Optimization Criteria for the Design of a Refrigerator Using Volume Consideration

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Abstract: *The global increasing demand for refrigeration in field of refrigeration air-conditioning, food preservation, vaccine storages, medical services, and cooling of electronic devices, led to production of more electricity and consequently more release of CO_2 all over the world which it is contributing factor of global warming on climate change. Cylindrical refrigerator increase the useful volume also helps in space optimization and to get maximum volume at minimum total surface area. Therefore, proposed design refrigeration is greatly needed, particularly for developing countries where maximum volume and low maintenance are needed. Also provide good with save in energy .The objectives of this study is design and develop a working cylindrical refrigerator interior cooling volume of 444115008.2mm^3 that utilizes the Vapour compression refrigeration effect to refrigerate and maintain a selected temperature from 5 •C to 25 •C. The design reduces the wastage of energy also reduce stresses on the refrigerator body. We are study on the efficiency of the machine and on adjustable refrigerator body requirements, options available and the final design of ASFB refrigerator for application are presented*.

Keywords: Cylindrical refrigerator, save space, maximum volume, vaccine storage

1. Introduction

Conventional refrigerators are having more total surface area as compare to ASFB Refrigerator design. Asfb utilize the maximum volume of the total volume. Also give sufficient increment in the total volume with respect to conventional design, it also provides extra space on shelves so that more volume can be used inside the body.

The glass door provide the clear view of the items hold in the refrigerator and sliding door help in easy access of refrigerator even at crowded kitchens and room .moving shelves , allowing user to easily access items and accessible to any area that are normally difficult in present design. It prove 360degree access to the shelves and shelves are capable of changing heights so that you can change the height of shelves as per demand of utensil. Water compartment grate help to prevent flowing of air and also help in regaining temperature after closing of the door. . There are less chances for cracks in a cylindrical refrigerator body than in a cubical body because of low stress consideration. Cylindrical design having less material weight as compared to convention design and also less number of welding joints are required.

2. Features of Proposed Design

I am proposing four changes in the present design,

1. Refrigerator Body Design
2. Shelves Design
3. Sliding Glass Door
4. Water Compartment/chamber

2.1 Refrigerator Body Design

To get particular volume we have to use bigger/large body or extra surface area, because of that there was extra mass on the body; this will be eliminated in proposed design.

2.1.1 Increase in Overall-volume
Proposed refrigerator is designed with concept for space optimization and to get maximum volume at minimum total surface area. Cylindrical shape is proposed for maximum use of volume in comparison to present design. On considering the refrigerator with dimension

Table 2.1: Calculation of proposed design

Propesed design			
Radius	300	Depth(H)	1500
Circumference of circular base			1884.955592
Area of Base		pi*r^2	282743.3388
Area of cylinder		2*pi*r*h	2827433.388
Total surface area		2pir^2+2pirh	3392920.066
Volume of Cylinder		pi*r^2*h	424115008.2

On considering with the present design having same total surface area and base area, we find the dimensions and compare

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Table 2.2: Volume consideration taking TSA and Area equal

If the Base Area (Present design = Proposed design)			
Propsed Design			Present design
r (mm)	300	l=b (mm)	?
Area	282743.3388	Area	282743.3388
Length of the rectangle= √pir^2			531.7361553
Width of rectangle = √pir^2			531.7361553
If Total surface Area (Pre design = Pro design)			
Propsed Design			Present design
h (mm)	1500	h	?
TSA	3392920.066	TSA	3392920.066
Hight of cuboidal design			1329.340388
Then as per dimensions the area and volume are			
Circumference of rectangle			2126.944621
Volume of Cuboidal			375862139.8
comparing Volume inPresent design vs pro design			
Proposed Design			Present design
Volume	424115008.2	Volume	375862139.8
Increase in volume			48252868.45
% increase in volume			**12.8379**

On comparing both the arrangements we find an increase of **12.84%** in proposed design volume as compared to present design.

2.1.2 Increase in Useful Volume as compared to Total

Volume on part wise consideration we find the useful volumein proposed design.

Table 2.3: Useful Volume calculation taking TSA and Area equal

Proposed Design			
Cooling unit (CU)			
Radius(mm	300	Depth (mm)	300
Volume (V) of CU	84823001.65		
Not useful V (Nuv)	84823001.65		
Useful Volume	0		
Ice Chamber (IC)			
Radius	300	Depth	298.5
Volume of IC	84398886.64		
Useful Volume	84398886.64		
Nuv	0		
Refrigeration Chamber			
Radius	300	Depth	779.71
Volume of RC	220457808.7		
Nuv 3-shelves	6561530.416		
Nuv 9- bearings	300591.5121		
Useful Volume	213595686.8		
Water Chmber			
Radius	300	Depth	119.9975
Total volume	33928493.8		
Nuv	168939.1449		
Useful volume	33759554.66		
3- partition at IC,CU and RC			
Radius	300	Depth	0.5975
Volume		506817.4348	
Nuv		506817.4348	
Uv		0	
Total useful volume with respect to total volume			
Total volume		424115008.2	
Useful volume		331754128.1	
%useful volume		**78.22268056**	**%**

On calculation we found that **78.22%** volume of refrigerator is useful in proposed design. Volume on part wise consideration we find the useful volume in present design,

Table 2.4 Useful Volume calculation taking TSA and Area equal

Present Design			
Cooling unit (CU)			
l=b (mm)	531.73616	Depth(mm)	300
Volume (V) of CU	84823001.65	mm^3	
Not useful V (Nuv)	84823001.65		
Useful Volume	0		
Ice Chamber (IC)			
L=B	531.73616	Depth	298.5
Volume of IC	84398886.64		
Useful Volume	84398886.64		
Nuv	0		
Refrigeration Chamber			
L=B	531.73616	Depth	609.050388
Volume of RC	172204940.2		
Nuv 3-shelves	6658223.454		
Nuv 6 slots	159520.8466		
Useful Volume	165387195.9		
Water Chmber			
L=B	531.73616	Depth	119.9975
Total volume	33928493.8		
Nuv	168939.1449		
Useful volume	33759554.66		
3- partition at IC,CU and RC			
L=B	531.73616	Depth	0.5975
Volume	506817.4348		
Nuv	506817.4348		
Uv	0		
Total useful volume with respect to total volume			
Total volume	375862139.7		
Useful volume	283545637.2		
% useful volume	**75.43873331**	%	
% increase in useful volume to toal volume			
Pro Design V %- Pre Design UV%		**2.7839473**	**%**

On calculation we found that **75.43%** volume of refrigerator is useful in Present design. And we get increase of **2.78%** useful volume to the total volume in proposed design.
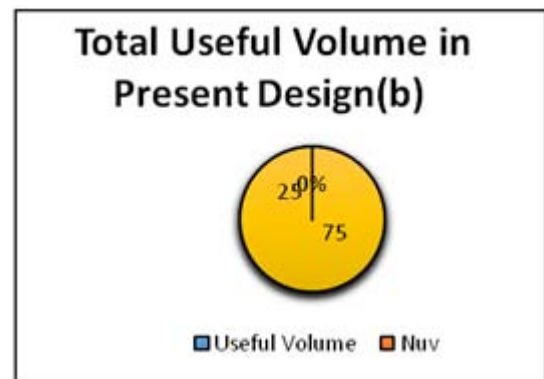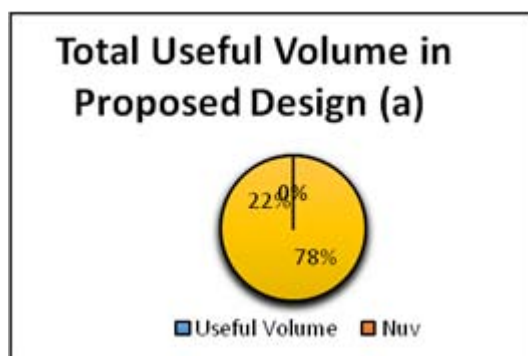

Figure 1: Total useful Volume (in percentage)

2.1.3 Material saving and easy production

The Production of proposed design refrigerator is easy compared to present design. Less number of welding joints is required in elliptical or cylindrical vessels than cubical ones.

On comparing the metal use ($.01g/mm^2$) we find that

Table 2.5: Calculation Mass of Material by calculation TSAat equal V

Present design		Proposed design	
l (mm)	531.7361553	r	300
b (mm)	531.7361553	h	1500
h (mm)	1500		
TSA	3755903.609	TSA	3392920.1
Total surface area difference		362983.54	
% increase in TSA		**10.69826**	%

Total surface area of square base is more than total surface area of circular base. Let the mass of metal is $.01g/mm^2$, then mass of material decreased by **10.69%** in proposed design.
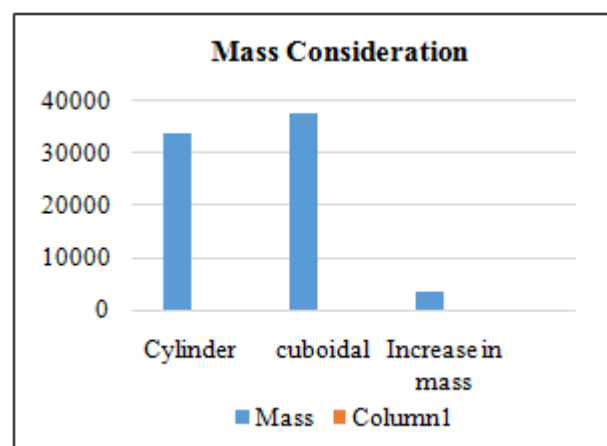

Figure 2: Mass Consideration (in grams)

2.1.4 Stress at Corners

We know that the stress at the point, in a section is directly proportional to its distance from the neutral axis. Therefore

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maximum stress in a section will be occur in the extreme fiber of the section.

Table 2.6 Calculation of Distance from neutral axis

present design		Proposed design	
l	600	r	300
b	600		
length of diagonal		Lenth of diagonal	
l	848.52814	l	600

As we can see that in rectangle the corner is far then in circle or in cylinder. Rectangular type of cross section are having problem of stress concentration. When carrying load, the stress acting at a corner is more than the stress acting on the sides. Because of this, the stress concentrates more at the corners. And because of this there are more chances of a body to break and leakage if they are made rectangular or cubical. There are less chances for cracks in a cylindrical body than in a cubical tank. You can imagine for the same length of axis, cylindrical cross section have more perimeter than rectangular shape. This makes the weight to be distributed over more area thus reducing pressure or load on vessel. Thus instead of a simple cylindrical vessel, ones give us more volume.

2.2 Shelves Design

Handling is difficult in present shelves, also our jug/utensils are usually in cylindrical shape so the volume at the edges of the shelve waste and remain unoccupied.

2.2.1 Increase in Useful volume at shelves

On comparing the no of maximum bottle that can arrange on the shelves we found

Table 2.7: Calculation of Useful volume on shelves

Taking bottle of 75 mm Diameter			
Proposed design		Present design	
Shelves (r)	295	Shelves L	531.7361553
		Shelves B	521.7361553
Area	273397.1007	Area	277425.9773
Max bottle	**52**	Max Bottles	**49**
Useful Hight for both the Design let			755.71
UVpro	173608474.5	UV pre	163592600.9
%UV	84.02757828	%UVpre	78.02995628
Volume % more used by Proposed design			**5.998**

On comparing the useful volume by shelves in both the design, we find that proposed design use **5.99%** more volume then the present design.
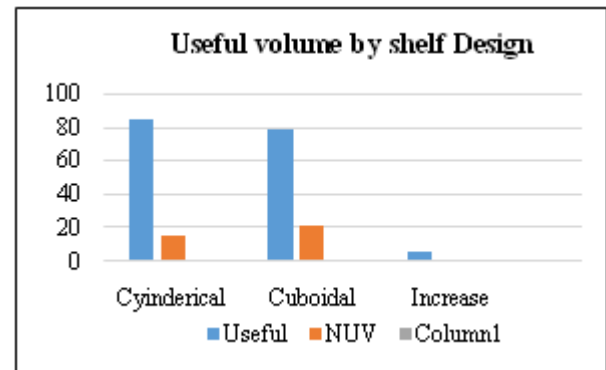
**Figure 3:** Total useful Volume in shelves (in percentage)

2.2.2 Adjustable Shelves / Shelf

The Proposed refrigerator concept contains the moving shelves that can rotates, allowing user to easily access items and accessible to any area that are normally difficult in present design. With rotating shelves that spin your food right into a front position as needed. In addition, the shelves are capable of changing heights or say can flips up and down easily so that adjusting of things gets simpler by lowering them or raising them as per need. Adjustable shelves also collapse to fit your space when you collapse the fridge body to save the wastage space and to reducing your energy use .

Shelves arrangements
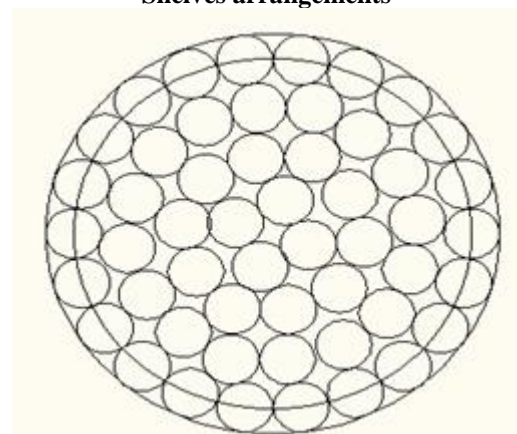
Bottles arrangement in Circular Shelves (52)
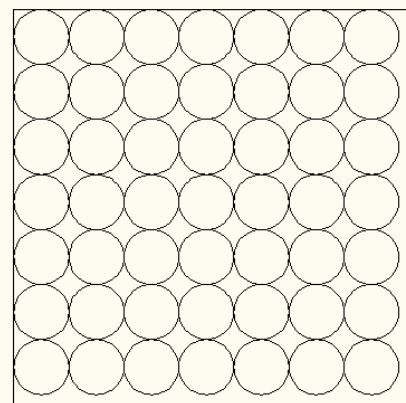
Bottles arrangement in Circular Shelves (52)
Figure 4: Shelves arrangement

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2.3 Sliding Glass Door

Proposed refrigerator is designed with concept for space optimization in crowded room and to save energy. The refrigerator with glass door that lets you see what your fridge holds. Outer door will be a made up of clear frosted glass. You will get to know whether the fridge is on without opening the door. The light switch will on and off when you open the door. The glass door slide into the cylinder foot print and save space to access the refrigerator. Space required accessing the refrigerator in present fridge

Table 2.8 calculation volume use to access the Door

present design		Proposed design	
l	531.7361553	R	340
w	531.7361553	t	8
H	1329.340388	h	1500
$V(mm^{3)}$	295201434.3	V	12096000
Difference in volume	283105434.3		
% save in volume	**2340.5**	%	

The fridge not only looks great but also save about **2340.5%** of volume to access the door. Also save energy with its ergonomic design. Present refrigerator use 2304 (proposed design door) volume at doors.

2.4 Water Compartment/Chamber

The refrigerator is designed keeping in view the energy that get wasted with the opening of the door for water bottles. The fridge is designed to minimize the flow of cool air outside. Water compartment great help to prevent flowing of air and also help in regaining temperature after closing of the door.

It is divided in sections, where the bottom section is for ice chamber and top section is cooled using normal or vapor compress refrigeration. Middle section is made up of heat insulating material with 3 adjustable shelves to keep your food / eatables cool.

Water is supplied to refrigerator by direct connection from RO of any other reservoir will store at the top of the compartment.

Also help in regaining the required temperature in the refrigerator through convection and transfer cooling from top toward bottom within effect of gravity. It will not use extra energy in cooling.

3. Scope for the Future Research

We are study on addition for this design .That design will collapse to fit the space and save energy as well. In this fridge you can increase the volume and reduce the volume as per our needs, it will save energy also reduce the cooling time so that we can attain the required temperature in less time. When there is no eatable item or less food inside the fridge. You can collapse it thereby saving upon energy and space. We may use sliding mechanism to collapse the body of the refrigerator. Also study on the efficiency of the machine

4. Conclusion

1) Increase of **12.84%** in total volume in proposed design as compared to present design.
2) Increase of **2.78%** in useful volume to the total volume in proposed design.
3) Mass of material used for making body decreased by **10.69%** in proposed design.
4) Stress concentrates and leakage reduce at corners.
5) Useful volume at shelves increased by **5.99%** in proposed design.
6) Shelves can **rotate**, allowing user to easily access items and accessible to any area.
7) Shelves are capable of **changing heights** or say can flips up and down easily.
8) Save about **2340.5%** of volume to access the door.
9) Water compartment **prevent flowing** of air and also help in regaining temperature after closing of the door.

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