

# Composite Wall Principle Based Energy Saving Machine for Dairy Industries

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**Abstract** – The project is principally based on providing an alternative method for saving time as well as energy required to melt the butter blocks for the ghee production in dairy process industry. The present method of butter melting has many disadvantages which are tried to overcome by us. Now a day the melting in each dairy plant is carried out in melting vats, by heat exchange phenomenon using high temperature steam. This system has too many losses of energy and more labour work as well as more time which are considerably affecting the overall production and profit of the dairy plants. In this project we are providing a unit which is able to melt the low temperature hard butter blocks with preheating so that there is saving in time required for further melting of the butter for ghee production. Also, it can minimize the heat energy (steam) required for melting of the butter by providing more surface for heat exchange of butter blocks.

**Keywords:** Composite Wall principle, Preheating, Milk Process Industry.

## I. INTRODUCTION

Ghee is one of the most popular milk products all over India. Since time immemorial, ghee has been used in Indian diet as important source of fat. Ghee, the Indian name for clarified butter fat is obtained by heat clarification and desiccation of sour cream, cream or butter. Because of his characteristic flavor and pleasant aroma, besides being a source of fat-soluble vitamins ghee occupies predominant position amongst milk product in India.

Ghee means pure heat clarified fat derived solely from milk or curd or from desi butter or from cream to which no coloring matter or preservatives has been added.

## II. OVERVIEW OF GHEE PROCESSING

The principle involved in ghee preparation includes concentration milk fat in the form of cream and butter, followed by heat clarification of fat rich milk portion and thus

reducing amount of water less than 0.5%. The brown colour residue (curd) is then removed as ghee residue from clarified fats.

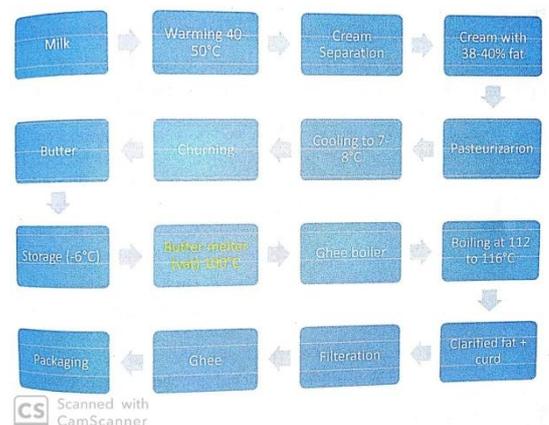


Figure 1: Ghee Processing

## III. DETAILS OF PRESENT BUTTER MELTING PROCESS

### 3.1 Present Procedure

After the production of butter blocks, they are stored for 5-6 month in cold storage room. After that these blocks are used for the production of ghee. For production the melting of the butter is mostly done in conventional butter melting vats.

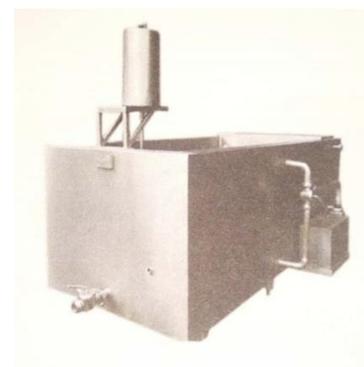


Figure 2: Ghee Melting Vat

The melting vat shown in the image consists of internal tubing in the side walls. The steam of about 150°C is passed through these pipes so that heat transfer, the heat reaches to the surface of well. The temperature of well surface is about 100°C. Very large amount of heat energy of steam is lost during this heat transfer. Two workers are employed for feeding of the butter block (1 block of 20kg) of -6°C temperature of the melting vat. Also, some butter blocks are cut into two pieces manually by using a cutter by two workers. For uniform melting of the butter in melting vat one other worker is also employed for constant stirring. The total time required for the melting process exceeds about two and half hour. This large time required is a result of less amount of butter surface available for heat exchanges.

This melted butter is then supplied to the ghee boiler where it is further heated up to temperature 140°C to separate the water content as well as the ghee residue. This further processing is also carried out with the help of high temperature steam. After this by carrying out with filtration, the pure ghee is produced.



Figure 3: Butter Cutting Cutter

### 3.2 limitation of present Method

The present method of butter melting has various disadvantages/ limitation as a result the entire ghee production becomes uneconomical with respect of Energy, man power, and time. This causes the poor use of available resources like Money, Fuel and labour.

These Limitations are mentioned below:

#### a) More heat loss

During the heat transfer through the steam walls a large amount of heat energy is lost to the surrounding. Also, heat is lost through the upper opening of melting vat as shown in the image. The temperature of steam supplied to it is about 150°C. But the surface temperature of wells of melting vat reaches only up to 100°C.

Thus, a large amount of the heat is lost during the melting of butter blocks.

#### b) More time loss

In present method of butter melting large butter blocks of mass 20kg is fed manually in the melting vat. Thus, very less surface of butter block is available for heat exchanger between steam and butter blocks. As the time required for heat exchanger is inversely proportional to the surface area available for heat exchange, the time required for heat exchange i.e. melting of butter is more. Hence time losses are more.

#### c) Drawback Cycle Continues

In the present method of butter melting, more amount of the heat energy generated is lost to surrounding as explained. As the heat loss is directly proportional to time required for butter melting, the increased amount of heat loss also increases. This heat loss further increases the melting time and cycle continues.

This drawback cycle starts at beginning of the butter melting and continues till the end of process. This drawback cycle is the most considerable disadvantage of the present method causing low production rate.

#### d) More Labour Required

In present method for butter melting in ghee section total 5 workers are required. Out of which two workers are employed for manual feeding of large butter blocks into melting vat, two workers are employed with manual cutter which has its own limitation and one employed for constant stirring. Thus, only for one operation of butter melting total 5 workers are employed.

#### e) Lack of Systematic processing

In present method there is lack of systematic arrangement as a result the labour is not able to work with full working efficiency. Due to this there is also lack of coordination between workers.

#### f) Increased Fuel Consumption

Due to more heat loss heat fuels loss the fuels required for steam production also increases. The other resources employed for steam production are also required for steam production are also required in more quantity such as water, etc.

**g) Increased Production Cost**

Due to more heat losses and time required for melting of butter, the drawback cycle continues and it effects the production, Due to a greater number of labours required the cost of ghee production increases. Also increased fuel consumption result in higher production cost of ghee.

**h) Reduced Rate of Production and Efficiency**

Due to increased production cost and reduction in production caused by more melting time and more heat loss, rate of ghee production and efficiency pf process is reduced to greater extent.

Along with this method of butter melting in melting vat to reduces the time required for butter melting, another method is implemented for cutting the butter into two pieces by dairy engineer has the following disadvantage:

- One block can be cut into two pieces only.
- Large force is required to be applied for cutting.
- Large amount of butter is wasted during cutting to improve handling.
- Two labours are required to be employed for cutting one block.
- Due to large cutting force required labour get fatigue.
- More chances of accidental hazard and injury to the worker.

**IV. MANUFACTURING PROCESS OF PROPOSED UNIT**

In order to avoid or minimize these limitation and economical loss of dairy industry we proposed the project work to solve problem of energy loss, time loss and provide the great economical benefit to the organization. To do this we developed a completely new and innovative idea for the process of butter melting. This most economical alternative method which is able to use for melting of butter for ghee production.

**4.1 Working Principle**

The proposed method is principally based on providing a best suitable alternative foe butter melting. Here in this project we try to overcome all the functional losses in the present method.

The working principal of proposed project work is,

1. The rate of heat exchange id directly proportional to the surface area available foe heat exchange.

2. The rate of heat exchange is inversely proportional to the time required for melting of butter.
3. The time required for melting of butter is directly proportional to amount of heat loss.

Thus, from the above statement it is clear that if the surface area of the butter block for heat exchange 4increases, the rate of heat exchange increases and the time required for butter melting decreases as a result the amount of heat loss decrease.

Thus, by using this principle we can minimize the heat loss by cutting of butter with electrical preheating. In this unit heat is transferred from aluminum heating coil to stainless steel blade and further to butter block. Due to this the solid butter is converted into aqueous, molten butter and ready for further processing.

**4.2 Construction**

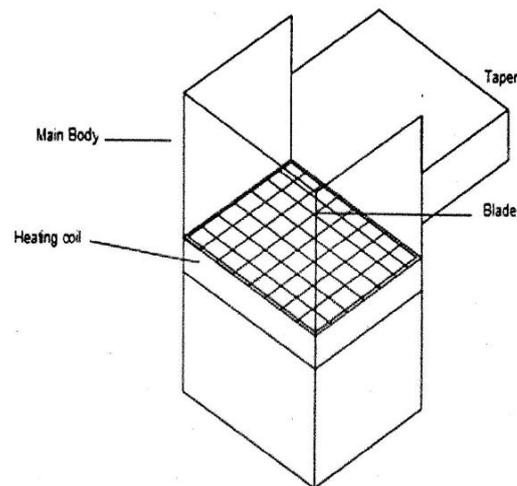


Figure 4: Construction Diagram

**4.3 Construction Details**

The construction of proposed unit for butter melting is as shown in the figure. The unit consists of various important components. Each component along with its overall specification and function it as mention below.

**a) Main body**

In this unit, to avoid the contact between butter and surrounding, hollow rectangular construction is done. This main body of the unit is very useful to minimize the heat loss to surrounding. The outer surface of main body is provided with a dense covering of glass wool to avoid the heat loss to the surrounding.

Material Used: Stainless steel (AISI 300 Series)

These grades of stainless steel have chromium (approx. 18 to 30%) and nickel (6 to 20%) as their major additions. A type 300 is the most widely used alloy of all stainless steel. 300 series stainless steel alloy resist corrosion, maintain their strength at high temperature and are easy to maintain.

**b) Glass Wool**

Glass wool is a thermal insulation that consists of intertwined and flexible glass fibers, which is used to prevent the outer human contact surface of the unit the low temperature for worker convenience and to avoid the loss of heat to the surrounding.

**c) Blade**

The main function of the blade is to provide a large contact surface area for heat exchange. The blade is used to cut the butter block with preheating. As a result, the butter gets melted after passing through this blade.

The blade is heated by using electrical heating and principle of heat transfer. The heat is transferred from electrical heating coil to the walls of blade and then after half an hour the temperature spreads evenly all over the blade.

Material Used: Stainless steel

As the blade comes directly in contact with the butter (food stuff), stainless steel of AISI300 series is used for the blade, as it has following properties:

- a) Non corrosive
- b) High strength
- c) High melting point
- d) Better than transfer rate [16-20W/ (m.k)]

**d) Heating coil**

For the purpose of heating, two electrical heating coils of capacity 1.5KW are used. These heating coils are covered with mica steel completely shock proof electrical heating coils are plated with aluminum steel to increases heat transfer rate. As the heating coils will not come will in direct constant better, aluminum is allowable.

As per the principle results, the heating coil reaches the temperature of 100°C within 15 min. To heating coil, the electronic controller and actuator arrangement is provided. The sensor is connected to the blade which senses the temperature of blade and displays panel. A 230V 50HZ AC supply is required for the purpose.

**e) Taper**

It is provided to keep the butter block for unwrapping. This part helps to achieve the conversion in the operation for the worker to feed the butter blocks of 20Kg for melting in the right way.

Material used: Stainless steel is used.

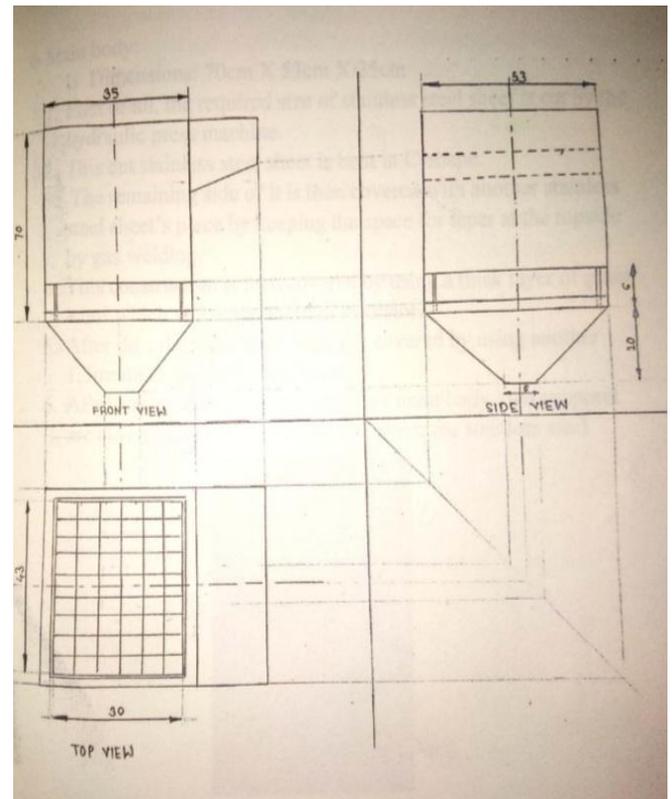


Figure 5: Design cum Assembly

**V. INDIVIDUAL COMPONENT MANUFACTURING PROCEDURE**

**5.1 Main Body**

Dimension: 70cm X 30cm X 35cm

- First of all, the required size of stainless-steel sheet is cut by the hydraulic press machine.
- This cut stainless steel sheet is bent in C-shape.
- The remaining side of it then covered with another stainless-steel sheets piece by keeping the space for taper at the topside by gas welding.
- This construction is then covered by using a thick layer of glass wool which will act as thermal insulator.
- After this, the main body is finally covered by using another 1.5mm thick stainless-steel sheet.

- After completing this construction of main body, two supports are also attached at the bottom to support the stainless steel.



Figure 6: Main Body

- Then electric circuit by using the controller and actuator with the help of electrical wires and other small components is built.
- Then this assembly is placed in the stainless-steel main body.



Figure 8: Heating Coil

### 5.2 Blade

Dimensions: 43cm X 30cm

- For the construction of blade, first of all the stainless-steel sheet is cut into 7 strips of dimension 43cm X 6cm and 10 strips of dimension 30cm X 6cm.
- A sharp cutting edge is then provided to these strips from one side by grinding.
- After these strips are meshed together by slotting and welding to form a blade like structure.
- At last a final finishing of the blade is done by buffing and polishing.



Figure 7: Blade

### 5.3 Heating Coil and Electrical Circuit

Dimensions: 6cm X 70cm (2 nos.)

- After completing construction of stainless-steel blade, the heating coils are attached to it by using nut bolt arrangement.
- Then this assembly of blade and coil is ready for service.

### 5.4 Taper

Dimensions: 44cm X 25cm

- A piece of stainless-steel sheet of dimension 44cm X 25cm is cut for this part by using a hydraulic press machine.
- Then, a plate of mentioned dimension is attached at the fourth side i.e. front of the main body where a space is kept for it.
- This plate is gas welded to the main body at an angle of 45° with the horizontal.
- This taper plate helps to sit the butter block of 20 kg for unwrapping it before it is subjected to melting.
- This provides a systematic arrangement for feeding the butter block into the unit.

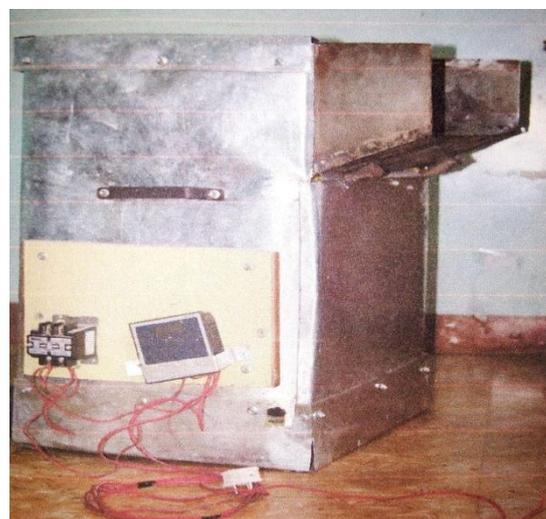


Figure 9: Taper

### 5.5 Funnel

- Here four pieces of stainless steel are cut by using a hydraulic press machine in a required dimension.
- Then these pieces are formed by hammering and bending.
- These pieces are attached with each other by screwing.
- The funnel is completely leak proof and the main purpose is to collect all the molten butter at less area.

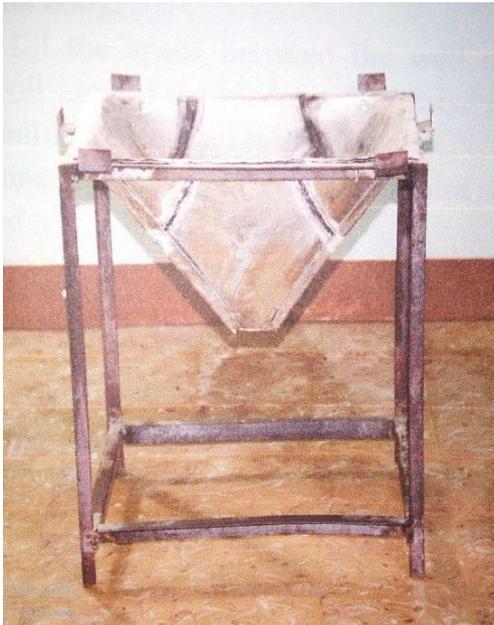


Figure 9: Funnel

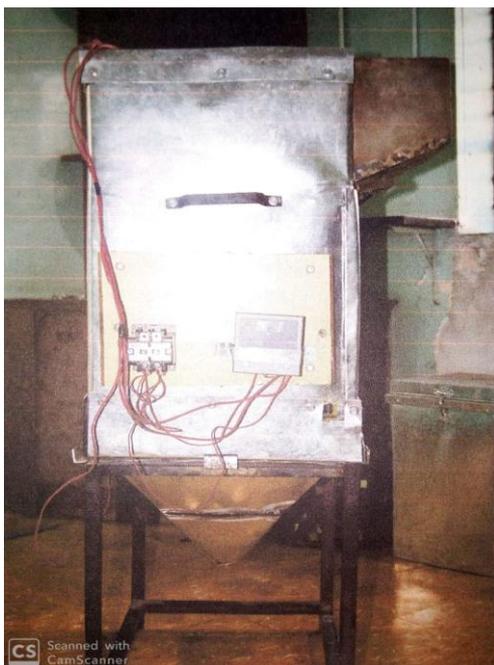


Figure 10: Assembled Machine

### VI. WORKING OF THE UNIT

- First of all, switch on the electric supply of machine.
- Once the supply is switched on, the heating coil starts heating by resistance heating phenomenon.
- After about half an hour, the temperature of coil reaches up to 150°C, then the controller will cut off the circuit as the set temperature is 150°C.
- It takes about 45 minutes to transfer the heat from the coil to the stainless-steel blade.
- And thus, the blade gets heated evenly.
- As soon as the blade is heated, the display will show the temperature reached.
- When the blade becomes hot sufficiently, the butter block is kept on the taper plate provided to the unit.
- Then the worker will start unwrapping the butter block when it is kept on the taper and then he will push the block in the unit in correct manner.
- Once one block of 20 kg is fed to the unit, other two blocks are also fed one after the other in the unit. This is done to increase the total weight on the lowest butter block, so that to increase the rate of melting.
- Once butter block comes in contact with the hot air which is enclosed in the unit, the heat is transferred from the hot air to the hard butter block of -6°C temperature and as a result it starts to become very soft. Thus, the melting becomes easier and fast.
- The air inside the unit is maintained at high temperature by preventing the heat loss to the surrounding by using glass wool covering.
- As soon as the butter block comes in contact with the 125°C temperature, sharp edged blade, it starts cutting.
- Due to the cutting, more surface of butter block becomes available for heat exchange.
- As a result, the butter block starts melting at this temperature.
- Then this molten butter will pass through the funnel whose inside surface temperature is already became very high due to which the small blocks which are in the stage of pre-heating are converted into molten butter.
- Through the funnel the molten butter can be collected in small container.
- Also, a provision can be made at the bottom opening of funnel to supply the molten butter directly to the ghee boiler by providing stainless steel piping.
- As the molten butter passes through the funnel it also gets heated.
- As this high temperature molten butter is supplied to ghee boiler, the heat energy required for further processing is also can be reduced to great extent.

## VII. RESULTS OF PROPOSED UNIT

### 7.1 Cost cutting Calculation

700kg butter block requires 325kg steam for melting.  
 i.e. 20kg butter block requires 9.28kg steam  
 Rate of the steam production: - Rs.1.5/1 g steam  
 The cost of melting 20kg block =  $9.28 \times 1.5 = \text{Rs.}13.92$   
 By testing we get following financial savings,  
 1 Cm butter cuts in 30sec.  
 The total time required to melt the butter block of  
 22cm height =  $22 \times 30 = 660$  sec. i.e. 11min.  
**Time required for 20kg butter block is 11 min.**  
 The consumption of Electricity by our unit is 3 unit/hour.  
 The consumption of electricity per 20kg block can be given as  
 $60/3 = 11/x$   
 $x = 0.55$  unit/20kg  
 The commercial rate of electricity = Rs.5.06/unit.  
**Cost of melting /20kg butter = Rs.2.783**  
 Saving of cost per 20kg =  $13.92 - 2.783 = \text{Rs.}11.137$   
 Considering the total production of organization,  
 Total production = 2000kg/day  
 i.e. 100blocks/day  
 Saving per day =  $150 \times 11.137 = \text{Rs.}1670.55/\text{day}$   
**Total saving in cost per year = Rs.6,09,750.75/-**  
 Considering labour charges,  
 Present system needs 5 workers  
 Charges/year =  $(300 \times 365) \times 5 = \text{Rs.}5,47,500/-$   
 Our unit needs only one worker,  
 Charges/year =  $300 \times 365 = \text{Rs.}1,09,500/-$   
 Total saving in labour charges due to our system  
 =  $5,47,500 - 1,09,500 = \text{Rs.}4,38,000/\text{year}$   
 Total saving due to our system,  
 Total saving =  $6,09,750.75 + 4,38,000 = \text{Rs.}10,47,750/\text{year}$

### 7.2 Advantages over Existing System

Advantages are as follows:

**a) Minimum time consuming Method:** In the present method, the time required for complete melting of one butter block weighing 20 kg is about 2 hours. The new designed method of melting consumes only 11 minutes to melt the butter block of 20 kg. Thus, about 109 minutes are saved, if four units of same design runs at same time. The time saving in process industry is most considerable advantage of this unit.

**b) Minimum Energy loss:** As the time required for melting is reduced to a great extent, the heat energy loss to the surrounding which is directly proportional to melting time is also reduced. In the present method of melting, steam is used for melting purpose through heat transfer which has more energy losses. Thus, more energy is required. Whereas in the

new method, electrical heating is used for melting purpose where very less amount of heat energy is lost to the surrounding.

**c) Minimum energy consumption:** The melting by using the electrical heating method consumes very less amount of energy as the heat loss and the time required for melting are reduced to great extent.

**d) Minimized labour work:** In the present method, about five workers are required but in the proposed method of butter melting, the labour can be reduced to one due to a systematic method of cutting and melting with preheating. Thus, the labour cost can be saved.

**e) Minimum operation cost:** As explained in the previous calculations, the present method of butter melting requires Rs.13.92 per 20 kg butter block. Whereas by using electrical heating method, this cost can be minimized to about Rs.2.783 per 20 kg butter block. Also, the labour expenditure is reduced from Rs.5,47,500 to Rs.1,09,500 with total saving of Rs.4,38,000 per year in the form of worker salary.

**f) Minimum handling and wastage of butter:** In the present method the butter is handled by five labors is reduced to the handling by one labour only which results in less wastage of butter. A lot of butter is wasted in the present manual method of butter cutting due to more human handling involved and by adhering to the cutting blade of manual cutter. This wastage of butter is greatly minimized in the new method of butter melting.

**g) Labour Safety and comfort:** In the present method, there are chances of human injury while cutting the block manually and also a very high cutting force is also required to be applied by the worker to cut the butter. It causes fatigue to the labour. In proposed method of melting, there are less chances of human hazard as the labour do not come in direct contact with the hot, sharp edged blade. Also, no cutting force is required to be applied by the worker and hence it results in better comfort and safety of labour.

**h) Increased production rate:** As the present method of butter melting consumes more time and money, this method is not fully capable for the efficient use of available resources. The production rate of the ghee is totally depending upon the melting rate of ghee as a result by increasing the melting; the production rate of ghee is increased.

**i) Increased efficiency of production system:** In the proposed method, the melting of the butter is carried out by using minimum energy. Also, the labour work is reduced to a greater extent as a result the production cost is also reduced to above

Rs.10 lacs. And thus, by reducing the cost of production for the same amount of production the efficiency of the production system is improved to greater extent.

### VIII. LITERATURE REVIEW

In this project, we are going to introduce an alternative method for melting of butter for ghee production. During our summer holidays, we visited some milk processing plants for observing the production system of milk products. At that time, we found that the process of melting of butter for ghee production is manually operated, very time consuming and uneconomical. This conventional process of butter melting has limitations with respect to huge energy loss and labour work.

The present butter melting is carried out in melting vat which works on the principle of heat exchange. But in this method, the high temperature steam is used for melting. This steam is produced conventionally in Fire type steam boiler and this steam is then supplied to melting vat through pipeline. The steam required for melting 20 kg butter block is about 9.28 kg as per technical information supplied by industry, this steam costs about, Rs.13.92 per 20 kg. Also, lack of systematic production causes involvement of about five workers for one task of melting.

In order to save the energy, time and labour work involved in the process of butter melting, we started research on another alternative of butter melting. We found that the use of electrical heating method for melting can save the time and energy. As per the sample calculations considering the total as 3 tons per day, Rs.10 lacs can be saved per year. In the proposed method, the heat is generated by resistance heating method.

### IX. RESULT ANALYSIS

By the chemical testing of the molten butter produced by using the proposed method, it is clear that the resultant product is not hazardous for human consumption and ready for further process. The organization has certified quality of molten butter.

### X. CONCLUSION

Our project work is completely successful by providing energy saving thereby cost cutting. It is thus concluded that by using the electrical preheating method for heat generation on composite wall principle applied for the melting of butter, for ghee production, the melting cost is reduced by about 80%. Also, by using proposed melting unit, the labours are reduced

to 80% saving the cost, of the present melting process. Thus, by using the proposed unit the production rate of the system and also the efficiency of ghee production unit is improved almost double.

This project is highly appreciated and certified by for its usefulness to DIPEX Competition as well as top authorities of some industries during this competition.

### XI. FUTURE SCOPE

It has a vast and wide scope to develop the similar solutions as per the need of individual industry. This has large scope all over India for the similar industries. We did the cost cutting and energy saving modifications in the co-operative Milk Processing Industry, established in 1968. The most of units used for milk processing are conventional and have some limitations. It is very difficult to modify this conventional machinery as it is process industry.

In future, we will visit other plant located all over India, and try to propose the solution for the respective problem of butter melting. We will utilize the principle of electrical preheating and heat transfer through composite wall principle as a modification to their present butter melting process. By providing an alternative method, we will try to save energy required for melting. As the heat energy is saved, it tends to save fuel consumption by steam boiler. Thus, we will try to solve the global problem of increased fuel consumption.

### REFERENCES

- [1] Dairy Product technology textbook, class XII, CBSE.
- [2] Textbook of Machine Design by V.B. Bhandari.
- [3] USDA (United States Department of Agriculture) Guidelines for the Sanitary Design and Fabrication of Dairy Equipment.
- [4] FSSAI (Food Safety and Standard Authority of India) Guidelines.

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