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A Study on Heat Enhancement of Plate Heat Exchanger Working Efficiency by using Turbulators in Dairy Milk Pasteurization System

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Abstract

The working plate heat exchanger efficiency of Bihar Sahakari Dugdh Sangh by placing different turbulators (Twist tape turbulator, Brock turbulator, and Wire turbulator). in the inlet hot water pipe. We got the working efficiency of Plate Heat Exchanger in these turbulators are 71.01%, 62.64%, and 63.31. The experiments proposed for counterflow models of the fluids. After modification by turbulators in the Plate Heat exchanger set up, we got that Twist turbulators are better turbulators than other turbulator. Then we again find working efficiency on different pitches of better turbulator. The working efficiency becomes on different pitches are 71.9%, 63.26%, and 62.97%. We compared this modified working efficiency without the modified working efficiency of the plate heat exchanger which used in Bihar Sahakari Dugdh Sangh. We got that the working efficiency of the Bihar Sahakari Dugdh Sangh plant is increased by placing a twist-tape tabulator in the inlet hot water pipe, and it is also dependent on the pitches.

Keywords:

Keywords: heat exchangers, turbulators, space heating, refrigeration, air conditioning, Plate Heat Exchanger

1. INTRODUCTION

The heat exchangers are generally utilized in procedure control to advance or extinguish synthetic responses (by warming or cooling, separately). The sustenance business utilizes warming to murder pathogen microorganisms (sanitization), either after canning or before bundling; the last is most helpfully made for fluid stuff in warmth exchangers. Sanitization, for example, the inactivation, all things considered, requires high-temperature handling, commonly at 120 ºC or more (for example under strain, for watery stuff); to execute even the safest spores. In the sanitization procedure, in any case, speedy warming to 60 ºC or 70 ºC is connected to murder most microbes without protein denaturing, yet different microorganisms remain, what infers that fast cooling after purification is required (what makes warmth siphons so helpful), and that vacuum or refrigeration is required a short time later. The ideal opportunity for-sanitization (or for cleansing) relies upon the microorganisms and the holding temperature.

1.1 Classification of the Heat exchanger

1.1.1 Plate warmth exchangers

A plate heat exchanger, PHE, is a smaller warmth exchanger where slim ridged plates (some 0.5 mm thick, twisted 1 or 2 mm) are stacked in contact with one another, and the two liquids made to stream independently along contiguous directs in the crease. The conclusion of the staked plates might be by cinched gaskets, brazing (for the most part copper-brazed tempered steel), or welding (hardened steel, copper, titanium), the most widely recognized sort being the first, for simplicity of review and cleaning. Furthermore, a casing (end-plates and fixing bars) verifies together the plate stack and connectors (now and then PFHE, representing plate-and-edge heat exchanger, is utilized rather than PHE). Plate get together is outlined in underneath fig. Appropriate channels, once in a while helped by the gaskets, control the progression of the two liquids, and permit parallel stream or cross-stream, in an ideal number of passes, one pass is generally utilized. They have huge conductance coefficients (up to K=6000 W/(m2•K) for fluid to-fluid use), are preferably appropriate for low-thickness liquids, the number of plates can be acclimated to the requirements, and the exchange surface open to cleaning (the last two favorable circumstances just for gasket gatherings; regardless, the gaskets ought to be changed whenever got off). The anticipated zone of plates is normally taken as the ostensible warmth exchange zone, despite the genuine bent surfaces and lost space in gaskets and ports.

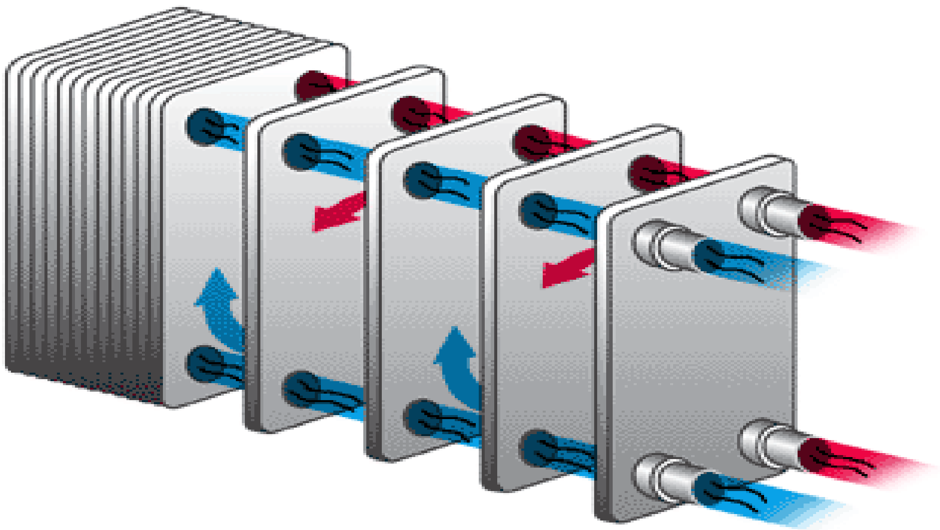


Fig.1.1 Heat exchanger's Plate

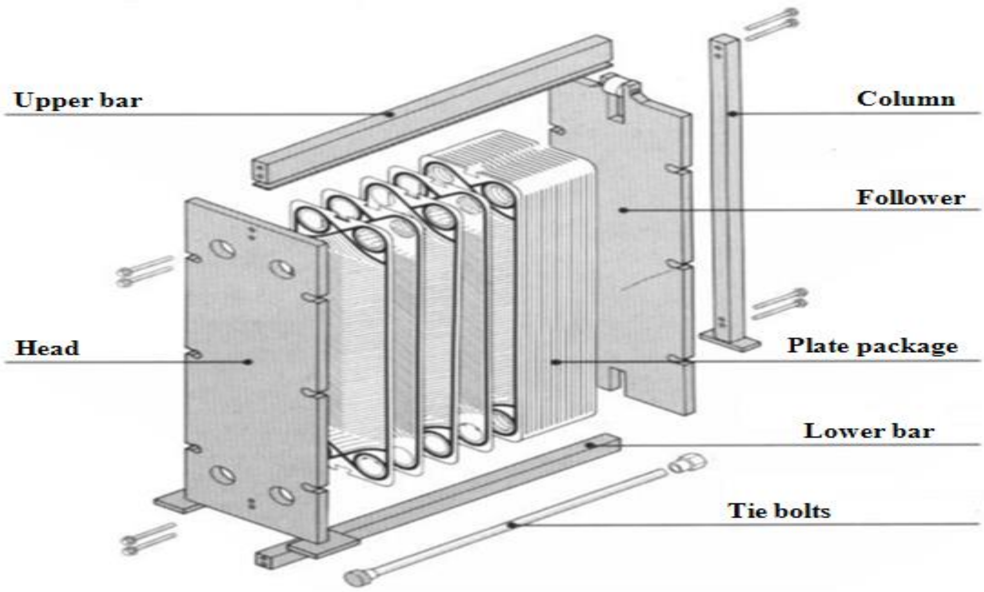


Fig.1.2 Flow design in arrangement Plate Heat exchanger

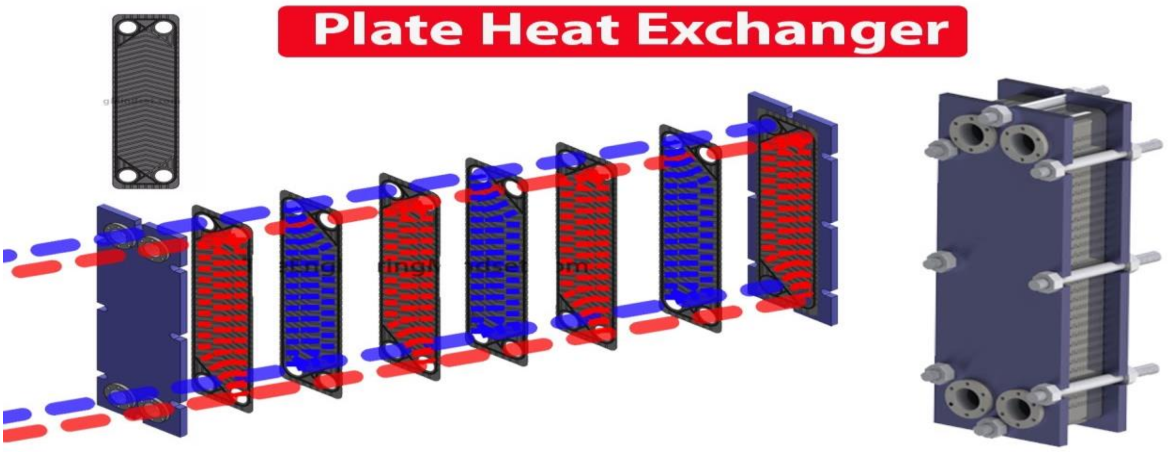


Fig.1.3 Plate heat exchanger

Civic chairman restrictions in PHEs are most extreme permitted weight (typically underneath 1 MPa, even though there are plans with 4 MPa), temperature run (normally constrained to 150 ºC by the gasket material, even though structures are permitting 400 ºC), and prize (however brazed PHEs are about the half price of workable PHEs). Albeit run of the mill, PHE application is in fluid to-fluid warmth exchange, exceptional plate plans have been produced for stage change applications. Higher working weights and still goof warm execution can be accomplished with half and half plate-shell heat exchangers, where a plate stack is welded inside a shell (for example a sort of THE with plates rather than cylinders). The PHE was created during the 1920s in the sustenance business (for the sanitization of milk), yet they are assuming control over all business sectors now in light of its minimization and effectiveness (3 to multiple times more than THE). They are utilized for procedure warming, cooling, in every cryogenic application, and as a middle of the road venture in local water radiators, where consumable boiling water (hot faucet water) is delivered in a halfway warmth exchanger from shut circle fuel-terminated boiling water, to limit strong testimonies. PHE is frequently named CHE (smaller warmth exchangers), even though the word minimized can be added to a warmth or mass exchange unit with an explicit region $>10^3$ m^2/m^3.

1.1.2 Merit and the bad mark of plate heat exchangers

The upsides of plate blade heat exchangers over cylinder balance, shell and cylinder and different sorts of warmth exchangers are:

1. The high incentive for by and large warmth exchange coefficient, U - For a similar two liquids, a level plate heat exchanger commonly has a U esteem a lot higher than either a shell and cylinder heat exchanger or a winding warmth exchanger.
2. Compact structure - The mix of high an incentive for the general warmth exchange coefficient and the general conservative arrangement of the level plate heat exchanger leads to its capacity to have a similar warm limit as a shell and cylinder heat exchanger as much as multiple times its size
3. Easy support and cleaning - The way that a plate and edge heat exchanger can be dismantled as examined in the past segment, takes into consideration simple cleaning and upkeep. A plate and casing heat exchanger can be intended to take into account simple expansion or evacuation of plates to extend or lessen its warmth exchange limit.
4. Temperature control - A level plate heat exchanger functions admirably with little temperature contrast between the hot liquid and the cool liquid.

Since the plate heat exchanger is commonly comprised of aluminum, the coefficient of warm conductivity is high and when the plate blade heat exchanger is worked beneath total zero, its malleability and rigidity can be improved.

1.1.3 The inconveniences of the plate heat exchanger are:

1. In plate heat exchangers, stream-entry is small to the point that the warmth exchanger square causes a decrease in weight. Alongside this, once the soil is shaped, the undertaking of cleaning and upkeep is troublesome.
2. It is important to see that warmth exchanger material ought not to be inclined to erosion.
3. In plate heat exchangers, if spillage between the entries happens, at that point it is hard to fix this.

1.1.4 **Selection of material**

The compounds of aluminum are the most appropriate material and are incredibly utilized for the assembling of plate balance heat exchanger. Hardened steel is additionally utilized for the assembling of plate balance heat exchangers. Be that as it may, the choice of the material relies upon the procedure temperature and weight. For the application in low temperature or cryogenic applications, the aluminum combination is broadly utilized in plate balance heat exchangers because of its low weight, high pliability, and expanding quality under low-temperature conditions. The blades and the sidebars (optional surfaces) are united with the isolating plates by vacuum brazing methods or by utilizing a plunge brazing strategy. An aluminum composite of a lower liquefying point is the brazing material for the aluminum-made warmth exchangers. Be that as it may, a nickel-based amalgam with a reasonable liquefying point, and having great welding qualities are utilized for hardened steel made warmth exchanger.

1.1.5 Manufacturing of the plate heat exchangers

In the assembling procedure of the plate heat exchangers, the fundamental standard is the same for all materials and all sizes. Initial various level sheets are set one above other and the folded plates are amassed like a sandwich development. The separating sheets (the isolating plates) are the essential warmth exchange surface. To shape a limitation between each layer, the separating sheets are put in an elective way with the layers of the plates framing a stack. Every one of the components for example the partings sheets, sidebars, the foldings, and the top sheets are held together by a dance under a foreordained burden. At that point, for shaping a warmth exchanger square it is put in a brazing heater. At that point during the welding procedure to guarantee the brazed joints stay in contact or not, the spouts and the header tanks are welded to the square.

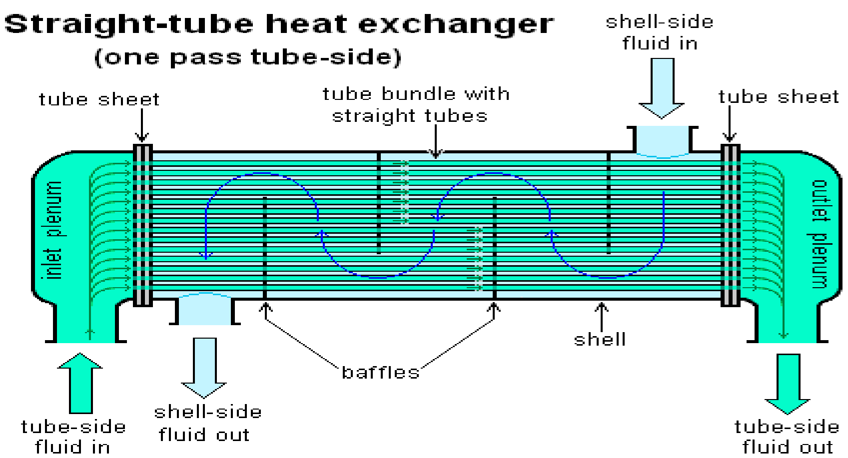
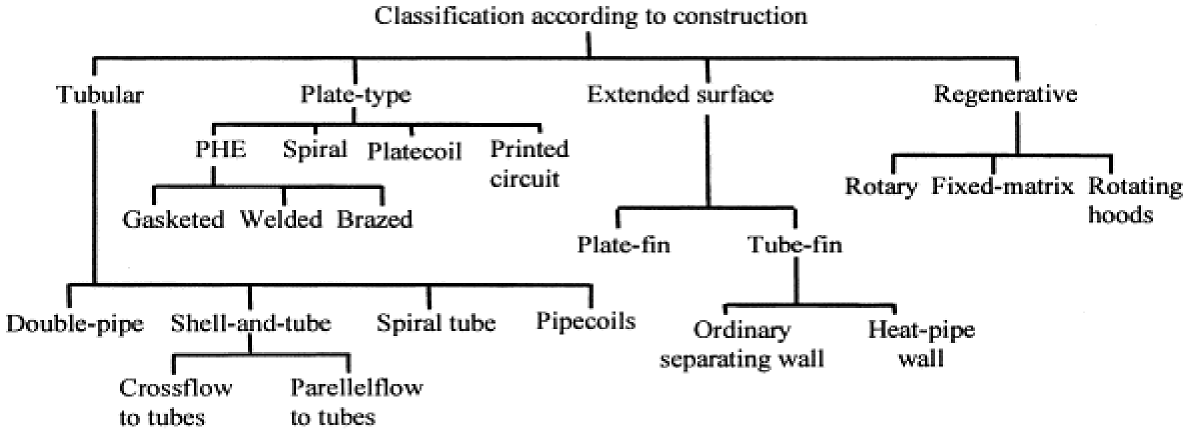
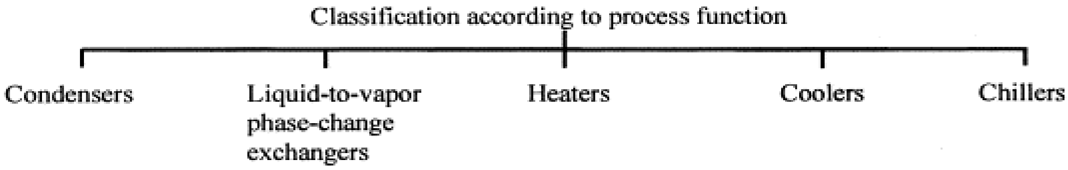


Fig.1.4 Heat exchanger



(a)



(b)

2. LITERATURE REVIEW

The heat transfer from primary fluid to secondary fluid is more than the modification system. It permits the temperature of fluid increase for some useful purposes in the manufacturing process. Various experiments were done in this area to enhance the rate of heat transfer to improve the efficiency of the system.

Tabish Alam et al [1] These paper are grouped into the active and passive method. In the active methods, the system needs some external power, however, passive method utilizes surface modification either on heated surface or insertion of swirl devices in the flow field. Active methods are very complex because of external power supply, although these methods have great potential and can control thermally. Passive methods include artificial roughness, extended surface, winglets, insertion of swirl devices in the flow which alters the flow pattern causes to disturb the thermal boundary layer, and consequently high heat transfer.

Chirag Maradiya, Jeetendra Vadher et al [2] This paper provides a comprehensive review of passive heat transfer devices and their relative merits for wide variety of industrial applications & the effectiveness of a heat transfer enhancement technique is evaluated by the Thermal Performance Factor which is a ratio of the change in the heat transfer rate to change in friction factor. Various types of inserts are used in many heat transfer enhancement devices. Geometrical parameters of the insert namely the width, length, twist ratio, twist direction, etc. affect the heat transfer.

Zhe Wang, Zan Wu et al [3] Firstly, the convective heat transfer coefficient (HTC) and pressure drop orrelations were predicted under the condition that water was employed as working fluid in both the hot and cold sides of the MPHE. Then, the effects of GnP concentrations of nanofluids on the thermal and hydraulic performances have been determined for the MPHE with the nanofluid in hot side and the water in cold side.

Atul Bhattad et al [4] In the present study, numerical as well as experimental investigations have been done on the plate heat exchanger using hybrid nanofluid (Al2O3 +MWCNT/water) at different concentration to investigate its effect on heat transfer and pressure drop characteristics. Discrete phase model has have been used for the investigation using CFD software and results have been compared with the experimental result as well as result of the homogenous model.

M.Thirumarimurugan et al [5] In this paper efforts have been made to study the performance of Plate type heat exchanger with miscible and immiscible systems. The experimental studies involved in the determination of outlet temperature of both cold and hot fluid for various flow rates. The water-water system, water-acetic acid system, water ethylene glycol system, water-toluene system and water- kerosene system at 9%, 10%, 20% & 25% composition were used to determine the performance of plate type heat exchanger i.e. overall heat transfer coefficient(U), effectiveness, cold side efficiency(c) and hot side efficiency(h).

Abhishek Nandan et al [6] This paper is presented to study the various theories and results given over the improvement of heat transfer performance in a plate heat exchanger. However, there is still a lack in data and generalized equations for the calculation of different parameters in the heat exchanger. It requires more attention to find out various possible correlations and generalized solutions for the performance improvement of plate heat exchanger.

M. Faizal et al [7] The corrugations on the plates enhance turbulence at higher velocities, which improves the heat transfer. The optimum heat transfer between the two streams is obtained for the minimum spacing of DX = 6 mm. The pressure losses are found to increase with increasing flowrates.

Dnyaneshwar B.Sapkal et al [8] This paper presents theoretical analysis of counter flow copper plate type heat exchanger and CFD analysis of pressure drop for milk and water over plate heat exchanger. The results of ANSYS validate results predicted theoretically. Knowing the hot and cold fluid stream inlet and outlet temperatures and mass flow rates of hot and cold fluid and respective heat capacities, and values of heat transfer coefficient.

Oana Giurgiu et al [9] The study presents a Computational Fluid Dynamics (CFD) numerical study for two different models of mini channels, included in plate heat exchangers structure. The influence of geometric characteristics of the two studied plates on the intensification process of heat transfer was studied comparatively. For this purpose, it was examined the distribution of velocity, temperatures fields and distribution of convection coefficient along the active mini channel. **Koen Grijspeerdt et al [10]** In this paper**,** the calculations can help identifying those regions where turbulent backflows and thus higher temperature regions near the wall can occur. These regions are the most sensitive to fouling and should be avoided as much as possible through better design. In this respect, CFD can be regarded as a valuable assistant for optimal designing of plate heat exchangers.

3. METHODS

A Plate Heat Exchanger is a type of heat exchanger that uses metal plates to transfer heat between two fluids. This has a major advantage over a conventional heat exchanger in that the fluids are exposed to a much larger surface area because the fluids are spread out over the plates.

A Plate Heat Exchanger is used in Bihar Sahakari Dugdh Sangh to pasteurize the milk, in dairy the hot water and milk flow in plate heat exchanger in the counter-flow direction to pasteurize the milk.

We analysed in plate heat exchanger which used by Bihar Sahakari Dugdh Sangh that the outlet pasteurization temperature of milk is fixed on 78°C but we observed that when the temperature of pasteurized milk become below 78°C, the pasteurized milk would not go for next process. It comes to the raw milk tank again to pasteurize. Therefore we observed that the working efficiency of plate heat exchanger is decrease. We used the twist turbulator to increase the working efficiency of plate heat exchanger by increasing the temperature of hot water. The hot water temperature increased by twist turbulator installed in tubular pipe before entering the hot water in plate heat exchanger.

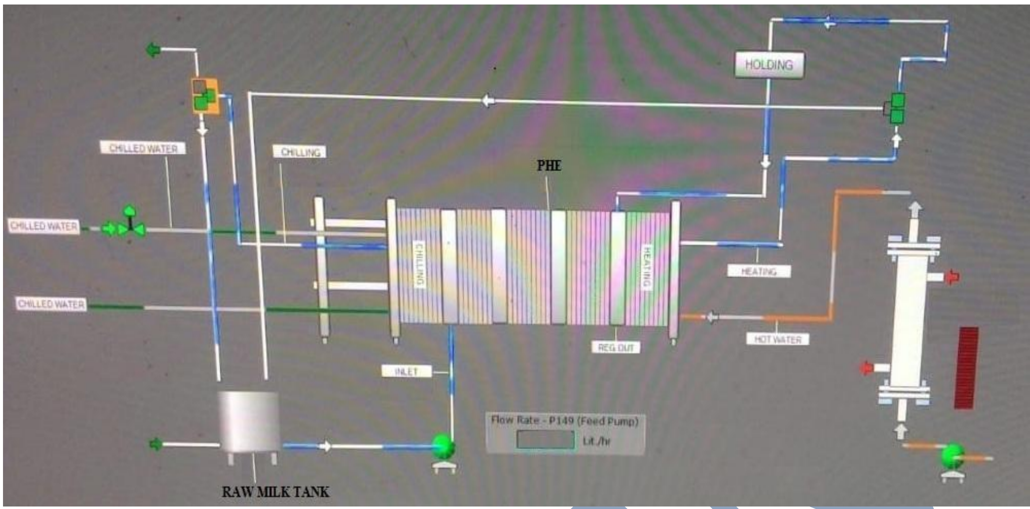


Fig. 3.1 Line Diagram of Plate Heat Exchanger used in BSDS before modified

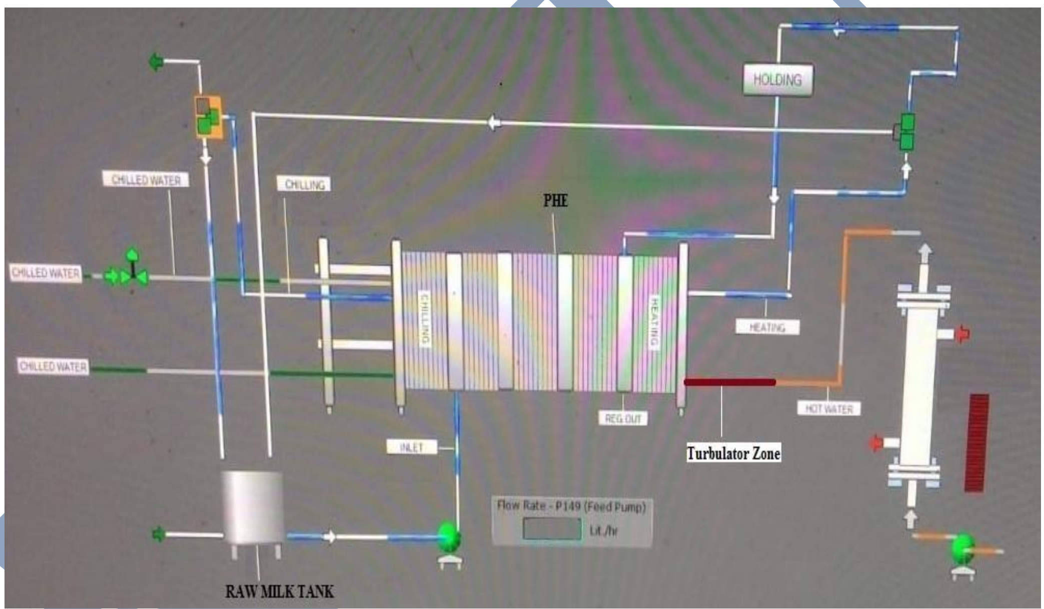


Fig.3.2 Line diagram of modified Plate Heat Exchanger used in BSDS

4. RESULT & DISCUSSION

The experiments were conducted without using any changes in hot water pipe in Plate Heat Exchanger in Bihar Sahakari Dugdh Sangh. It means that the actual working reading of Bihar Sahakari Dugdh Sangh and calculate the efficiency of pasteurization milk, and the same is done using different Turbulators and better turbulators of different pitches.

The experimentation was carried out with the inlet hot water pipe of plate heat exchanger without and with using Passive heat transfer enhancement methods by using twist turbulators. Overall heat transfer coefficient and Nusselt number are calculated for modification with pitch 1cm and without modification. Parameters were plotted for number of observation, these all graphs are plotted to compare the performance of with and without turbulators of different pitches used in inlet hot water pipe

4.1 Compare the calculated value with and without modification

Table 4.1 Comparison of overall heat transfer coefficient with and without turbulators

Observation no.	Heat transfer coefficient U ($w/m^2 °c$) without Turbulators.	Heat coefficient h ($w/m^2 °c$) with twist tape Turbulators (p =1cm)	Heat transfer enhancement factor(η)= (h with turbulators /h_w without turbulators)
1	305.09	845.09	2.77
2	314.15	989.57	3.15
3	349.35	849.35	2.43
4	339.46	839.46	2.47
5	331.41	947.83	2.86
6	321.89	821.89	2.55
7	307.67	907.68	2.95
8	328.67	928..67	2.82
9	311.56	937.21	3.01
10	284.78	924.78	2.96

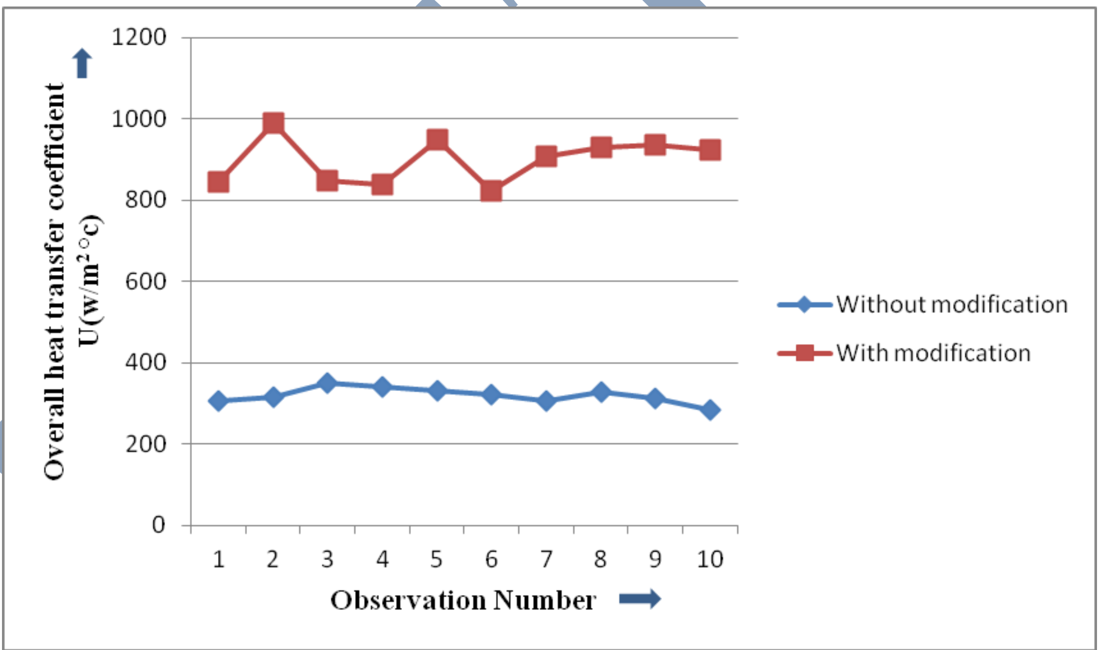


Fig.4.1. Overall heat transfer coefficient (U) Vs Observations Number

Table 4.2 Comparison of Reynolds number with and without turbulators

Observation no.	Reynolds number (Re) without Turbulators.	Reynolds number (Re) Turbulators (p =1cm)
1	6884.81	7032.57
2	6636.20	6684.52
3	6255.36	6543.45
4	6684.52	6855.98

5	6830.64	6947.53
6	6259.85	6725.63
7	6973.72	7130.05
8	6394.58	6939.80
9	6884.81	7074.29
10	6597.70	6770.49

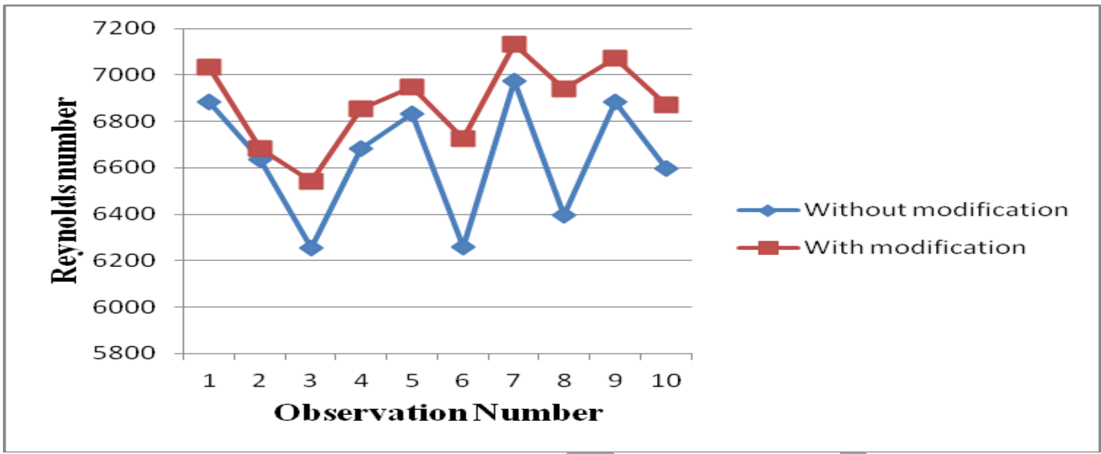


Fig.4.2 Reynolds Number (Re) Vs Observations

Table 4.3 Comparison of Nusselt number with and without turbulators

Observation no.	Nusselt number (Nu) without Turbulators.	Nusselt number (Nu) with Twist tape Turbulators (p =1cm)	Nusselt number ratio = (Nu with twist tape turbulators / Nu without turbulators)
1	28.50	85.5	3.00
2	29.40	87.40	2.97
3	33.06	99.18	2.43
4	31.75	84.77	2.67
5	30.99	70.96	2.29
6	29.78	78.62	2.64
7	28.72	81.56	2.84
8	30.88	80.91	2.62
9	29.11	78.95	2.67
10	26.57	76.52	2.88

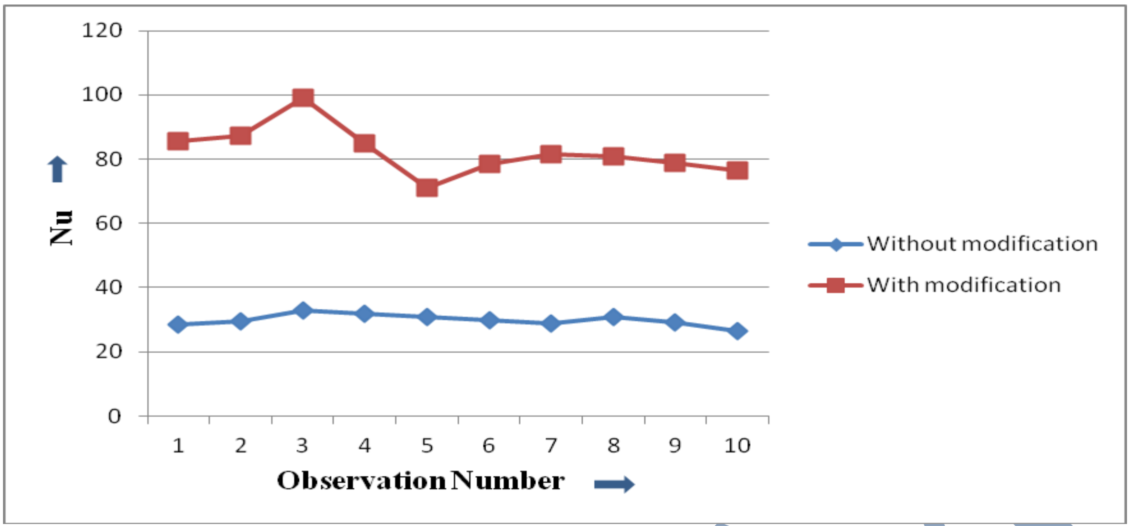


Fig.4.3 Nusselt Number (Nu) Vs Observation Number

5. CONCLUSION

The following conclusions of this experiment are:

(a)The experiment showed that there is a definite improvement in the rate of pasteurized milk by 71%. Thus the system efficiency is improved.
(b) The experimentation has indicated that the heat transfer is increased.

© The additional time for the milk pasteurization in Plate Heat Exchanger can be recovered by using the turbulators in the system.

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