CREATIVE DESIGN OF A FLIP TOP CAP MOLD

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ABSTRACT:

Plastic closures incorporating a flip top cap are in high demand in pharmaceutical, processing and packaging industries. The use for quality and cost are driving the industries to search for improved cap closing solutions.

Creative design on flip top cap mold provides a complete changeover which is very simple and quick. It is the work process which has a user perspective.

The project deals with the creative design and analysis of the mold. Creative design is either to identify the defects and find a solution, and makes the necessary changes during the design process or to improvise the given design for better performance. Here we tried to improvise the design by making a major change in the hinge which acts like the back bone of the flip top cap.

A mold required to produce flip top cap in injection molding is designed according to the chosen cap. The 3 dimensional (3D) view of the cap was designed using computer-aided design (CAD) software Creo Parametric 2.0. The cap thus created was then used to create top and bottom cavity inserts of the mold. The manufacture feature of Creo is used to extract the core and cavity and also to locate positions for inserts that are necessary to complete the mold design. Final step is to create mold base assembly using Expert Mold base Extension (EMX) in Pro-E, which completes the whole design process of the flip top cap mold.

In order to perform structural and thermal analysis, a 3D model is designed in Solid Works. Which is then imported to Ansys Workbench 15.0 where analysis (structural and thermal) is carried out? Optimum thickness of the plate and the temperature of the plastic flow was obtained?

Keywords-*creative design, creo parametric2.0, expert mold base extension, ansys workbench*

INTRODUCTION

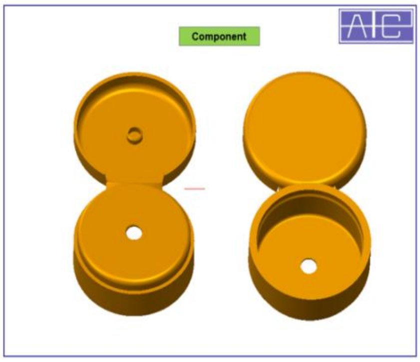
Defining a Creative Design:

It is the work process which has a user perspective and drives development based on your specific customers' needs. Realization of a concept or idea into a configuration, drawing, model, mold, pattern, plan or a specification (on which actual or commercial production of an item is based) and which helps achieve the item's designated objective. A product is creative when it is novel and appropriate. A novel product is original not predictable. Creativity is the quality that you bring to the activity you are doing.

Details are as follows:

Given: Flip top cap design and its dimensions

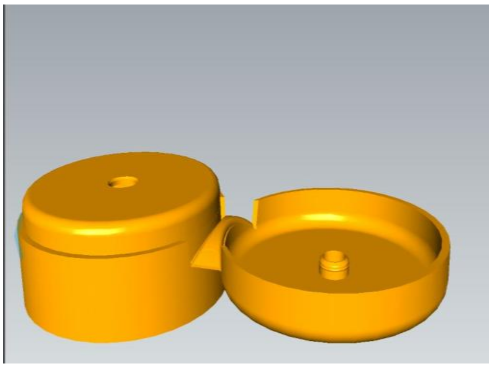
Original cap shape
Hinge: dead flat hinge
Surface finish: glossy
No hand rest.



Client Requirement:
Cap mold for the given dimensions of the flip top cap

Proposed changes:

Hinge: living hinge – butterfly
Surface finish: matte
Snap on the spud of the lid.



Let's take a closer look at each these proposed changes.

HINGE:

A movable joint or mechanism on which a door, gate, or lid swings as it opens and closes, or that connects linked objects.
Typically the hinge used during this process is a biased hinge and butterfly hinge is a biased hinge.

LIVING HINGE over DEAD FLAT HINGE:

Living hinge: A living hinge is a thin section of plastic that connects two plastic bodies together. Since it is very thin it enables the two bodies to move rotationally to angles of 180 degrees and greater. [1]

What are living hinges used for?

When you need something that connects two sides together and allow rotational movement a living hinge will likely do the trick .It can take the place of a traditional hinge in most cases and do it with less parts and no assembly.[2]

Advantages of living hinge over dead hinge:

- Living hinge is durable and with good design it can last for millions of cycles.
- It is plain and simple.
- It is a uni body design.
- Economical.[3]
- Less number of inserts are required for living hinge during its design while dead hinge requires more number of inserts.
- Satisfactory closing effect is obtained in living hinges than in dead hinges and hence it is recommended in industries to save time.

Hence a living hinge is considered due to its advantages and living hinge is proposed to the client.

BUTTERFLY HINGE:

Butterfly hinge

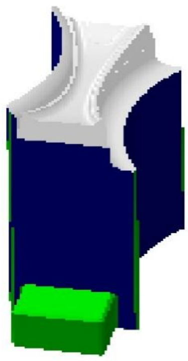
A butterfly hinge is commonly used on dispensing caps. The advantage of a butterfly hinge is its flipping action. Once the hinge is opened or closed past a certain angle the hinge will spring to the other position and stay there .So the cap will flip to the open or closed position.[4]
Hence a butterfly hinge is proposed rather than the flat hinge because it cannot come to the other position like the butterfly hinge and remains in its position making the cap closure completely manual.

Its life is less and hinge failure is more likely during frequent usage. In industries it is not recommended due to its time consumption while opening and closing. This incurs great loss to the industry.

Hence a butterfly hinge is suggested to the client. [5]

Butterfly hinge design considerations:

1. During the mold design the insert is placed to get the shape of the hinge.
2. Insert is designed in such a way to get the required effect.
3. The hinge web stretches, acting as a spring to give these hinges their biased behavior.[6]
4. This hinge does not have a central pivot.
5. Design of the Insert is first made in solid works and developed in Creo to get the shape.



Hinge insert

6. This insert is placed in the mold and plastic flows to get the shape of it.
7. This is the change that can be made on the mold to get the shape of the Insert.

SURFACE FINISH:

Surface finish all known as surface texture or surface topography is the nature of the surface as defined by the 3 characteristics of lay, surface roughness, waviness. Surface texture is one of the important factors that control friction and transfer layer formation during sliding.[7]

WHY MATTE OVER GLOSS?

- Matte surface finish is recommended over gloss finish due to the following advantages:
- Surface scratches may be harder to see.
- Harder to see micro marring – swirls, spider webbing in the finish.
- Hides imperfections because it absorbs more light.
- Dirt is not more apparent on the surface.
- Due to these advantages matte finish is preferred to gloss finish[8]

Matte finish cap vs Gloss finish cap

Hence, Matte finish is proposed to the client.
Another proposed change is introduction of snap on the spud of the lid. [9]

SNAP ON THE SPUD OF THE LID:

A Snap top closure is composed of a body and a lid connected by a hinge .Usually the lid contains a spud or seal that coordinates with the spud or the orifice to cause a seal when the lid is closed.

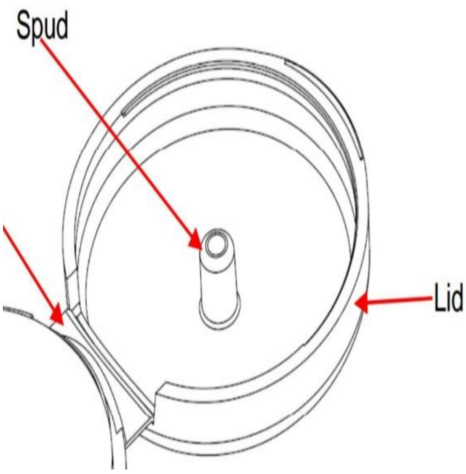
Snap top closures can be produced in a wide variety of shapes, sizes, and orifice sizes.[10]

Advantages of introducing snap on the spud of the cap:

- It incorporates perfect closure with a click sound.
- It provides proper sealing effect to reduce any kind of leakage which is otherwise not possible with normal closures.
- In pharmaceutical industries proper sealing is very important which can be incorporated with the help of the snap.

Design considerations:

Insert has to be designed to get that shape on the spud of the lid .The insert is separately designed in Creo according to the dimensions and placed in the mold to get the snap over the spud.
Hence it is recommended to the client.
To conclude the creative design process, these are the three changes proposed to client



Spud with snap

This design of a flip top cap mold provides a complete change over, which is very simple and quick. This is called CREATIVE DESIGN.

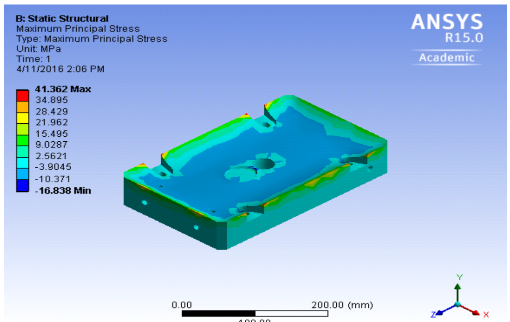
After creative design modelling is done using creo and then the bottom and top cavity plates are selected and analysis is carried out.

Structural analysis on the bottom plate:

Pressure of 17.5N/mm^2 is applied normal to the plate.

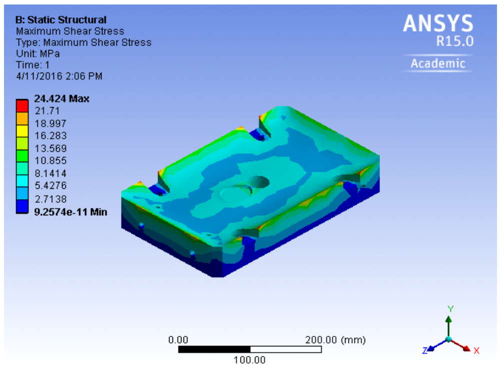
Thickness of the plate = 56 mm

Maximum principal stress:



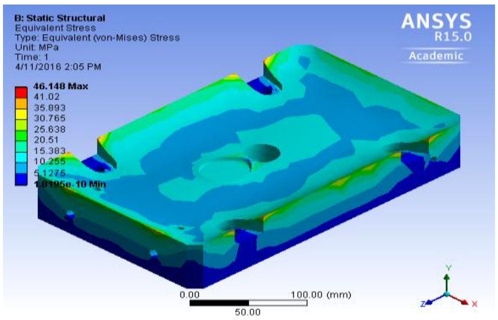
Max principle stress

Maximum shear stress:



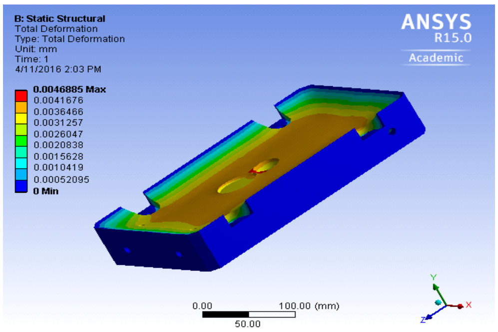
Max shear stress

Equivalent stress:



Equivalent stress

Total deformation:

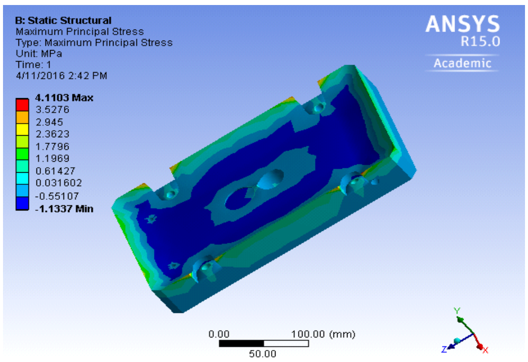


Total Deformation

When the thickness of the plate is changed:

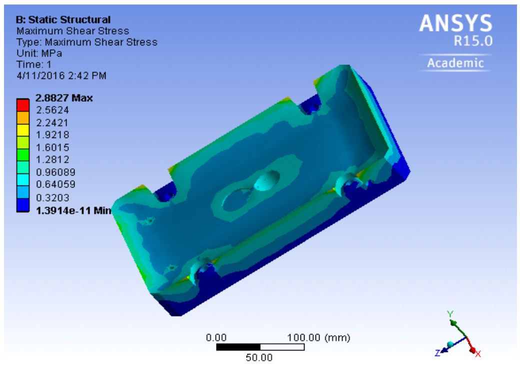
Thickness = 48 mm

Maximum principal stress:



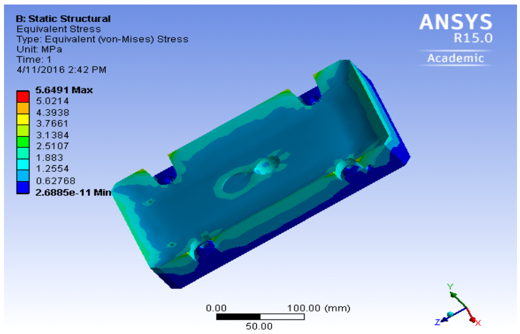
Max Principal stress

Maximum shear stress:



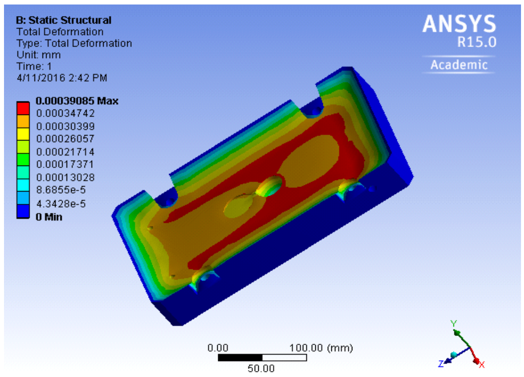
Max shear stress

Equivalent stress:



Equivalent stress

Total deformation:



Total Deformation

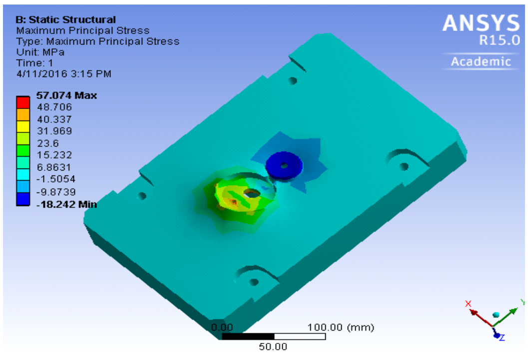
After changing the thickness by keeping the load constant it is observed that the deformation is very less and the stress values obtained are very minimum.
Hence the structure (design) is safe from failure

STRUCTURAL ANALYSIS ON TOP PLATE:

Thickness of the plate=56mm

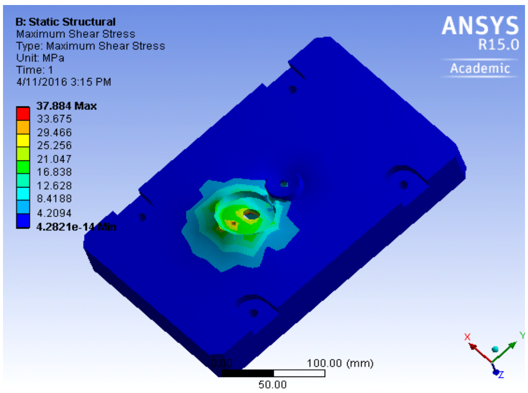
Pressure applied=17.5 N\mm^2

Maximum principal stress:



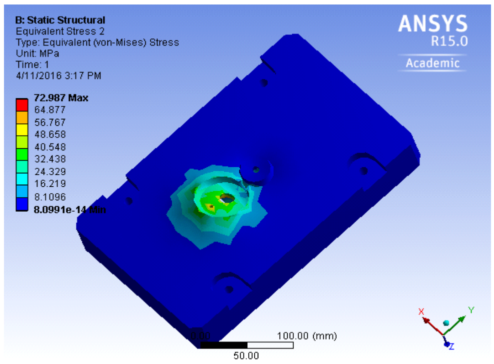
Maximum principal stress

Maximum shear stress:



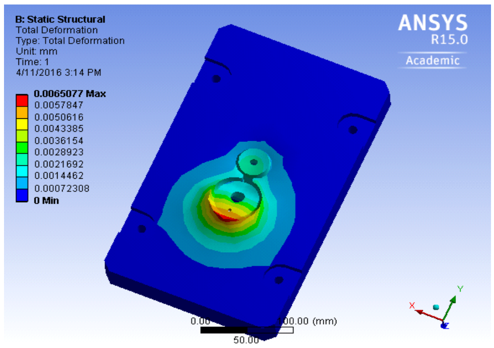
Maximum shear stress

Equivalent stress:



Equvalent stress

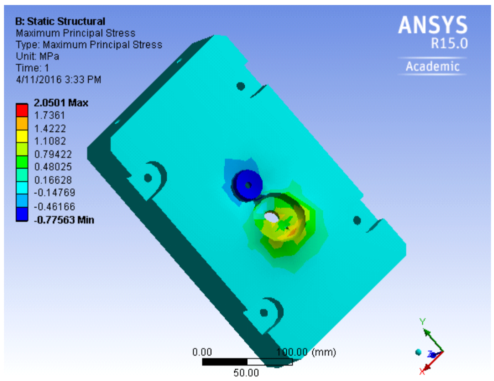
Total deformation:



Total Deformation

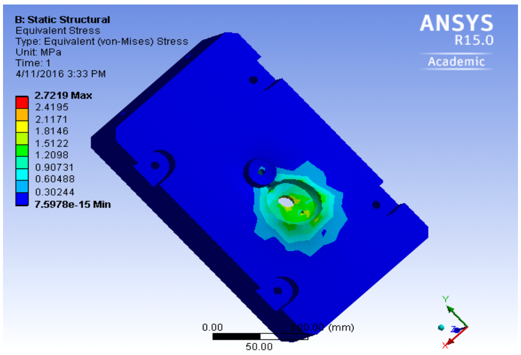
When the thickness of the plate is changed to = 48mm

Maximum principal stress:



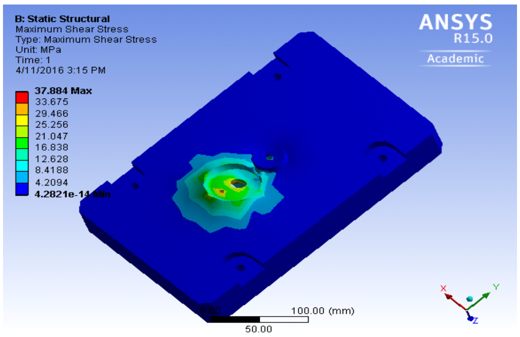
maximum principal stress

Equivalent stress:



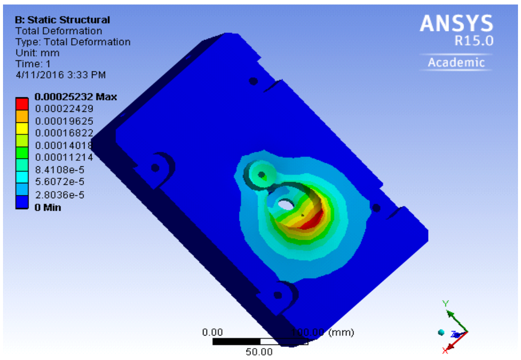
Equivalent Stress

Maximum shear stress:



Maximum shear stress

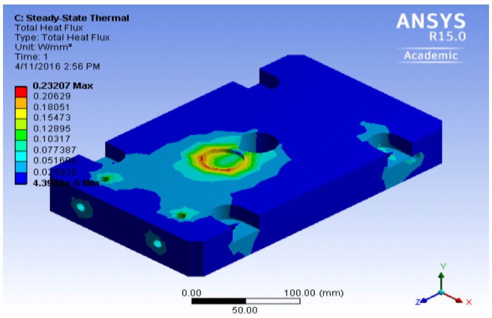
Total deformation:



Total Deformation

Hence the top plate is safe from failure after changing the thickness of the plate .The deformation and stress values observed is less when the thickness is change

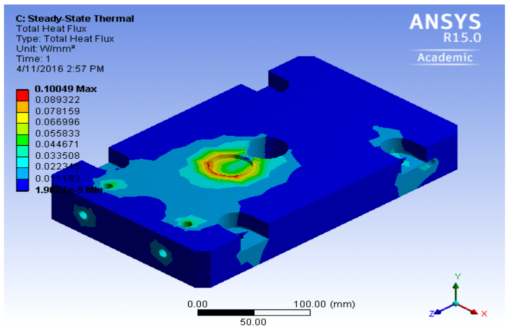
THERMAL ANALYSIS for bottom plate:



Total heat flux

When the temperature is changed to 55°C:

:

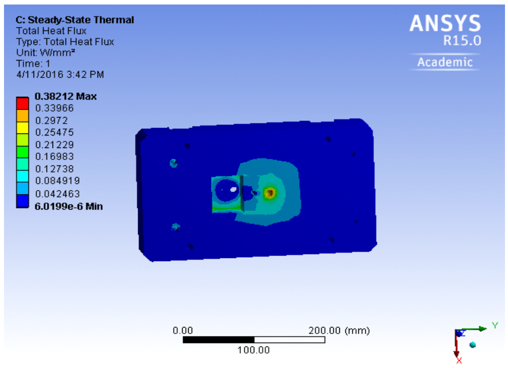


Total heat flux

THERMAL ANALYSIS ON TOP PLATE:

When the temperature is 110°C:

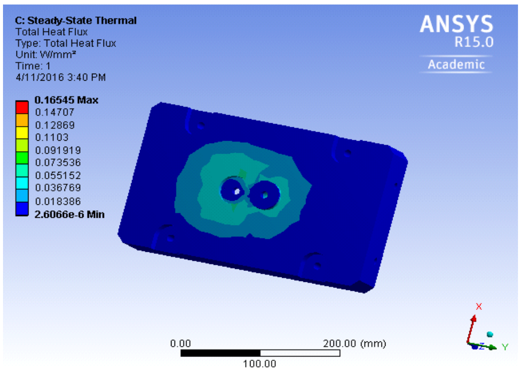
Total flux:



Total heat flux

When the temperature is changed to 55°C:

Total flux:



Total heat flux

RESULTS

Structural analysis:

The results for structural analysis are as follows:

For bottom plate:

Maximum principal stress = 4.1103 Mpa (max)

-1.1337 Mpa (min)

Maximum shear stress = 2.8827 Mpa (max)

$1.3914e^{-11}$ Mpa (min)

Equivalent stress = 5.6491 Mpa (max)

$2.6885e^{-11}$ Mpa (min)

Total deformation = 0.00039085 mm (max)

1.0 mm (min)

Maximum shear stress = 37.884 Mpa (max)

$4.2821e^{-14}$ Mpa (min)

Equivalent stress = 72.987 Mpa (max)

$8.0991e^{-14}$ Mpa (min)

Total deformation = 0.0065077mm (max)

1.0 mm (min)

For top plate:

Maximum principal stress = 2.0501 Mpa (max)

-0.77563 Mpa (min)

Maximum shear stress = 3.3307 Mpa (max)

$1.0523e^{-14}$ Mpa (min)

Equivalent stress = 2.7219 Mpa (max)

$7.5978e^{-15}$ Mpa (min)

Total deformation = 0.00025232 mm (max)

$2.8036e^{-5}$ mm (min)

For plate with thickness 56 mm:

For bottom plate:

Maximum principal stress = 41.36 Mpa (max)

-16.838 Mpa (min)

Maximum shear stress = 24.42 Mpa (max)

$9.257e^{-11}$ Mpa (min)

Equivalent stress = 46.148 Mpa (max)

$1.819e^{-10}$Mpa (min)

Total deformation = 0.0046885 mm (max)

1.0 mm (min)

For top plate:

Maximum principal stress = 57.074 Mpa (max)

-18.242 Mpa (min)

After the analysis of the mold is done, as per the results obtained, the plate with thickness of 48 mm is found to be more ideal dimension for the cavity plates.

Thermal analysis:

For top plate:

At 110 degrees celcius:

Total heat flux: 0.38212 W\mm^2 (max)
6.0199e^{-6} W\mm^2 (min)

At 55 degrees celcius:

Total heat flux: 0.16545 W\mm^2 (max)

2.6066e^{-6} W\mm^2 (min)

For bottom plate:

At 110 degrees celcius:

Total heat flux: 0.23207 W\mm^2 (max)
4.3944e^{-5} W\mm^2 (min)

At 55 degrees celcius:

Total heat flux: 0.1049 W\mm^2 (max)

1.9027e^{-5} W\mm^2 (min)

Therefore, according to results obtained for top and bottom plates, 55 degree celcius is found to be ideal.

CONCLUSION

Plastic closures incorporating a flip top cap are in high demand in pharmaceutical and packaging industries. The use for quality and cost are driving the industries to search for improved cap closing solutions.

Creative design is a concept which provides a complete changeover which is very simple and quick. This concept also helps to make the required changes before the design itself.

When a client approached the industry with a cap model we applied the same technique to improvise its function. We made three changes in the given design itself one to improve its appearance another to improve the hinge design to have better opening and closing and the other is snap on the spud of the cap for satisfactory closing effect.

To obtain these changes on the cap we need to make changes on the mold itself. Hence during the design itself proper care was taken regarding the design of inserts. After modelling it then the core and cavity plates are taken and structural along with thermal analysis is carried out to get the reliable and optimum thickness of the plate and the temperature of flow of the plastic.

By employing creative design on the cap mold the cap is expected to

- perform more effectively
- Have a longer life
- Satisfactory closing effect
- Leak proof

These are the factors which we are expecting after manufacturing the cap by injection molding process.

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