those steps in a single-function device are less, simpler and without close attention

The following pictures are an ILLICO MOULINEX device in which the preparation steps are simple and short (Figure 2-1).

Figure 0-1: Moulinex Illico manual

2.1.3. Advantages of a single-function device at the usage phase:

The proper power and speed of single-function device; compared to the food processor in which required to be regulated. In some cases, such as Citrus Juicer in which the speed is too high or Mixer in which the speed is low and in Meat Grinder the engine power is low.

2.1.4. Advantages of a single-function device at the step of putting back:

The last step of preparation is moving the device from the cabinet and putting it on the table

A. It weighs lower than a food processor

B. It has a smaller size

2.1.5. Conclusion:

In summary, overall steps of preparation, usage and putting back in single-function devices are more practical than the food processors. Regarding this fact that some disadvantages of a food processor is inherent and unchangeable, however much the practicality of the food processors whether

in usage or preparation phase is optimized, the position of it in the market will be improved.

2.2. The food processor market analysis

There is a significant variety of this product from different aspects such as different power engine, dimensions, attachments, body quality and finishing in the market. In fact, it can be fall into 4 or 5 categories from the low quality to the professional one. Here, the food processors are categorized from various points of view.

The food processor can be categorized in several ways;

2.2.1. By capacity and the engine power

By measuring the liquid quantity which can be poured in, the capacity is categorized as follows[vii]:

- **Up to 3 cups**:

is practical for low amount of materials and the effectiveness of attachments are limited. Like “Cuisinart Mini-Prep Plus”(Figure 2-2).

Figure 0-2: Cuisinart Mini-Prep Plus

- **Between 4 and 12 cups:**

With normal dimensions and it is suitable for families with 3 to 6 members. Its capacity is between 1.5 to 2 liters. And its power engine is between 500 and 700 watts, Like “Tefal Vitacompact” (Figure 2-3).

Figure 0-3:Tefal Vitacompact

- **Between 18 and 20 cups:**

This is mainly suitable for large amount of ingredient quantities. The capacity is 3 liters. And its power engine is between 800 and 1200 watts. Like ”Moulinex masterchef 8000” (Figure 2-4).

Figure 0-4: Moulinex masterchef 8000

- **More than 30 cups:**

With 6 liters of capacity is suitable for professional usages. Moreover, they are huge and expensive. The power engine is usually more than 1000 watts. Like “Cooking Chef Kenwood KM086” (Figure 2-5).

Figure 0-5: Cooking Chef Kenwood KM086

2.2.2. By pinning shaft:

- **By speed of spinning shaft :**

The speed of spinning shaft is different based on usage and type of blade. For example, the speed of a juicer (with centrifuge system) is 18000 Rpm, a blender is 12000 Rpm, the attached grinder disc is 800 Rpm and a slow speed juicer is 80Rpm.

The food processor based on several attachments requires being able to work with slow and fast speed simultaneously. As an index, the speed of the blender is the fastest and the grinder discs are the slowest. Therefore, the food processor has a power transmission system that makes it possible to decrease speed/ increase power with the coefficient of 10. In fact, from one side, the shaft of the engine is directly connected to tools and produce the fastest speed (according to engine speed) and on the other side, it is connected to the power transmission system with the coefficient of 10 causes to decrease speed/ increase power.

The power transmission system in older devices has usually 2 shafts, one of them has a small wheel and the other one has a big wheel with the ratio of 1:10 which are connected together with a belt (Figure 2-6).

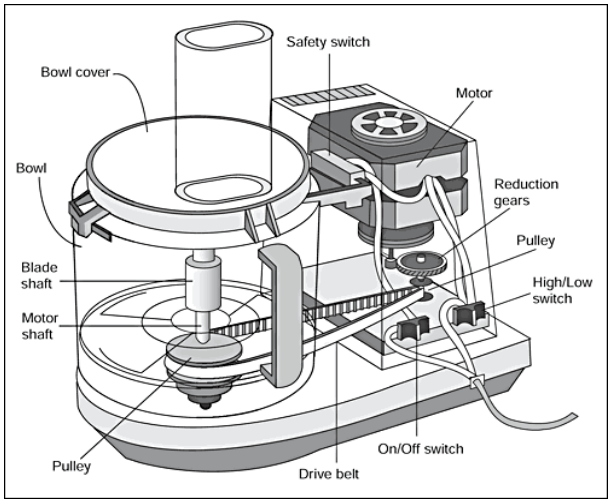

Figure 0-6: Belt transmission system

In newer devices, “Direct drive system” is used in which there are two spinning shafts which are spinning in different speeds (Figure 2-7).

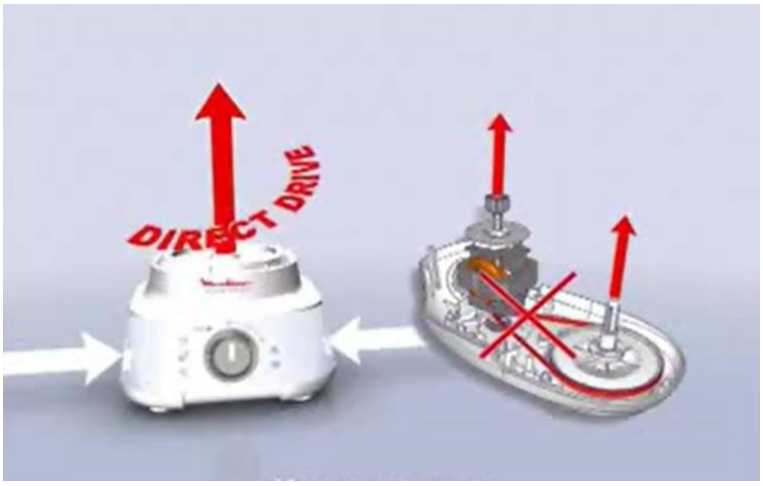

Figure 0-7: Direct drive transmission system

The food processor has a speed regulator switch in order to change power and speed.

- **By quantity of the spinning shaft**

The food processor has at least two spinning shafts, otherwise, in case of existence of only one shaft, and without using the speed reducer system, the performance of the device would be limited.

But professional devices sometimes have 4 spinning shafts with different speed/power. According to the required speed and power, tools will be put in the proper position.

- **By direction of the spinning shaft**

The spinning shaft may have three different types: from the bottom, from the top and front (Figure 2-8).

from the front from the top from the bottom

Figure 0-8: Direction of the spinning shaft

Those tools which are connected to the bottom shaft, can work close to the bottom of the bowl (different kinds of blades) or close to the bowl cover (such as slicing disks)(Figure 2-9).

Figure 0-9: Different attachment position on bottom shaft

There are two or three models that are installed on the front shaft, such as meat grinder and spaghetti slicer, etc. these tools are not important in home food processors and professional food processors usually are equipped with a shaft in this direction (Figure 2-10).

Figure 0-10: Kenwood Cooking Chef Spaghetti Pasta Cutter Attachment

Those tools which are installed on the upper shaft have some applications like mixer. But in new models of shaft, there are some tools that power up through the lower shaft, but if the spinning shaft is rotated 90 or 180 degrees it can be used as a mixer or meat grinder (Figure 2-11).

Meat grinder
90 degree rotation

mixer
180 degree rotation

Figure 0-11: Particular accessories

In several models of food processors, the device has 3 shafts itself, but by rotating the body, these shafts will be positioned in different directions and find new applications.

2.3. Food processor machine layouts

Variety in number of rotating axis and also varieties in direction of torsion leads to creating different approaches and numerous layouts which will be discussed.

2.3.1. Simple two axis layouts

Most of the food processors with moderate price are using this layout. In this layout , as it is mentioned one side of the motor axis is connected to a blender, which needs to rotate in high speed, and the other side is connected to the low speed high power tools through a belt. The main advantage of this method is the low price power transmission topology, like “Moulinex masterchef 3000” (Figure 2-12).

Figure 0-12: Simple two axis layouts

In this lay out there are two axes which have different speeds from the bottoms and the rotation of the shaft is provided by the attachments when it's necessary.

2.3.2. Direct drive Layout:

In this layout the two rotating axis are situated in same place, this is a new method, and the machines which are using this topology have smaller body than the previous layouts, like "Kenwood FP925 Multipro" (Figure 2-13).

Figure 0-13: Direct drive layouts

Like previous lay-out, in this lay out also there are two axes which have different speeds from the bottoms and the rotation of the shaft is provided by the attachments when it's necessary.

2.3.3. Dough machine layout

In this layout which is invented by the Kenwood, it's possible to use the axis from the top, bottom and the front of the machine, which is shown in the figure 2-14. The machine has 3 axes from three different directions, this topology provide the possibility to use three different spinning shafts with three different speeds. Usually mid-professional machines and professional machines are using this topology. It should be mentions that all the machines that are using this topology are not necessarily using two different spinning shafts with different speed.

Figure 0-14: Dough machine layout

The advantage of this method is to prepare the dough easily; the drawback of this topology is that these machines are so huge.

2.3.4. Rotational body layout

This layout which is used in moderate/low moderate quality products provides the possibility of using axis from the top and bottom. These kinds of machines till now use only one axis and they do not have speed reducers, as a result they are not commonly used (Figure 2-15 - Smoothie).

Figure 0-15: Rotational body layout

The main draw back of this topology is not to have speed reducers and limitation on main bowl capacity

2.3.5. Glass bowl layout

In this layout, the motor and its belonging components are installed on the lid, and the main bowl is fabricated by glass. The advantage of this design is that by applying the glass material the bowl could be directly exposed to heat and it is possible to use it to serve food (Figure 2-16).

Figure16-0 : Glass bowl layout

2.3.6. MUM Bosch layout

This layout which is the newest layout in which the motor is rotating around an axis and this rotation provides the possibility to work in different angles. This layout is exclusively for “Bosch MUM“ and it provides the possibility of using different axis with different speeds (Figure 2-17).

Figure 0-17: MUM Bosch layout

2.4. The investigation of accessories in the food processor

The accessories in the food processor can be categorized as follows:

2.4.1. Bowles:

Which are directly assembled on the base appliance consists of those with or without assembled blade. On the other hand, they can also be divided into different categories based on the diameter of the bowl. Considering two rotational shafts with two different speeds, the diameter of the bowl indicates and specifies the considered place on the processor (Figure 2-18).

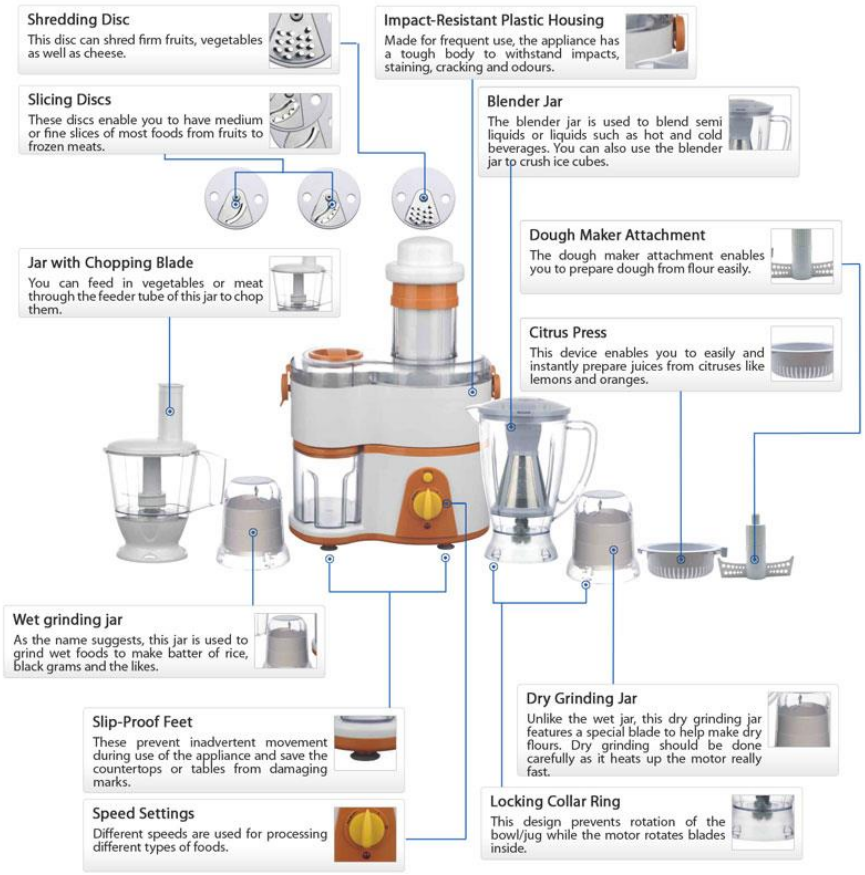

Figure 0-18: Accessories chart

- **Blender:** regularly consists of an approximately 1.2 liters bowl with fixed blade which may be dismantled and washed separately in the single-purpose appliances. It has a low diameter and works at high speed.
- **Mini Chopper:** is a bowl with the capacity of approximately 1 to 2 measuring cups and fixed blade. It has a low diameter and performs at high speed.
- **Large Bowl and its lid:** does not have fix blade and blades and discs should be individually proportioned to the dimensions of the bowl and work in it independently. It has a significant diameter and is assembled on the low speed/high power shaft.

2.4.2. Blades& Disks:

Regarding to their applications, are fabricated from metal with plastic stand or fully plastic devices. They are assembled on the large bowl frequently. However, they may be assembled on the low speed/high power, if the appliance has two separated shafts. For example, despite of implementing the plastic blade for dough preparation at low speed, metal blade at high speed is required for chopping any kind of vegetables instead. The speed controller may fulfill this deficiency.

Disk**s are** plates which perform at intermediate speed and locate next to the lid at top or bottom of the large bowl.

2.4.3. Special Tools:

- **Mixer:** is assembled on the large bowl and requires variable speed. In the machines with shafts from bottom the load transmission axis is intentionally twisted of 180 degree around its main axis.
- **Meat Grinder:** does not have bowl and implements with the low speed/high power shaft. In the machines with shafts from bottom the load transmission axis is intentionally twisted of 90 degree around its main axis. Other components could be assembled on it if required.
- **Citrus Juicer:** does not have bowl and is assembled on the low speed/high power shaft and performs at low speed.
- **Vegetable Dryer:** is assembled on the large bowl and performs at variable speed.

2.5. Quality via Marketing View

The available domestic appliances may be divided into following categories considering quality issues (Figure 2-19):

- **Cheap:**

This category of products includes following priorities respectively: 1-Price 2-Beauty.

- **Domestic:**

This category of products includes following priorities respectively: 1-Price 2-Durability 3-Beauty.

- **Semi-Professional:**

This category of products includes following priorities respectively: 1-Durability 2-Beauty 3-Price.

- **Professional:**

This category of products includes following priority: 1-Durability.

- **Luxury:**

This category of products includes following priorities respectively: 1-Beauty 2-Durability.

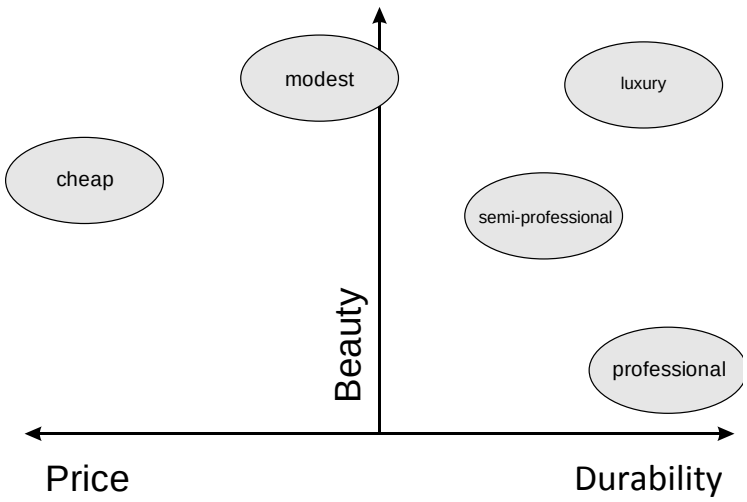

Figure 0-19: Durability - price

2.6. Marketing-Price-Quality and Built-in Appliances

Further analysis on market and comparing prices of products reveals that none of the built-in appliances is included on the cheap category.

The wholesale built-in products include built-in oven and built-in stove are categorized into modest, semi-professional, professional and luxury considering the price.

Those products with short supply include built-in coffee maker and built-in microwave, is categorized into semi-professional and luxury considering the price.

However, there are some built-in products which exclusively categorized into luxury products such as coffee dishes heating drawer and steamed oven (Figure 2-20).

Figure 0-20: Miele appliance

We can rank this product as semi-professional machine (Figure 2-21& 2-22).

Figure 0-21: Price target

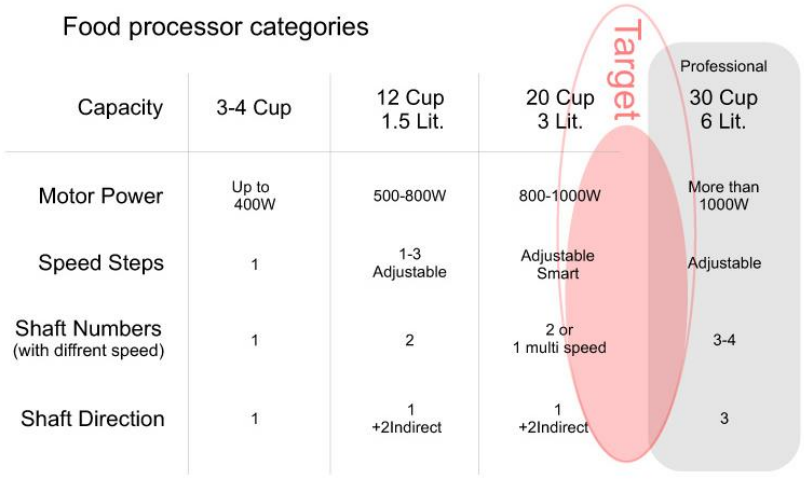

Figure 0-22: Category target

Chapter.3

Brief & Important factors in design

The investigation aims to optimize the design procedure of food processors rather than the available and existing optimized one considering the following issues due to previous experiences:

A- Optimizing the location of accessories in pack away phase.

B- Making the preparation phase of the appliance shorter and easier to use.

The satisfactory result is expected to occur when better usability of the appliance, leads to users' daily use, by constraining the preparation period and simplifying the complication of commissioning procedures.

3.1. Optimizing the location of accessories in pack away phase

The kitchen area is technically divided into 5 zones considering the usability: consumable material store zone, non-consumable material store zone, washing zone, preparation zone and cooking zone [viii](Figure 3-1). As their names indicate, each zone has a specific performance. The user usually performs preparation activities in relevant zone. If the appliance is portable, the user usually moves it into preparation zone. Determining pack away place of the product on preparation zone of the kitchen area lead to optimize preparation procedures.

Figure 0-1: kitchen zones

This zone of the kitchen frequently includes cupboards. As mentioned before, some issues may be arisen when the appliance keeps on the cupboard permanently.

Keep the appliance above of the cupboard also lead to some ergonomic issues.

This is considered to be the best place for the appliance to keep below the cupboard and inside the drawer.

Keeping the appliance inside the drawer has following advantages:

- It is in the appropriate range, from the ergonomic aspect.
- It will be as available as possible.
- The portable mechanism of the drawer can be physically liable.
- The space of the kitchen table will not be reduced while using the food processor.

3.2. Brief

Thus the Brief will be:

The built-in food processor applicable inside the cupboard

3.3. Design methodology

The food processor consists of accessories which used to divide into major and minor parts.

Major parts include motor unit, speed controller, safety system and main bowl which has significant role on the design procedure. Considering the design issue, available space should be first assessed for inserting the appliance into the cupboard and also for other design parameters like usability.

3.3.1. Cupboard

The cupboard may be supplied whether in fix module dimension or customizable dimension. The dimensions in customizable form depend on the demand of the installation place. Although each supplier offers its own products according to their certain standards criteria, boundaries are restricted to minimum width of 35 cm up to max 90 cm. Suppliers usually provide cupboards with usual width of 35, 60, 75 and 90 cm.

Despite of the width criteria, the height of the cupboard is highly variable. The total height of the cupboard can be estimated about 10 cm up to max 76 cm.

The cupboards have to meet the standard of 55 cm depth.

The nominal width of the cabinet box is 60cm but the shelves dimensions are calculated according to the thickness of wood sheets and the shelf side walls which do not follow a predetermined standard but usually the thickness of the drawer slides are between 16 to 20mm. The thickness of the drawer slide is different. Here we consider the “Watson& Dunn” products as a reference.

There are two types of drawer slides, in first group the drawer slide is connected to the side walls; thickness of the rail is about 13 mms. This type can resist on loads up to 45 kg (Figure3-2).

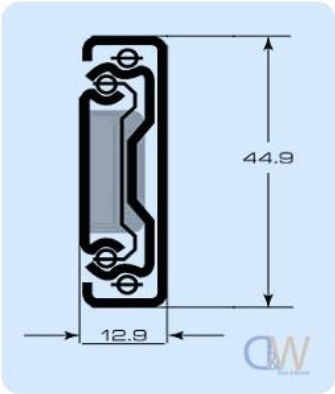

Figure 0-2: Thin standard drawer guide

In this case, by considering 18mms for the sidewalls, the calculated width of the drawer will become 600-18-18-12.9-12.9=538.2 mm.

Another type of the drawer rails are connected on the bottom side wall of the drawer. The main advantage of this type is that they can carry up to 100kg of load, as it's shown in the figure (Figure3-3).

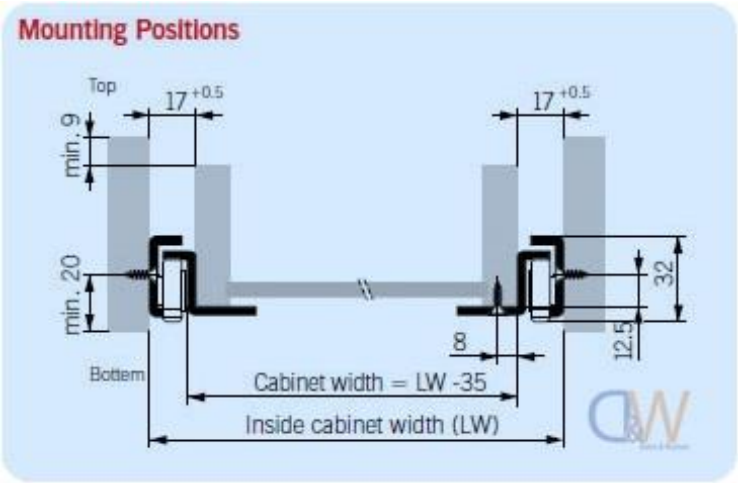

Figure 0-3: High loud standard drawer guide

As it's obvious the occupied space is 17 mm but the sidewalls are positioned on the rails , as a result by considering 18 mm for the thickness of the side walls the final evaluated width will become: 600 – 18-18-17-17=530 mm.

The rest of appliances like oven, dishwasher, etc. can be arranged inside the cupboards with 60 cm nominal width. Thus, the cupboard with 60 cm nominal width (55.5cm available width) and 60 cm nominal depth (56.8 cm available depth) is considered as a design benchmark (Figure3-4).

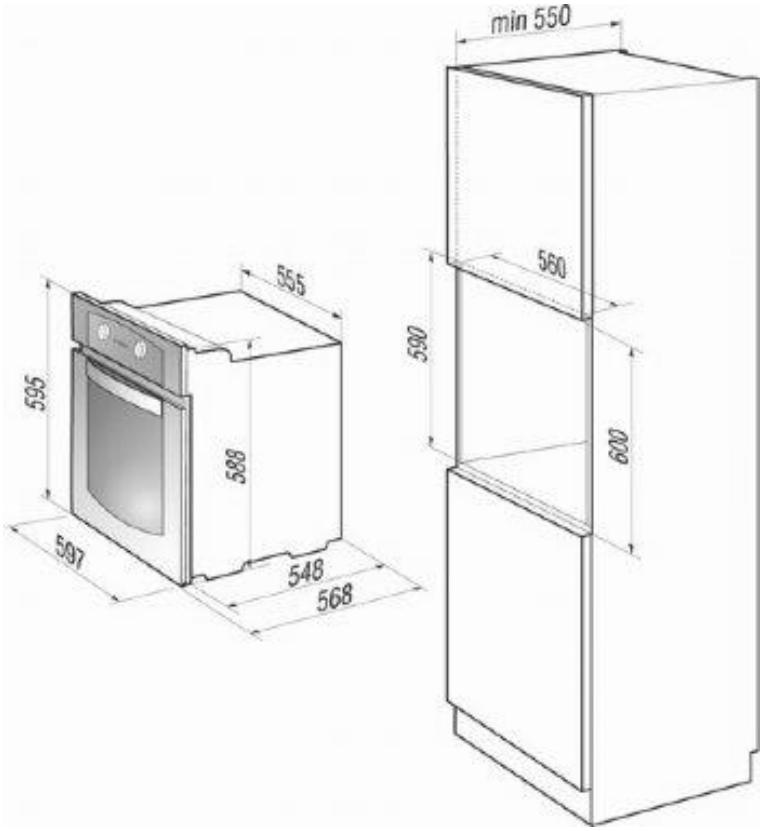

Figure 0-4: Built-in accessories dimension

There is other drawer slide that the side drawers' walls are sold with the drawer slides, such as "Blum" drawer slides.

3.3.2. Usability optimization:

Usability optimization may be one of the effective factors of determining large bowl dimensions. As stated before, there is a guide on the cover of the large bowl of "Moulinex masterchef *3000* food processor" which it helps usability efficiency. Based on this, two appliances with different levels of usability are compared to analyze the usability efficiency approaches as follow:

First, “Moulinex masterchef 8000” an appliance with lower usability level. Its commissioning procedures include 4 steps as shown in following figure. These steps are analyzed in following table (Figure 3-5).

Step	Description	Required Accuracy
1	Placing the bowl on the base	
1-1	Placing the bowl on the base	low
1-2	Engaging the lid on the bowl properly	high
2	Putting on the lid	
2-1	Putting on the lid in its position and engaging the lid on the bowl	high
2-2	Turning the lid until it is locked	high
3	Turning the lid until the processor is locked	intermediate

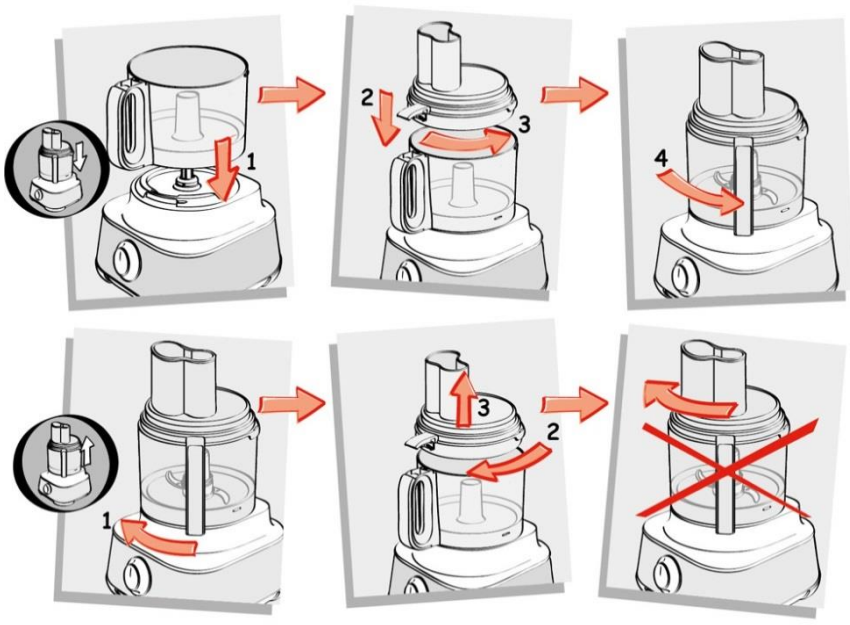

Figure 0-5: Moulinex MASTERCHEF 8000 manual

Secondly, “Moulinex masterchef 3000” is an appliance with higher usability level. The commissioning procedures of the large bowl include 2 steps as shown in following figure. These steps are analyzed in following table (Figure 3-6).

Step	Description	Required Accuracy
1	Placing the bowl on the base	low
2	Putting on the lid	
2-1	Putting on the lid then align the marking on the lid with the marking on the bowl	high
2-2	Pushing the lid until it is getting locked	low

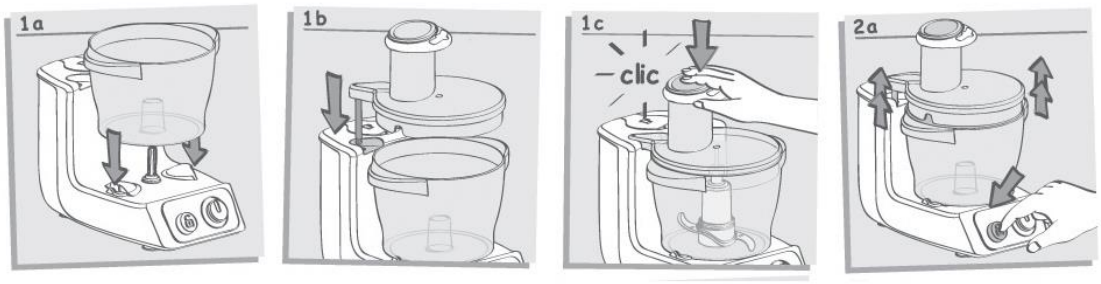

Figure 0-6: Moulinex MASTERCHEF 3000 manual

It is evidently found that reducing preparation steps and required accuracy reduction are led to increase usability efficiency.

The second idea is winner in comparison. The tall height of this idea is its unpleasant point and is considered to ultimate height of the model

3.3.3. Main bowl capacity

The quality of the proposed model is considered to compete against semi-professional products and its volume must be competed against modest food processor about 1.5 to 2 liters. Following has shown dimensions of food processor ″Moulinex masterchef 570″ with 1.5 liters capacity, the bowl has the diameter dimensions 170 by 80 height and external dimensions: 170 mm of diameter and height of 128mm and 100 mm height for the feeding pipe. Meaning that the bowl has 128mm height but only 80 mm of it has made up the internal space of the container and the rest are dedicated to the connection guide of bowl to the processor and lid to bowl.

The height of the lid will be at least 36 cm considering aforementioned dimensions and fully locking lid idea. To decrease the height of the cupboard and consequently optimize the arrangement of the space, the diameter of the large bowl should be increased with reducing its height while the total capacity remains constant. Further calculation will be determined other dimension as following: 200 mm large bowl diameter, 75 mm height and 2355 mm which is suitable for this machine

3.3.4. Motor unit

One of the significant factors which may determine the performance and position of the new products among other competitors is the power of its motor unit. The motor units which may apply in the conventional food processors and other kitchen appliances entitled as “universal” motors and have considerable various types. A motor unit with the power of 800 watts can be appropriate for a food processor with the volume of 1.5 liters. However, increasing the diameter of the large bowl will lead to select a blade of high diameter and consequently need a more powerful motor unit.

In order to estimate the power of the motor for our application, we can somehow assume that the operating condition of this design and “master chef-570” are more or less the same, with the only significant difference between their lengths of blades. If we only consider that the torque load which is

applied to the blades is due to the contact force between the blades and the ingredients, with some simplifying assumptions it is possible to demonstrate that the torque load applied to the motor is quadratic proportional to the length of blades.

When the length of blade increases, both the arm of the force applied to the blade and the value of contact force itself increase, as a matter of fact that the amount of ingredients in contact with the blade at higher diameter perimeters increase.

$T(\text{Torque}) \propto r(\text{arm}) * F(\text{force})$

$F(\text{force}) \propto r(\text{arm})$

$T(\text{torque}) \propto r^2$

So, in our application when we try to increase the length of blades (i.e. radius) from 80 to 92, we would have 1.15 times increase, and according to the mentioned relation we can say that we would have approximately $(1.15)^2=1.32$ times increase in the torque load, and consequently the power of the motor.

As a result, a 1000 watts motor unit should be employed instead of 800 watts to supply required energy for rotating the bigger blade and to satisfy the market considering the quality ranking of the product.

3.3.5. Speed reducer/power expander system

More investigations and measurements on ”Moulinex masterchef 570” clearly identify its internal mechanisms. Following figure (Figure3-7) illustrates two load transmission shaft of the appliance as follows: one has high speed and is directly connected to other accessories like blender at one side and is connected through a linked pulley to a bigger one at the other side. The bigger pulley rotates the shaft and large bowl consequently. As a result, the ratio of

the smaller pulley to the larger one can be determined the reduction amplitude of this speed reduction system.

In this machine the larger pulley has 160 gears and the smaller one has 16 gears so the reduction coefficient becomes 1/10. (It's the ratio between number of gears 16/160 = 0.1)

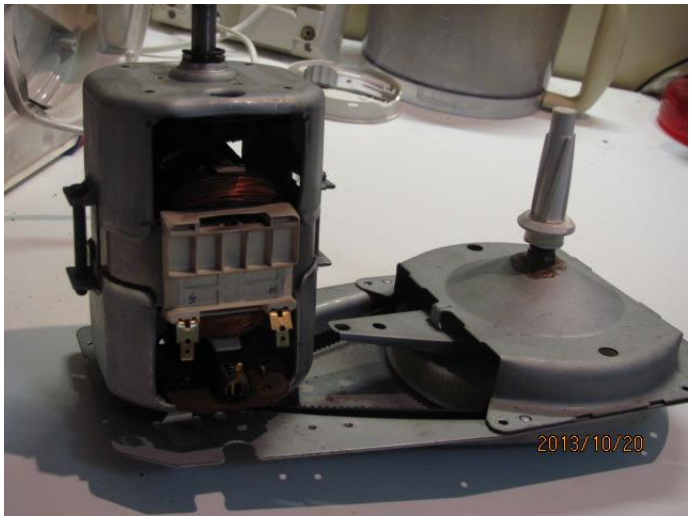

Figure 0-7: Moulinex MASTERCHEF 570 Speed reducer/power expander system

3.3.5.1. Speed reducing and load transmission proposed models

As stated before and can also be seen in "Moulinex masterchef 570", two load transmission shafts are exist in two parts. In this appliance a clutch system lead to interrupt load transmission to the lower shaft (the location of the large bowl) when the lid of the higher part is opened (in order to apply the blender).

The safety system will be activate when the large bowl is assembled likewise assemblage of the other accessories.

But new models like "Moulinex masterchef 8000" or "KENWOOD multi pro excel fp980"have two rotating shaft with different speed in same place. This system has two rotating joints of different diameters at the connection point of other accessories to the appliance (figure 3-8) it could not be possible to dismantle and analyze the components of the appliance with such system

unfortunately, however considering to its performance, it will be logically concluded that the end joint of intermediate shaft connected to motor unit directly and performs at high speed. The end joint of external shaft surrounded the end joint of the intermediate shaft and rotates around it at lower speed. The end joint of the external shaft is connected to speed reducer then.

Figure 0-8: KENWOOD multi pro excel fp980

The most compacted speed reducer for this application entitled as “planetary gearbox” (figure 3-9).

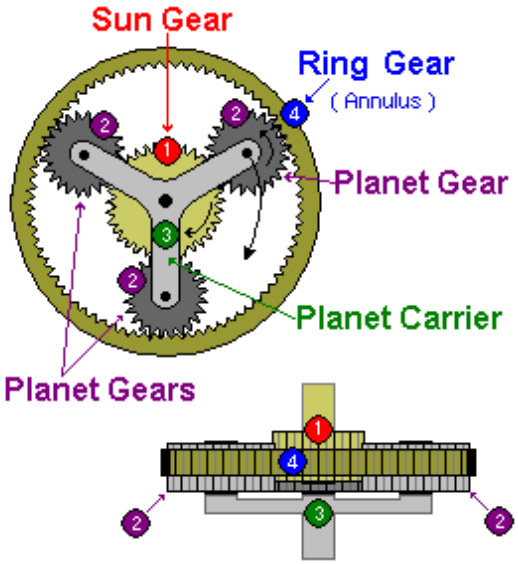

Figure 0-9: Planetary gearbox

The intermediate shaft rotates corresponding to the speed of the motor unit if this system applies in the food processor. However, the probability of applying this system to achieve the ratio of 0.1 may require large external gear. The higher is the diameter of the gear, the higher is the dimension of the gearbox. Consequently the more simple speed reduction systems will be applied i.e. “spur” gears (figure 3-10).

Figure 0-10: Spur gears

This system has simple detail and usually applies in the domestic appliances which require gearbox.

3.3.6. Safety system standards

According to IEC 61032, rotating devices should be out of direct reach (except plain rotary gears). The safety system in the food processor is responsible for avoiding and interrupting the appliance electrically when rotating equipment or blades are available and easy to touch.

3.3.7. Safety system

Safety system consists of one or more electrical sensors (which connected to the appliance controller) and interconnected mechanical devices between the sensor and the controlled location if required.

For instance Masterchef 570Moulinex has a micro switch. The main bowl has important rule in safety system , if it won't situated in a predetermined position and the main bowl cover is placed on it , the top extra part on bowl cover will execute the micro switch as an operator (figure 3-11).

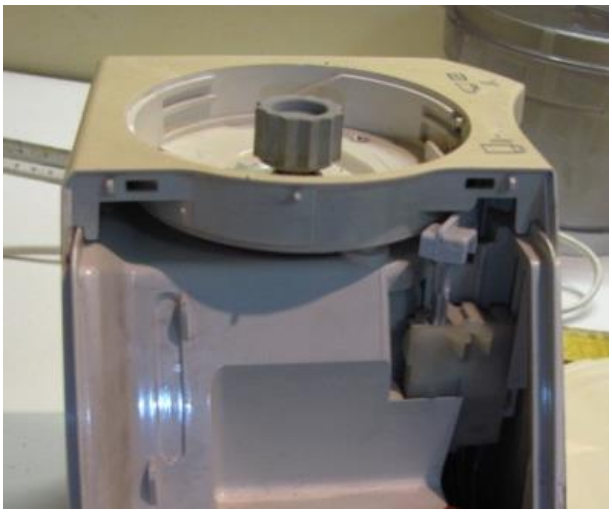

Figure 0-11: Moulinex MASTERCHEF 570 safety system

In this machine the blender jar is positioned in another place, the blender is also has a little part on its own body to carry on safety system. Thus except the microswitch there are other parts which are the components of safety system.

In this machine, cause both axes are connected to the motor, in case of connecting the blender the machine should become active and rotates the main axis of the machine. But there is a mechanism in this machine which acts as a clutch system, placing the blender on its own position leads to movement

of a leverage which unlock the main pot shaft and as a result the in case of connecting the blender the main pot shafts doesn't rotate (figure 3-12).

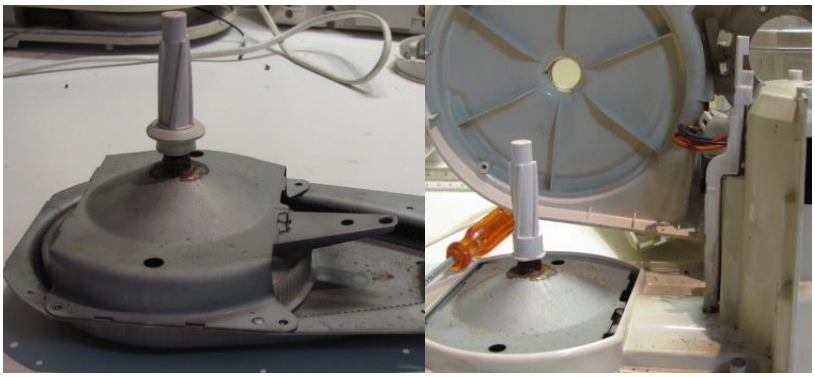

Figure 0-12: Moulinex MASTERCHEF 570 clutch system

Sensors have many different types. The hulk effect magnetic sensor or optical sensors provide facility to control small home appliance. The domestic appliances usually employ Microswitches. They switch the lever of the electrical circuit on or off.

Micro switches have two main draw backs:

Firstly, microswitches are one of the significant factor of failures in appliances most of the time and the more the number of the microswitches, the more the probabilities of failure in the appliance.

Secondly, each microswitch separately requires stand and supports to assemble, the lever of transmitter from the appliance to sensor, etc. which eventually lead to raise complexity of the appliance production procedures.

3.3.7.1. Microswitches

Microswitches have many different types including low voltage microswitches, high cost of failure applications microswitches, sealed switches microswitches, etc. but basic microswitches are the best for food processor considering their performance. Basic microswitches can be used with or without lever. The levers are available with or without roller (Figure3-13).

Figure 0-13: Microswitches (without roller – with roller)

The applied load to lever and corresponding displacement are significant parameters to apply microswitch (regardless of voltage). Microswitches have been offered with 15 up to 400 gr activation load. The displacement of the lever is also constrained to 4 mm. from dimensions it's clear that microswitches are very tiny sensitive devices which are liable to fail. Thus, microswitches apply in controlled amplitude of activated lever to move not greater than predetermined quantity somehow. One of the conventional solutions is to apply following illustrated mechanism (Figure3-14).

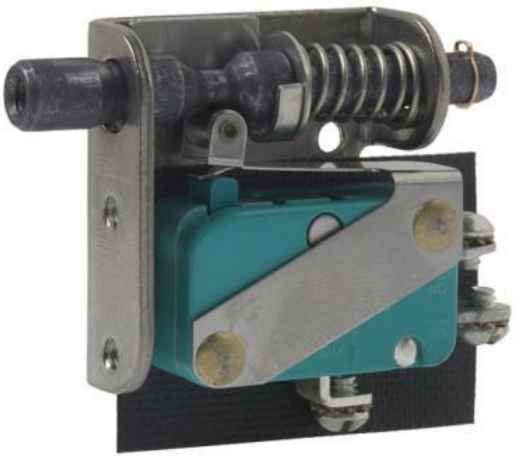

Figure 0-14: Microswitche support

As stated before, one of the main design parameters of safety system mechanism is the amplitude of the lever of the microswitch. The main part is related to control two points i.e. the place of small bowl or the lid of the large bowl.

Chapter.4

Design

4.1. Motor location layouts and accessories location

According to reviews about the dimensions of drawer, the final top dimensions of the machine will become 540*550 mm. In this step we'll calculate the location of the motor and accessories.

Motor can be located in front or back side or in middle side of the machine.

We consider back side for the location of motor, because while the drawer is open and machine is working meanwhile, machine weight and drawer weight and the applied load caused by the operator are situated on the rails. That's why by reducing the distance between centroid of the force and the hinged point, we'll have less resultant moment.

Also the motor is located beside the drawer case, this position leads to more space optimization (Figure4-1).

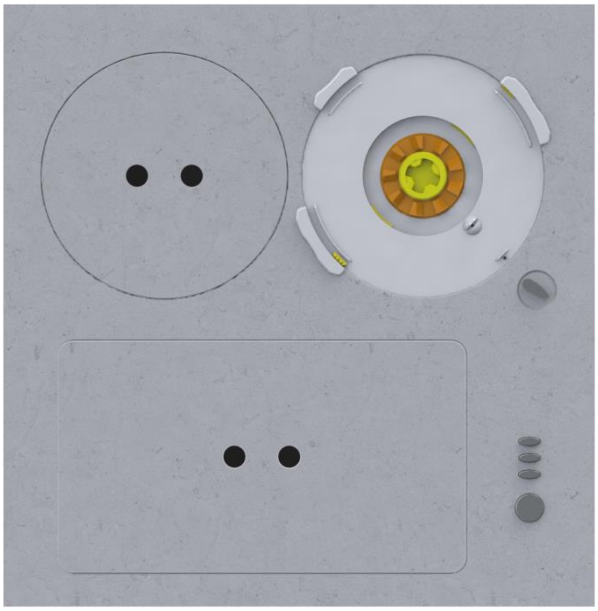

Figure 0-1: Motor location layouts and accessories location

4.2. Main bowl and the bowl cover

There are two ideas regarding design of main bowl and the related cover and the method of mounting the cover on main bowl. Both ideas are willing to remove the side guide to make the topology simpler while using the machine. These new ideas lead to invent new methods for opening and closing the main bowl cover.

4.2.1. First idea:

Flexible arms and pins are engaged and hold the lid and bowl. Flexible arms made of a flexible polymeric material which is injected on the lid. There are two pins around the body which arms can be connected to and activate safety system simultaneously (Figure4-2).

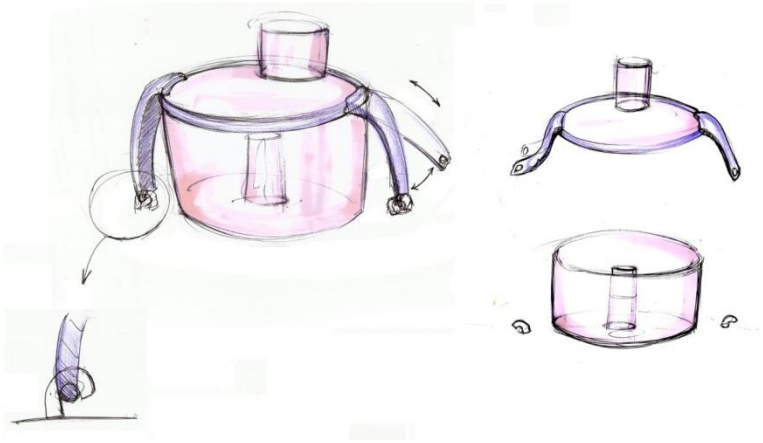

Figure 0-2: Main bowl and the bowl cover- Idea 1

4.2.2. Second idea:

Consists of the lid perfectly locks the bowl. The lower part of the lid on the main body can be fixed through two mobile hooks and activate the safety system (Figure4-3).

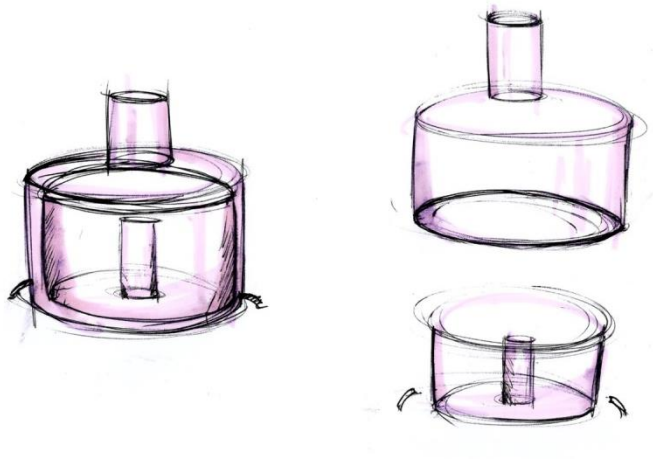

Figure 0-3: Main bowl and the bowl cover- Idea 2

	First idea	Second idea
Complication of locking the lid	7 from 10	1 from 10
Required accuracy for locking the lid	6 from 10	4 from 10

By comparing we understand that the 2nd plan is more appropriate. The draw back related to this method is the over height, Cause it's an important design factor it may lead to determine the final height of the drawer.

4.2.3. Main bowl development

In developing phase first we consider a hollow cylinder, d=200mm, h=70 mm then we consider another cylinder which is located in it as a cover. The external cylinder that acts as a cover is connected to the machine from the bottom ledges (Figure4-4).

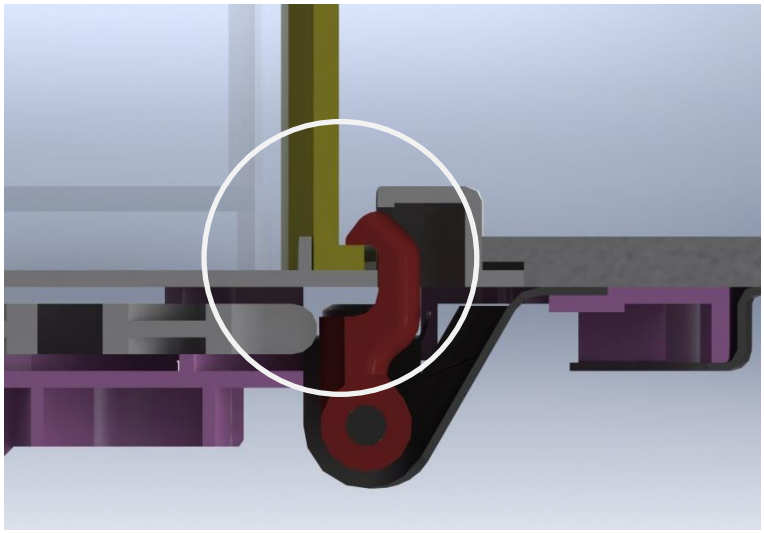

Figure 0-4: Clamping main bowl cover

But the entire cylinder has a featured part on its bottom surface, this part which is in cylindrical shape, helps to position the main pot on the shaft and also provide the possibility to connect to the machine (Figure4-5).

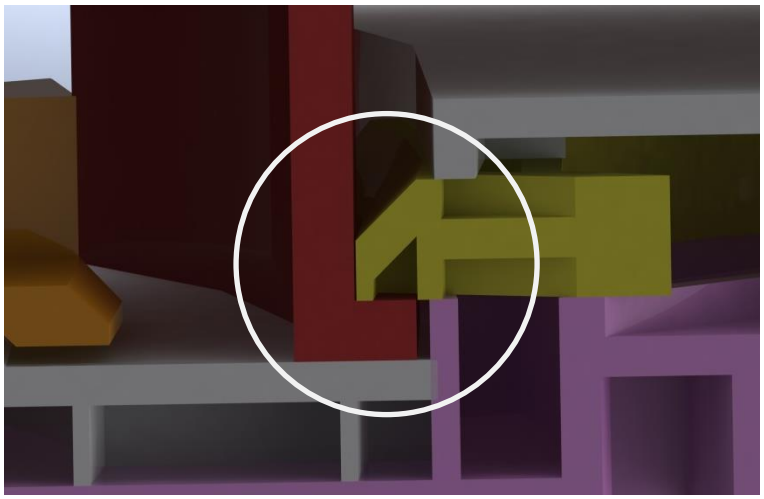

Figure 0-5: Clamping main bowl

The offered materials for these two parts are chosen by CES2011. The used parameters are in the following order.

In horizontal axis we choose young modulus/mass to figure out the lightest and the most toughness materials.in vertical axis we'll have hardness Parameter.

The hardness, *H*, of a material (units: MPa) is a quick, crude measure of its strength. It is measured by pressing a pointed pyramidal diamond or hardened steel ball into the surface of the material under a load F .It would make sense to define the hardness as the indenter force F divided by the area of the indent projected normal to F but because of a quirk of history it was divided instead by the total surface area of the indent, and this has stuck. It is approximately related to the quantity we have defined as σ_y ix. This parameter is important because in main bowl the materials are crashed to the sidewalls with high speeds that may lead to scratch the wall, and also in connecting edge all crashes may lead to erosion and abrasive wear (figure 4-6).

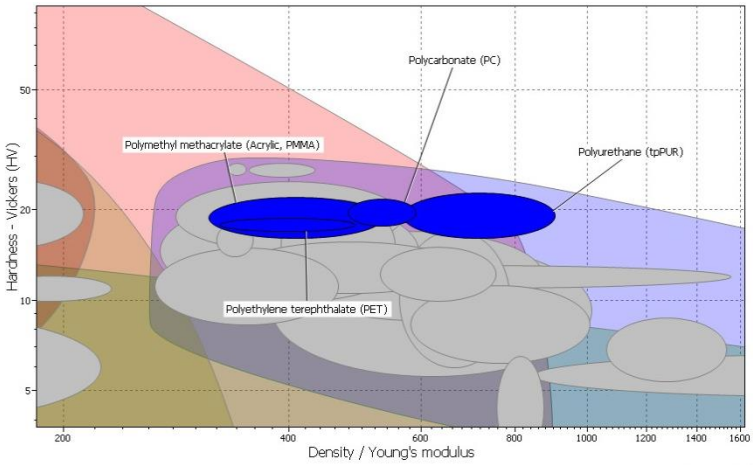

Figure 0-6: Hardness-Young's moduls/density

To have better choice we may consider about transparency, durability in case of expose to water, wine and natural oils.

Transparency: the choice of this parameter is due to the competitive market. All the existing products in the market are made by transparent or steel materials. The polycarbonate has also optic characteristic, however, its transparency feature is sufficient in this application.

Concerning the durability, the situations that this product might be exposed to would be solely water, wine, and natural oils.

After the filtering process the final four remained materials were:

PET, PC, Polyurethane, PMMA

This part would not be exposed directly to heat sources, by the way, it is expected that it would be used to contain hot water or cooked ingredients with high temperature about 100^0 (the boiling temperature of water).

Among them only polycarbonate have maximum service temperature over 100 centigrade. Thus the chosen material is polycarbonate.

Across the borders between the main bowl and the related cover we may use isolation materials to prevent the leakages, thus we can use overmoading process on the bowl cover to have a plastic gasket (Figure 4-7).

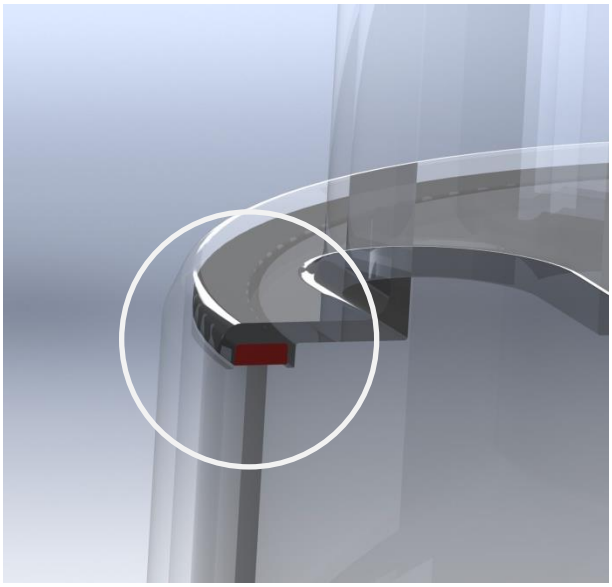

Figure 0-7: Main bowl and bowl cover sealing

Normal elastomers are usually categorized in thermoset groups and among them there are some which they have nutrition grades[x]. But thermoplastic rubbers are utilized to use in overloading process and we may find them in markets with different brands, here we have GLS company products as our reference.

This company is providing the process of over molding of thermoplastic elastomers (TPE).

In the catalogue we may find the possibility of implementation of plastic products with other type of plastic materials, among the mentioned materials VARSAFLEX material earns nutrition grade and has the capability to stick on PC without using mechanical joints. To produce parts for over molding process there exist many parameters in which most of them are important and should be considered and also other parameters which are important are those that are related to design of the parts.

- **TPE Part Design Basics**

• The wall thickness of the substrate and overmold should be as uniform as possible
To obtain the best molding cycle time Wall thicknesses ranging from1.5 mm to 3 mm will ensure good bonding in most overmolding applications.
• If the part requires the use of thick TPE sections, they should be cored out to minimize shrinkage problems, reduce the part weight and lower cycle time.
• Transitions between wall thicknesses should be gradual to reduce flow problems, such as back fills and gas traps.
• The use of radii (0.5 mm minimum) in sharp corners helps reduce localized stresses.
• Deep, unventable blind pockets or ribs should be avoided.
• Long draws should have a 3-5° draft per side to aid component ejection.
• The TPE thickness should be less than or equal to the thickness of the substrate to prevent
warpage; this is especially critical for long, flat geometries

Provide a 0.38mm – 0.76mmdeep groove on the substrate, along the edge of the TPE overmold[xi] (Figure 4-8).

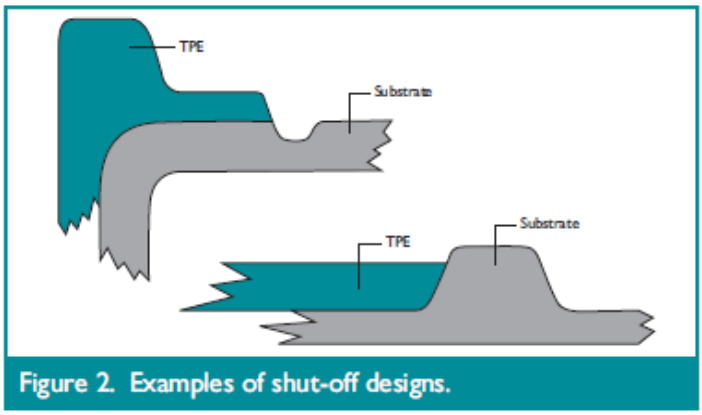

Figure 0-8: TPE shut-off design details

4.3. Hooks

Hooks are responsible for making bowls stable on the appliance. Hooks must be adapt considering two different size of bowls i.e. proportion to small bowls and the lid of the main bowl. The hooks of the small bowls are located on the hosing part of them but the hooks of the large bowl are supplementary pins on the surface of the appliance (Figure4-9).

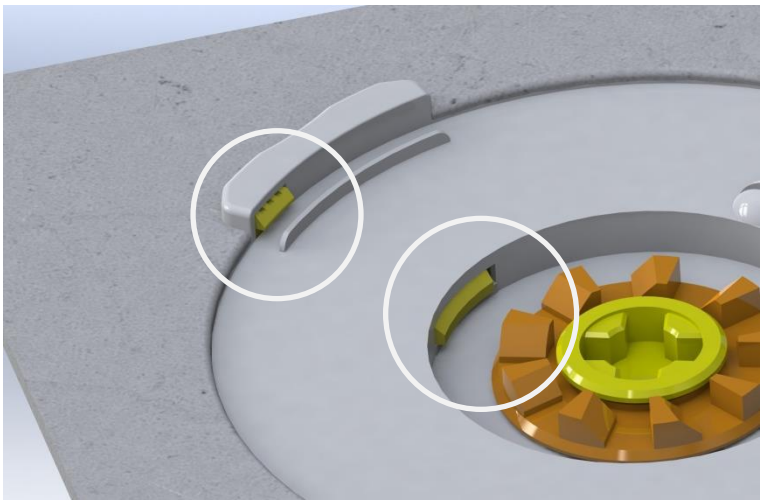

Figure 0-9: Hooks position

While opening the arms, external clamps are pushed back by the bumps ، Considering to the rotational axis of the arms and their different range of move, external hooks mechanism require auxiliary system and one-part arms could not be possible (Figure 4-10).

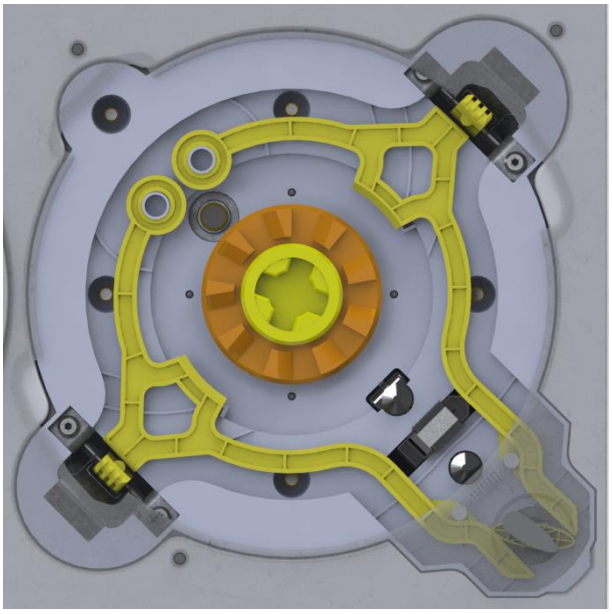

Figure 0-10: Hooks mechanism

The edge of this hooks act like one-way system and a little load due to assembling bowls push hooks backward and make bowls stable (Figure4-11).

However, to open up and release bowls, main arms should be move backward. Arms connected to safety system in other place and lead to move the pin of the hook in safety mechanism and interrupt the appliance due to return of the pin of the hook.

The arms are always closed by spring and open up when the bowls will be released. The arms of the hooks are released through the locking lever mechanism.

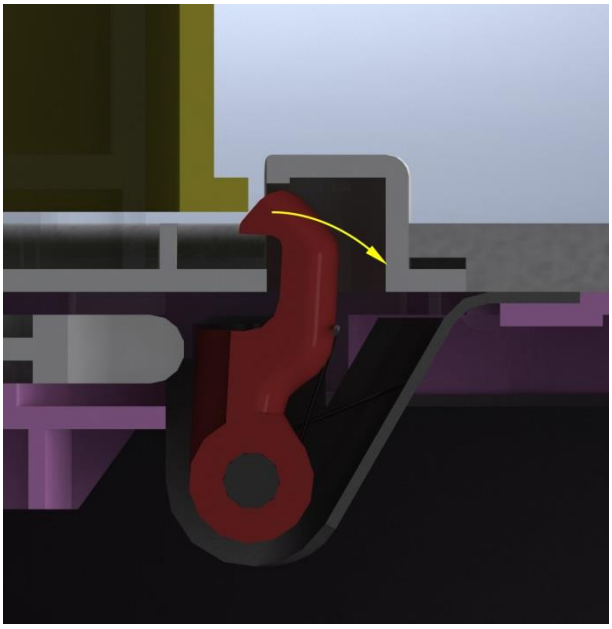

Figure 0-11: Clamping mechanism

This mechanism consist of a small lever out of the appliance and available for user and an internal mechanism. This mechanism constrains the rotation of the lever to 90 degree (Figure 4-12).

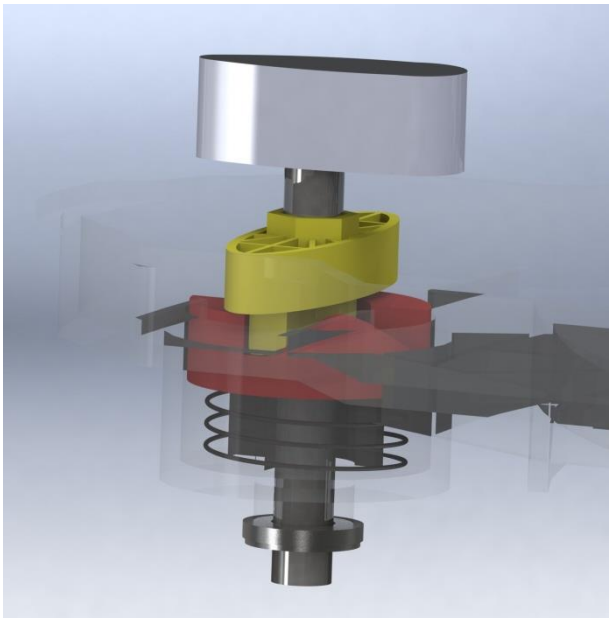

Figure 0-12: Hooks arms lever mechanism

The oval shaped part which connected to the lever axis touches the arms permanently. The oval shaped part touches levers at its longer side and when lever rotates 90 degree makes the arms release (Figure4-13).

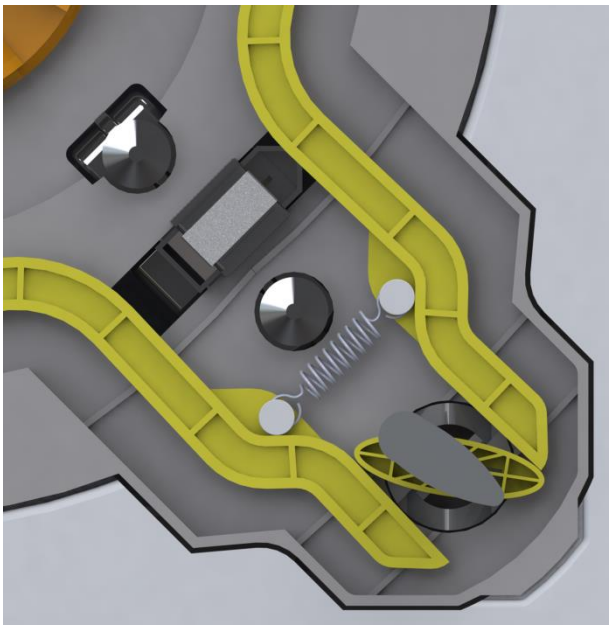

Figure 0-13: Hooks arms spring mechanism

4.4. Motor-Appliance Layout

To decrease the height of the appliance, the vertical assembly is chosen by rotating the unit of 90 degree around main axis and the width of the unit, governs the occupied height rather than its height consequently. Load transmission system requires two helical gears in this new configuration. The occupied height of the motor unit is about 10 cm in this configuration. This is an appropriate occupied height (Figure 4-14). But because of the height of the cupboard which is determined by the height of the large bowl assembly and those complicated issues which are involved in vertical configuration of motor unit, straight configuration is applied.

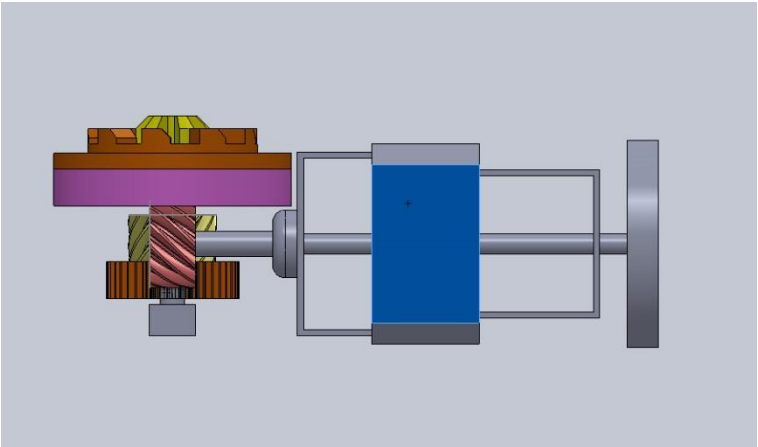

Figure 0-14: Perpendicular motor layout

In final idea this lay out motor shaft directly provide one of the rotating axis.

4.5. Power transmission:

To obtain the reduction factor of 0.1, the design procedure employs four gears. The reduction factor of each gear will be identified according to following formulas:

$$T_{transmissionratio} = \frac{\omega_{out}}{\omega_{in}} \overset{desire}{\rightarrow} \frac{1}{10}$$

$$V_1 = V_2 = V$$

$$r_1\omega_1 = r_2\omega_2$$

$$\frac{\omega_2}{\omega_1} = \frac{r_1}{r_2} \rightarrow \frac{N_1}{N_2} \qquad N = number\ of\ teeth$$

$$\frac{\omega_{out}}{\omega_3} = \frac{r_3}{r_{out}} = \frac{N_3}{N_{out}}$$

$$\omega_2 = \omega_3$$

$$\frac{\omega_2}{\omega_{in}} = \frac{r_{in}}{r_2} = \frac{N_{in}}{N_2}$$

$$\frac{\omega_{out}}{\omega_{in}} = \frac{\omega_{out}}{\omega_3} \rightarrow \frac{\omega_3 = \omega_2}{\omega_{in}} = (\frac{N_3}{N_{out}})(\frac{N_{in}}{N_2}) = (\frac{20}{76})(\frac{28}{69}) = 0.1067$$

As illustrated below, the four gears have following configuration: The gear which connects to the axis of the main gear has 28teeth. The gearbox has an auxiliary axle which two gears can assemble. The gear below the axle has 69teeth and the above has 20teeth. These two connected gears remains constant against each other. The fourth has 76teeth which is linked to the end joint of external shaft, is connected to main rotating axle through a ball bearing but rotates with lower speed and different spin direction (Figure 4-15).

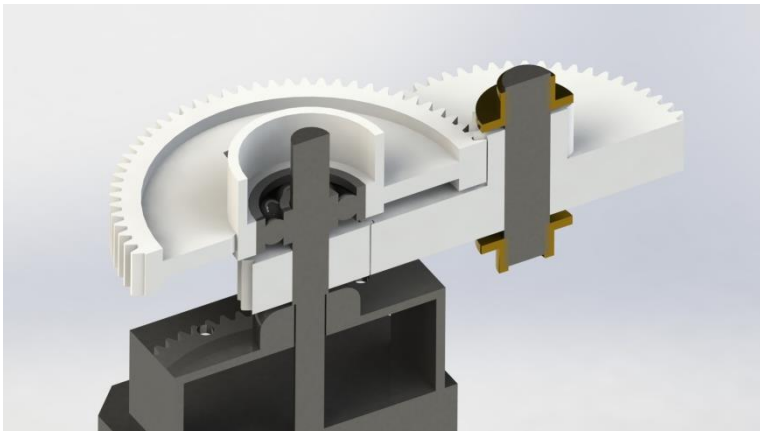

Figure 0-15: Power transmission composition

Where the 4th gear is connected to the Motor shaft, it's not possible to use botches and bearings must be used. It's because the maximum torque of the motor is 15000 rpm and the connected gear rotates at 1500 rpm and the total torque is much more than the resistance torque for botches and bearings must be used, the reliability of the considered bearing is 28000.

4.6. Gear box body

In this product gearbox body has an important structural role cause it's connected to the motor and all the applied forces on the shaft in applied to this body through the rotating motor (Figure 4-16).

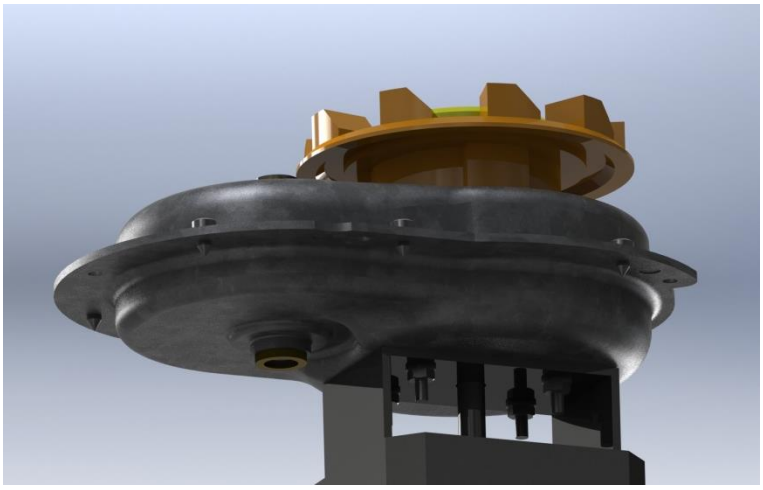

Figure 0-16: Gearbox body as a structural part

In first simulation of gearbox body we consider it as two part metallic body that each part is created using sheet metal bending method, but this topology has some draw backs. It is huge in matter of size and there is also the possibility of insufficient mechanical strengths where the bush is positioned and also it's not possible to use bumps to strengthening the body frame (Figure 4-17).

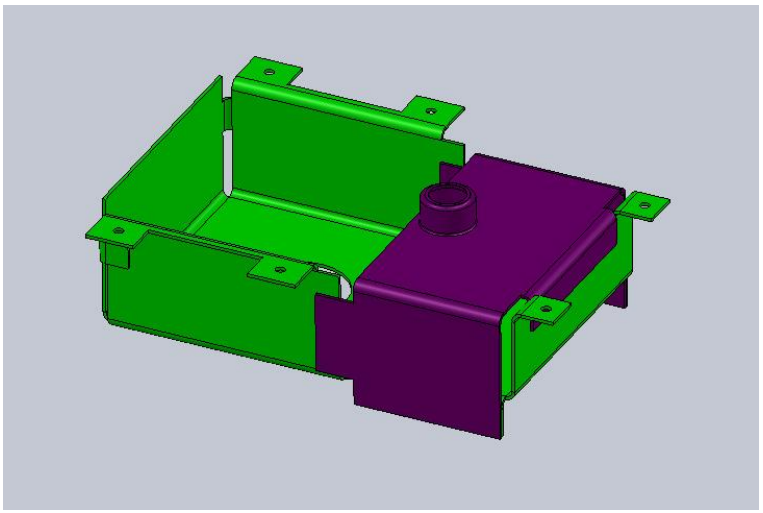

Figure 0-17: Gearbox body –initial idea

In optimization process we use two metallic half frames manufactured by cutting and form pressing method. These two parts are located in correct position with respect to each other and are connected by bolts (Figure 4-18).

Figure 0-18: Gearbox body

Gear box body that includes all elements of power transmission is connected to related supports through 5 plastic dampers.

Choosing the dampers is based on catalogue of FIBRT company, this dampers are in cylindrical shape d=8 mm, h=8 mm which got screwed from both sides. As it's mentioned in catalogue these dampers has stiffness range of 60-70 N/mm.

4.7. Motor support

As it is mentioned combination of motor and gearbox is installed on related support.

It’s necessary for this support to have sufficient mechanical strength to resist under the loads applied as weight of gearboxes and motor, and also the loads caused by vibration as a result of movements of the motor and other applied force on supports (Figure 4-19).

Figure 0-19: Motor support as a structural part

Thus we need to pay attention to select appropriate material for enough strength, for this reason selected parameters in CES 2011 software are estimated accordingly.

In horizontal axis the ratio of Young Modulus/Density is used to find the material with the highest stiffness and the vertical axis is used to fine the most suitable one in case of price and cost . In limit section ,in Eco-parameters sub section , Recycle parameter is choose and we set the Minimum of maximum service temperature to 95 centigrade (Figure 4-20).

Motor surface temperature in modern motors can be high enough to be very uncomfortable to the touch. Surface temperatures of 75° to 95° C can be found on T frame motor designs[xii].

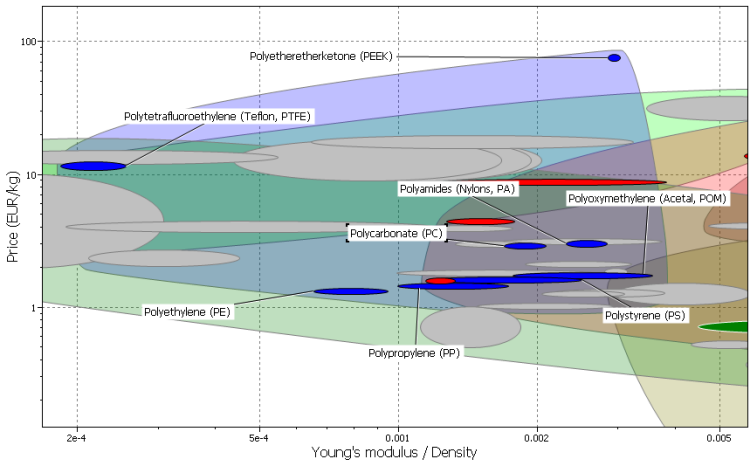

Figure 0-20: Price-Young's modulus/density

As it is shown we may choose seven materials.

From point of view of straight and maximum service temperature, the PEEK is the best material but it is so expensive.

The next alternative is POM by considering the strength of materials. But this material has high shrinkage coefficient. It's suitable in high performance application in which its natural lubricity is exploited.

Another reason that prevents the use of this material is the maximum temperature service. This material is 76.9° C to 96.9° C. According to the choice of 96 for the maximum temperature service parameter, this material exist in the list of solution options, but, considering a safety factor, it is possible to say that from the point of view of maximum temperature service, it is not possible to use this material.

Considering strength of material the next alternative is Polyamide which its application is so close to what is required in our system.

The maximum temperature service of this material is 110° C to 140° C, which is a proper value.

After the Nylon the next useful material is “PS” but according to the above mentioned diagram, even the best PS act as a mid-range Nylon Thus they’re not useful.

The following results is evaluated by Solidworks, applied force is 150 Newton,

The following displacement is achieved (Figure 4-21).

Nylon 6/10 displacement =0.07

Nylon 101 displacement =0.59

In this analysis the value of applied stress to the part is 5.8 MPa, which is lower than the yield stress of the material equal to 50-94 MPa.

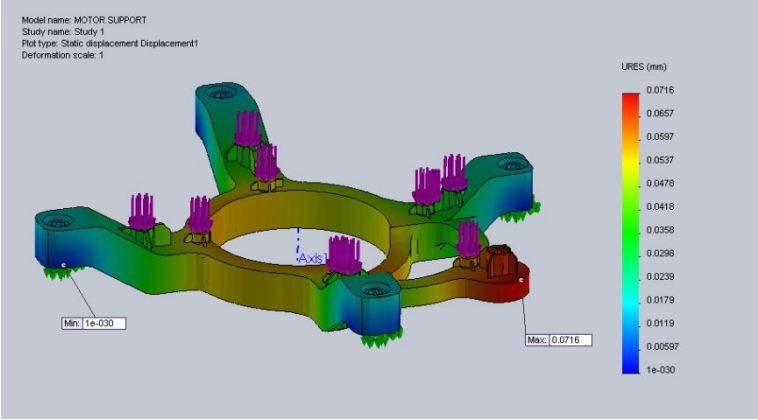

Figure 0-21: Motor support analyst

This part includes 9 intermetallic inserts, 5 used in connecting edges and remained 4 is situated where the part is joint to the chassis.

4.8. Safety system

As stated before, bowls and the food processor accessories can be dimensionally divided into two categories considering their performance

includes: mini-bowl of about 110 mm diameter like mini chopper, blender, etc. and large bowls of about 250 mm diameter.

Considering two various dimensions of bowls, the safety system should be able to diagnose their existence at two target points and the motor unit be authorized to perform at these conditions without any objection.

This level of hazard level (with two diagnostic points) is probably adequate considering safety code, because the safety system interrupt the motor unit either of the picking the mini bowl or opening the lid of the large bowl up. But from the design aspect, in the safety system, making bowls stable at their location is a remarkable parameter which should be considered. It means, the safety system additionally avoids implementation of the appliance if supporting hooks would not be locked. On the other hand, the safety system of the appliance requires 3 target point includes: mini bowl existence diagnostic point, large bowl existence diagnostic point and locking supporting hooks diagnostic point.

The safety system can possibly be created in two methods: firstly consist of the assembled microswitches in three proper places. The safety system perform electrically then. As it's mentioned this system have some disadvantages.

The second method includes a microswitch and transmitting lever from considered places to microswitch like "Moulinex masterchef 570". This system leads to complicated design procedures and increase the required force to switch lever. However, it can be entitled as the best safety system considering its less cost and less complication in production processes.

4.8.1. Safety mechanism operation method

The main parts of the mechanism include two arms, two transmitting levers, moving frame and a microswitch etc. as illustrated below (Figure 4-22).

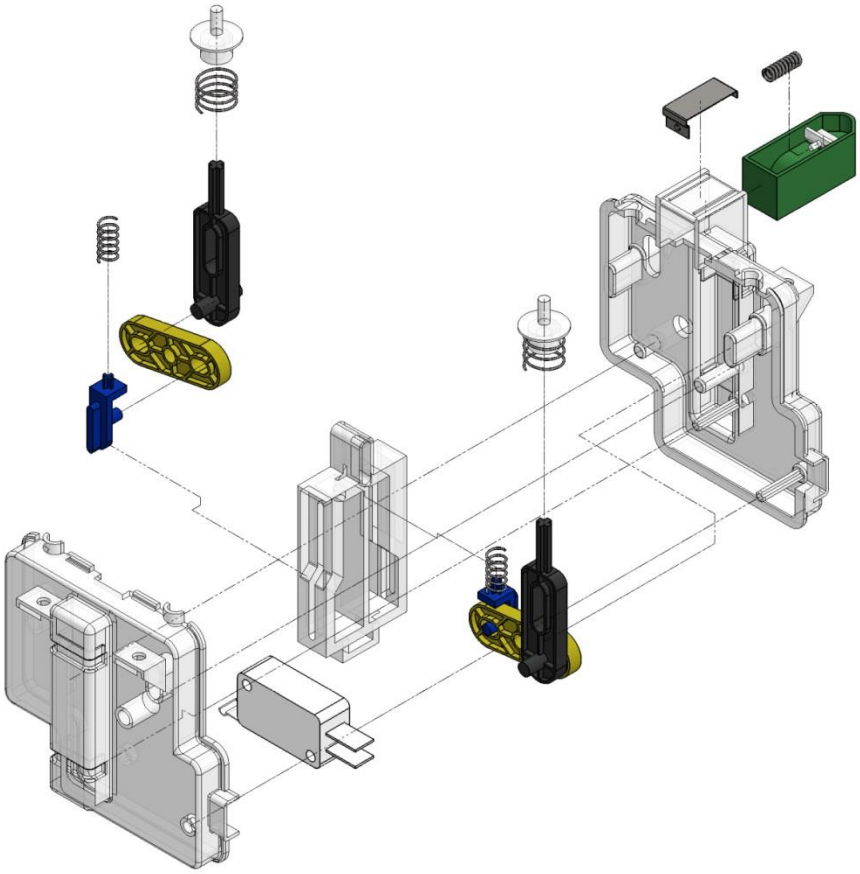

Figure 0-22: Safety system (explode view)

The performance of this mechanism is as follow: afterwards, one of the levers is loaded, the load conveys to the existing spring in the central portable frame through the arms. The spring pushes up the central portable frame and leads to move the lever of the microswitch (Figure 4-23). The existing springs switches mechanism to passive mode in return.

The hook pin locates above the central portable frame and connects to the hook arms and move cyclic with arms. The pin is constrained the move of the central portable frame if the hooks would be open and the central portable frame can easily move upward if the hooks is closed.

Hence, the system will be activated if one of the safety levers is getting pushed and the hooks are close.

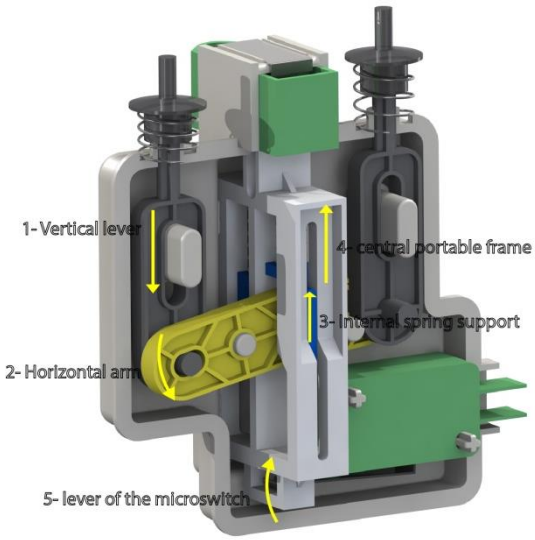

Figure 0-23: Safety system mechanism

In order to avoid allowing liquid to enter the mechanism, vertical arms head ha a special lip form design, which guides the liquids toward out of the security mechanism.

In the design phase of this mechanism, first of all, the two parts of body where joint to each other by five snap fits. But in the optimization phase was used ultrasonic welding to join the bodies (Figure 4-24).

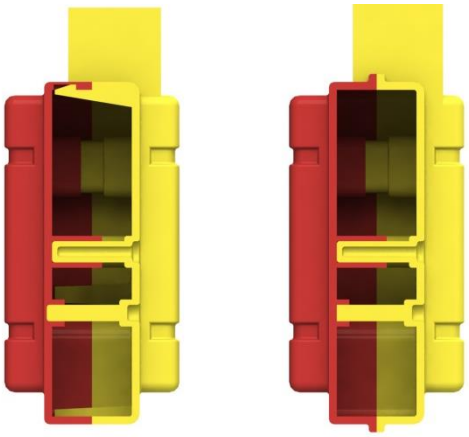

Figure 0-24: Safety system body development

4.9. Structure

The above mentioned parts and mechanisms are not flexible. But there are other types of parts that their main role is to create the system structure, it means that these parts have to determine and provide the exact position of the mentioned mechanisms.

4.10. Main support-top surface

Usually food processor machines have a plastic/Metal body in which cover all the mechanisms which designers are free to choose its shape and color, so all the visual aspect of the product is related to this part. In built-in products the only part that is available for the designers to modify is the outside part which is positioned inside the cabinet.

In this type of products it's only the top surface that is visual to the operator.

According to dimensions of this surface let the operator to use it as a temporary work surface, so it is required for this surface to have good mechanical strength.

One of the advantages of putting the machine into the drawer is to provide space-system for equipment that let them to get in the correct place,so the positions of the accessories are also defined by the upper surface.

This part also provide the main pot seat , the mentioned surface need to place on a support which can resist against the applied loads , the main support is defined for this job.

Main support transmits the applied load to the chassis, and also provides the position of some mechanisms and shape the internal structure of the machine.

In first idea we place the accessories box in upper surface and the main support provide the required strength.

In 2nd idea we divide the top surface into two separated parts, the first half (top surface) is made by “Corian” and the upper body is made with PC by plastic injection manufacturing method, cause Corian is available only in shape of spread sheets the main support is required to keep the accessories, seat of the main pot is provided by the upper body. The doors of the reservoir boxes are made from Corian Material (Figure 4-25&4-26).

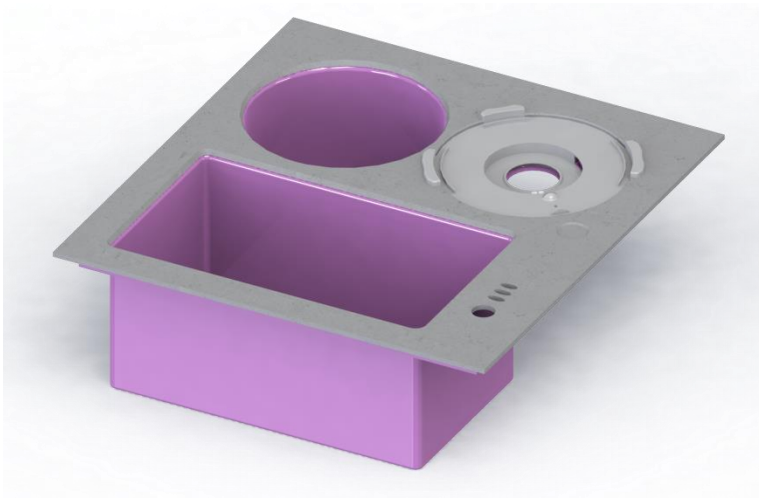

Figure 0-25: Corian as top surface

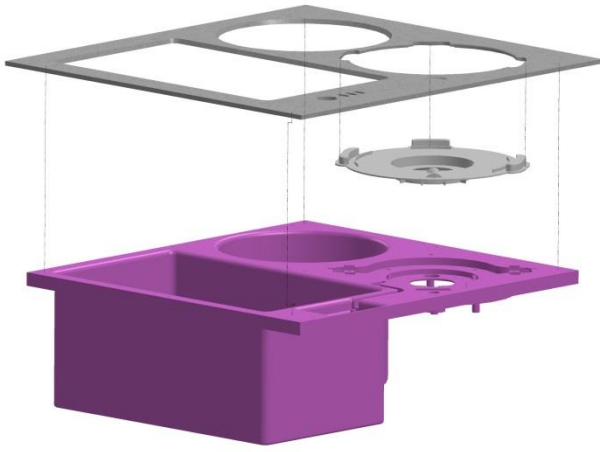

Figure 0-26: Corian as top surface (explode view)

- **Croian:**

Croian Composed of ±1/3 acrylic and ±2/3 natural minerals. These minerals are composed of Aluminium TriHydrate (ATH) derived from bauxite, an ore from which aluminium is extracted.

Corian® surfaces are hygienic. Because it is a non-porous material, bacteria and mould cannot be trapped and roliferate in its joints, nor underneath the surface. Corian® is an inert and non-toxic material. Under normal temperature conditions, it does not emit gases[xiii].

The advantageous features of this material either from aesthetic point of view, or deformability and strength, made it one the most promising solutions for the kitchen furniture design. That's why it has been chosen for the upper surface material. The upper surface of the machine is the only part that would allow enhancing the visual qualities of the product; it's fascinating to see this material connecting the food processor machines to the kitchen furniture.

Another reason to use Corian is to reduce the manufacturing cost, according to circulation of 5000 to 10000, removing of one part of 540*530 mm means removing of plastic molds in the product there for maybe there will a possibility to produce the machine in lower circulation.

It’s possible to cut the material using grinder tools and to glue the material by stick the same material while it’s not completely solid. To stick the material to other type of materials we can use silicon gums. There’s no data related to ultrasonic welding of this material in production catalogues.

Using this material as machine cover we can stick upper body part to top surface using silicon gums, to use silicon gums there should be a narrow space (1mm) on the edges.

4.11. Chassis layout:

This part transmits the whole weight of the structure and applied load to the drawer. In sketch we consider chassis as a formed sheet metal which includes the connecting clamps, in the sketch the chassis is defined as a bottom surface cover (Figure 4-27).

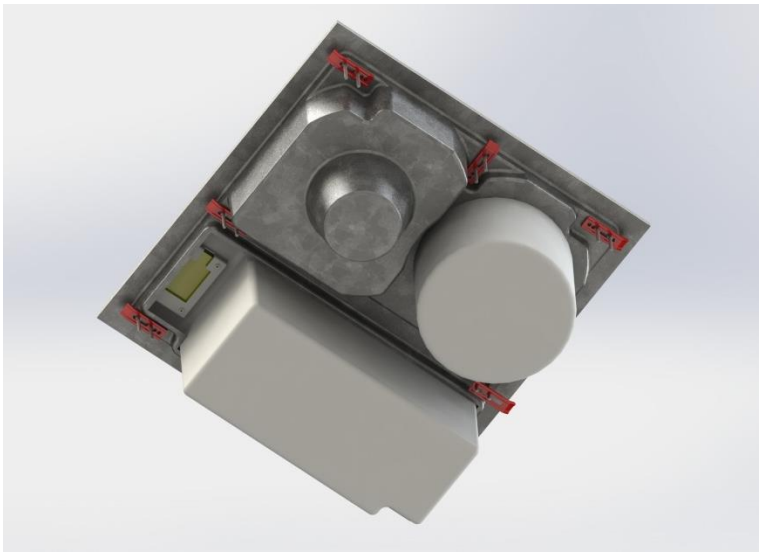

Figure 0-27: Formed sheet metal part as chassis

In this idea connecting clamps can displace in up-down direction about 50 mm and front-back direction about 24 mm (Figure 4-28).

Figure 0-28: Formed sheet metal clamping system

There are some drawbacks related to this plan because it's complicated and expensive to produce. So it's better to simplify the model using another idea.

In 2nd idea chassis is defined as metal frame which includes the machine circumstances and two rods provide the connecting ports for supports to link to the motor. To connect the machine to drawer it's needed to have separate part linked to the drawer and then place the machine on it (Figure 4-29).

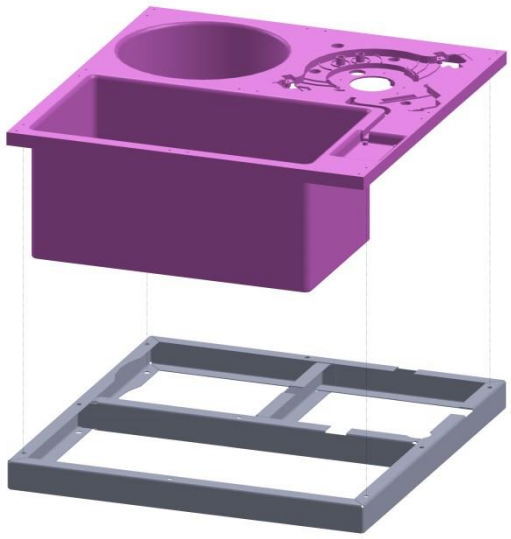

Figure 0-29: Metal frame as chassis (explode view)

4.12. Optimization of the chassis

To do the optimization we remove the accessories reservoir and chassis seats, we just keep mechanism seats. The accessories reservoir is made by plastics with thermoforming method which is less expensive.

And chassis is linked to the plane metallic sheet which has bended edges. In this new design several grooves are made on chassis to place the main support to install the accessories reservoir (Figure 4-30).

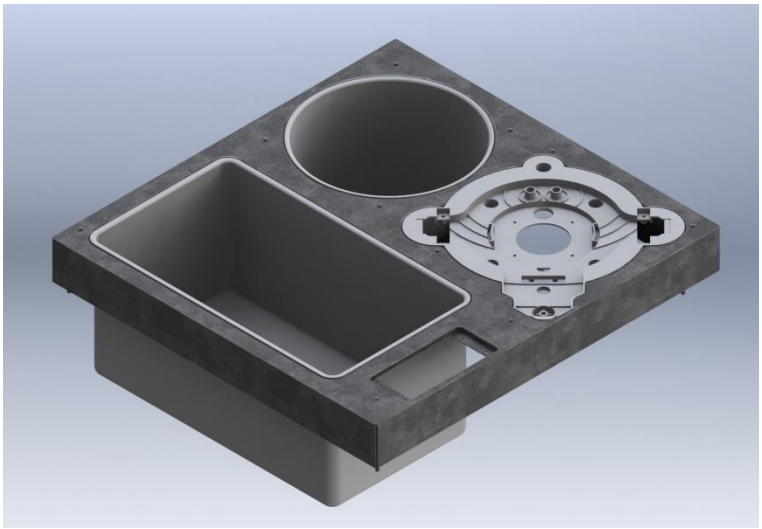

Figure 0-30: Optimized metal chassis

4.13. Chassis

The chassis is made by a plane sheet metal, which it could be produced with one the following procedures, depending on the demanded quantity of production.

1- Prepared by laser cutting and formed with local press machines and bending process.

2- Forming and cutting the whole body by the aid of punch and matrix mold

All the applied loads are carrying on chassis and transmitted to the handles and finally to the drawers.

4.14. External shaft complex

This complex transfers motor force to attachments. As it's obvious from the figure this complex is kept between main pot and the machine (Figure 4-31).

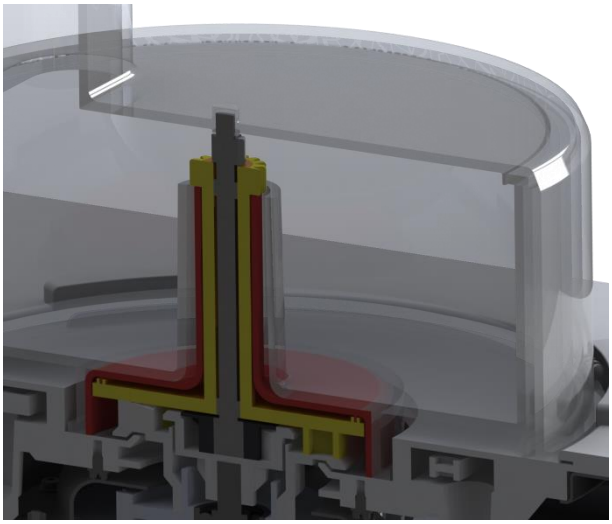

Figure 0-31: External shaft complex

This complex includes central axis, outside shaft and the body

The main axis is made by the steel and transfer the motion of main gear to the accessories. This axis is connected to the bottom part of the main bowl cover through it's upper point.

The outside shaft is made from two plastic parts which are connected to each other using ultrasonic welding method. This part transfers the motion of external gear to the attachments. The body covers these two parts.

4.15. Assembly

In the assembly phase, are joined to each other in the form of 9 subassemblies. Accessories and the clamps of the drawer are assembled by the operator (Figure 4-32).

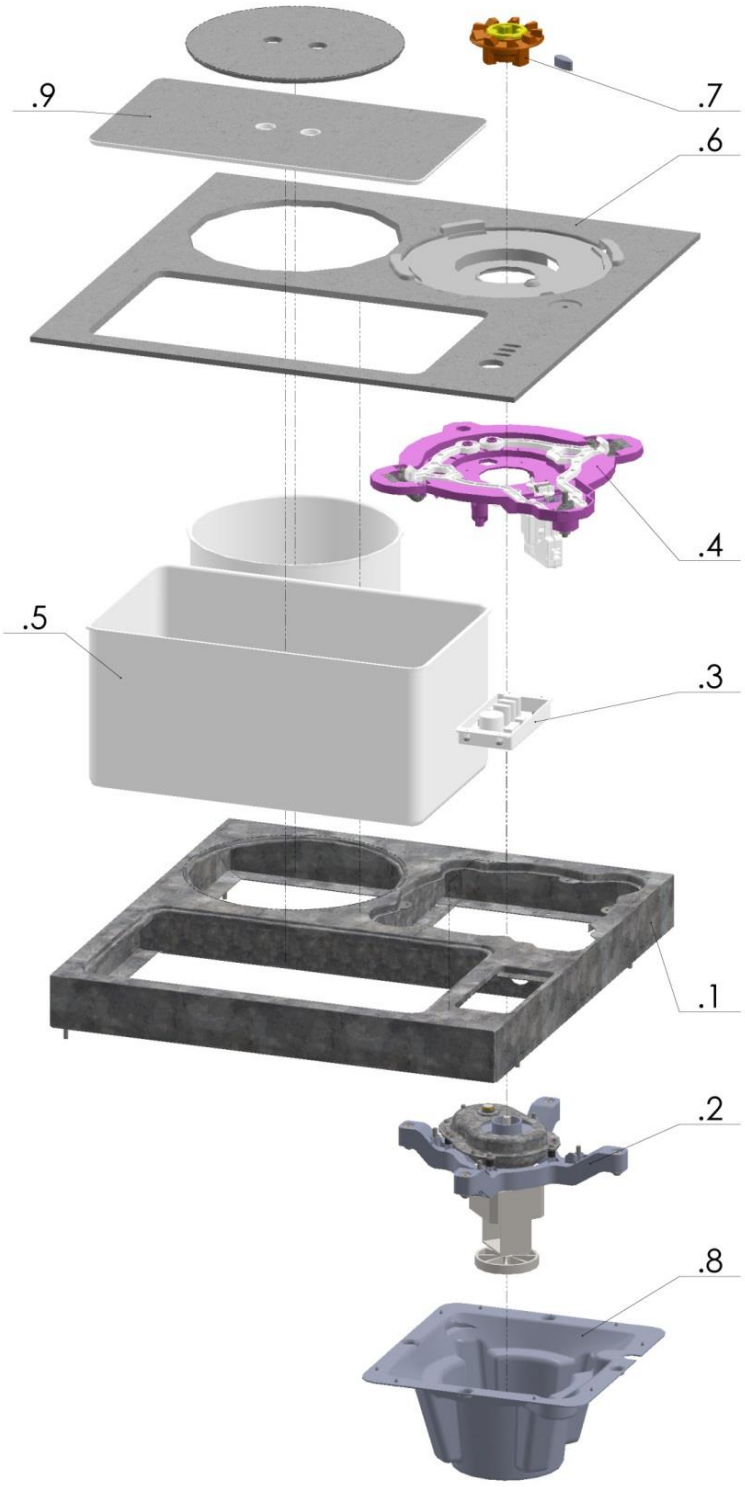

Figure 0-32: Assembly lay out (explode view)

4.16. Installation in the drawer

To have better justification considering different thicknesses for the wood sheets and different thicknesses for the rails there should be tolerance to have more safe installation phase. We consider the upper sheet regards to maximum drawer width (540mm) but the chassis size is 498mm. In this way we can connect the machine into drawers which have width more than 12.9 mm and also with side wall thickness more than 18mm.

Since the machine needs to be bolted to the drawer, and also the engine needs air circulation, the drawer bottom should be completely or partially removed. In the following figure (Figure 4-33), the appropriate drawing for machine installation is demonstrated.

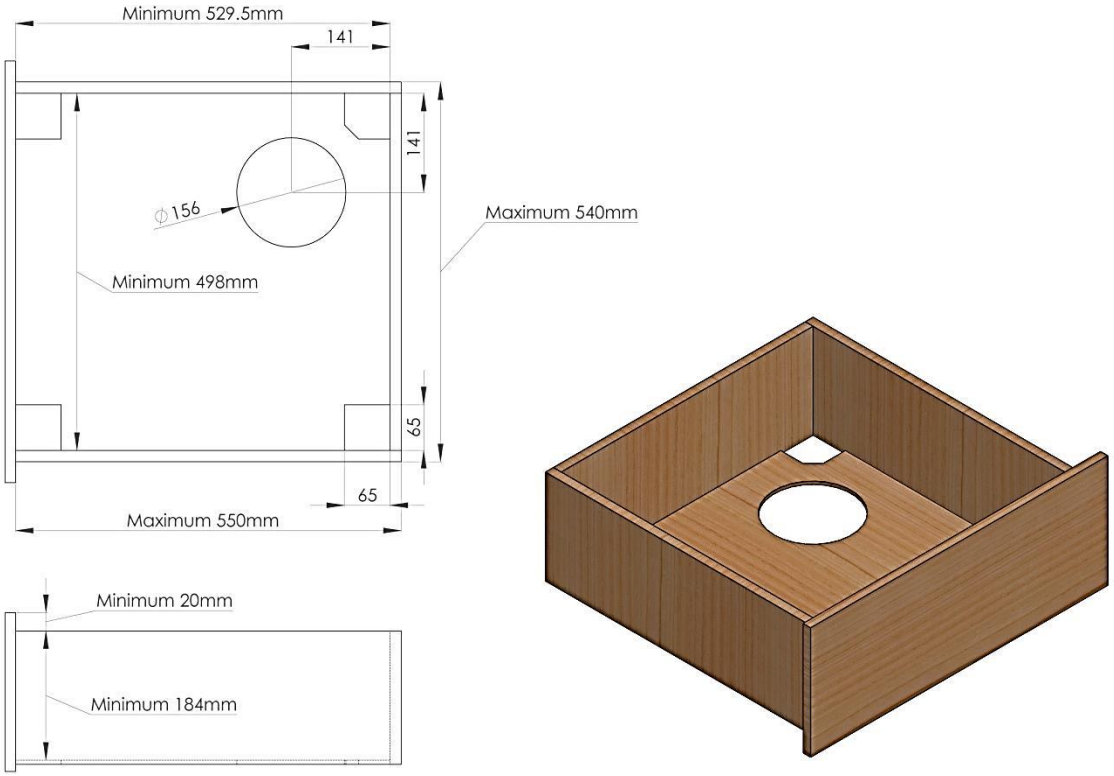

Figure 0-33: Drawer properties

4.17. Development:

This plan which is the base plan of production of this product is designed considering the width of 60 mm as the minimum width for drawers, which covers most accessories of food processing machine. In case of development there is also possibility to try on wider widths like 75 to 90 cm, in which in this case we can cover all the related accessories inside the drawer.

Also with some modification in design there is possibility to add Ice cream maker tools and warmer elements to the mentioned accessories so at the end of the day it can be called as a complete food processing machine in kitchen which can provide all solutions and all needs for food processing in kitchen so it can stay on lead regard to its old competitor “single operation machine.”

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