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ENERGY LOSSES IN FOOD PROCESSING

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ABSTRACT

Thermal energy losses form heat unit; square units, cylinder units and discarded hot water in "one of dairy production plant" at 10th of Ramadan City were 1207.40, 105.66, 343.28 and 977.99 MJ/h, respectively. The thermal energy losses from steam pipes and exhausted pipes were 897.86 MJ/h and 239.09 MJ/h, respectively. The percent of thermal energy losses from horizontal steam pipes represents a percentage of 93.37% while vertical steam pipes thermal energy losses represents 6.63% of total thermal energy losses form plant steam pipes, respectively. The percentage of horizontal steam pipes, vertical steam pipes and and total steam pipes insulated formed about 96.77%, 51.83% and 93.78% from total horizontal, vertical and total plant steam pipes, respectively. The percent of thermal energy saving due to insulated the steam pipes by using three different insulation materials were compressed fiberglass covered with aluminum slab with a thickness of 2 inches , commercial fiberglass covered with aluminum foil with a thickness of 2 inches and commercial fiberglass covered with aluminum foil with a thickness of 1inch saving 87.07%, 78.92% and 76.96%, respectively, while insulated the exhausted pipes by compressed fiberglass covered with aluminum slab with a thickness 2 inches saving 94.21%.

Keywords: Thermal, energy, losses, heat, Insulation materials, saving, plant.

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INTRODUCTION

Quantify the energy losses in food processing plants such as heat losses from discard hot water, heated equipments surface, steam pipes by convection, radiation and establishment of heat transfer can be applied to compute heat losses and change fuel boilers from solar to natural gas.

Pagan and Price (2008) said that the housekeeping plays crucial role in maintaining and optimizing cleaning procedures and systems to improve their water efficiency.

Vasanthi and Viramuthu (2008) indicated the water recycling in food, water purity standards and an overview of opportunities for water savings and recycling in food processing plants. Bertsch (2007) described the development of electricity and gas prices on milk processing and dairy factories, diesel consumption for the sector decreased between 1983 and 2005 from 3.0 to 2.2 liters/1000 liters milk.

Ranjan (1998) discussed the implementation of energy management systems (controlling electricity costs, controlling peak demand and consumption, and managing electrical distribution); and energy cost-saving potential. Unido (1995) suggested ways to reduce energy consumption by replacement of low efficiency chiller, repair of steam leakage, recovery of drainage as a preheat of feed water and insulation of (boiler, steam pipes, valves and cooker).Using a condensate as a preheat feed water for boiler recovered. Walshe (1993) reported that there are opportunities for improvements in energy efficiency and Suggested methods includes: establishment of minimum specific fuel and electricity consumption guide lines for dairies; re-use of hot steam condensate.

Ahmed (1992) found that 33% from thermal energy were lost due to line leakage, poor insulation, bad maintenance for relief valves and instruments equipment, and hot water lost in drainage. Good house keeping saved 13% from consumed thermal energy.

Sadasivam (1990) showed that 2-25% of thermal energy and 4-13% of electrical energy units could be saved by applying energy conservation measures in milk and milk products.

Boardman (1986) revealed that, the boiler operation is improved by returning condensate as feed water, preheating air for combustion of fuel, insulating the boiler and recovering heat from the fuel.

Rao and Katz (1976) reported that heat losses occur from un insulated steam pipes, as well as discarded hot water. A computer programe named Cnsrv, which employed well-established heat transfer principles, establishes the magnitudes of the heat losses.

Rao *et al.* (1976) compared thermal energy losses and the energy saving by insulation and heat recovery. The losses from poorly insulated ceiling and walls of buildings, discarded hot water and un insulated steam pipes and process equipment with 1 inch.

The objective of this study are to

1- Accounting and comparing thermal energy losses for un-insulated steam pipes, hot equipment surface, and discarded hot water.

2- Comparing between different insulation materials with a different thickness to prevent and limit thermal heat losses from steam pipes surface and choose the best.

Symbol Used in Equations

General Symbol

T_r = Temperature of mean (K^o)

T_s = Temperature of surface (K^o)

K= Thermal conductivity (W/mK^o)

h_c = Convection heat transfer coefficient (W/m^2K^o)

L = Length (m)

$\overline{Nu_L}$= Average nusselt number for vertical steam pipes

$\overline{Nu_D}$= Average nusselt number for horizontal steam pipes

Q_C = rate of convection heat losses (W/m)

A = Area (m^2)

F = Transfer factor

T_a = Temperature of surrouding (K^o)

Q_R = rate of radiation heat losses (W/m)

q = rate of heat transferred (watt)

Subscription

c = Convection

R = Radiation

s = surface

i = Inside of a particular object

o = Outside

Greek letter

β = Diverse of temperature mean

(1/K)

σ = Stefan –boltzmann constant

5.67×10^{8} ($W/m^{2}K^{4}$)

ν = Kinematic viscosty (m^{2}/s)

μ = Viscosity, kg / m h

ρ = Density, kg / m^{3}

ε = Emissivity,dimenensionless

Dimensionless number.

Gr_L = grashof number, $\beta\Delta TgL^{3}/\nu^{2}$

Pr = prandtl number, $c_{p\mu/k}$

Ra_L = Rayleight number, Gr_L Pr,

Ψ = Prandtl number function

MATERIALS AND METHODS

The experiments were carried out in "One of dairy production plant " at 10th of Ramadan City.

Plant A consists of four departments (1 , 2 , 3 and 4) to produce milk , juice ,butter and Feta cheese. These parts were run as follows:

Part No. (1) boiler room and cooling unit no. 1:

Its called boilers room including boilers, distribution batteries and steam pipes.

The vapour unit in plant A:

It consists of many parts and its responsible for feeding all production lines with requirements of steam and this units include the illustrated parts in figure 1.

Boilers:

It illustrates in Fig. 1, there are two boilers in the plant the first can produce 7 tons steam/h and work at pressure from 8.8 to 9 bar while the other boiler can produce 7 tons steam/h also and work at pressure from 10 to 13 bar . the boilers can produce saturated hot vapour at temperature 170 °C then this vapour pumped through two pipes to the distribution batteries which including many vapour lines and control taps .the butteries and vapour lines provides vapour to part no. (2, 3 and 4) including all unites and equipments with its requirements of vapour.

Distribution battery no (1) illustrated in fig. 1

The steam pumped to the distribution device which called battery number (1) from the two boilers in two pipes. The battery number (1) responsible of providing the vapour to part no. (2 and 3) and battery number (2) which also provide part numbre (1) with its requirements of vapour. The distribution battery number (1)

Part no. (1): Boilers room and cooling unit no. (1)

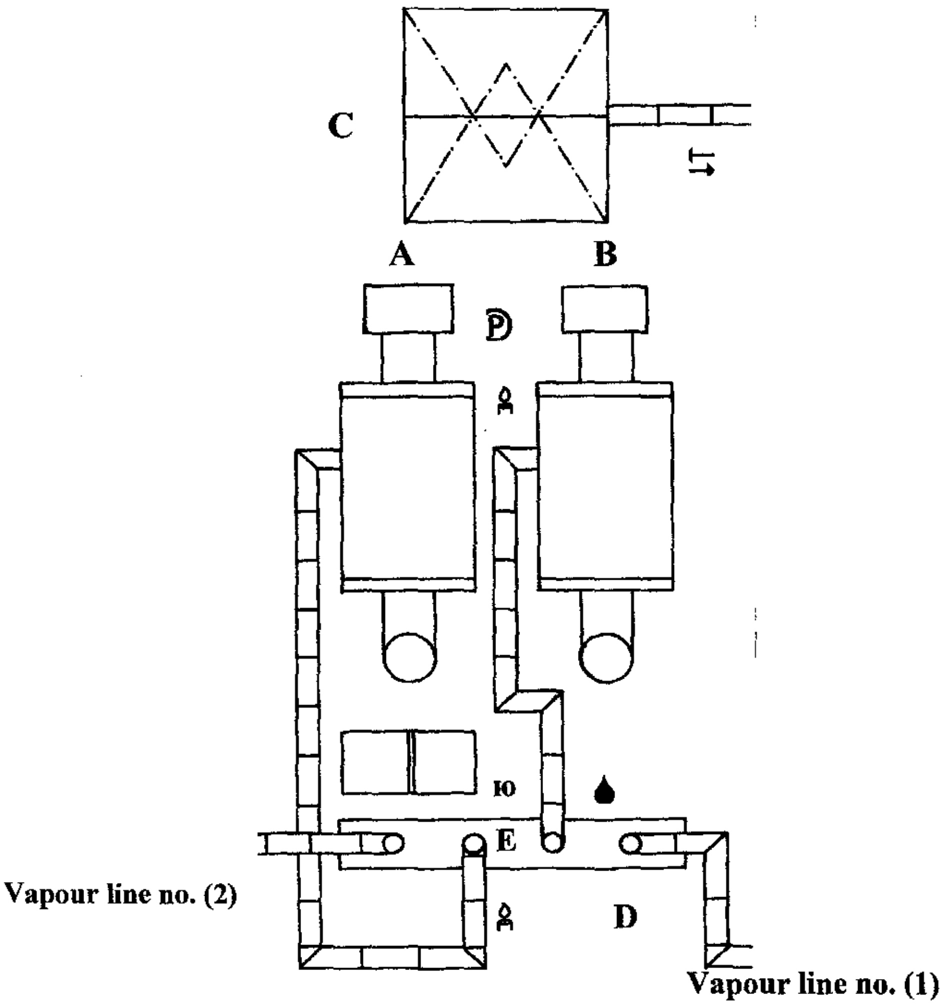

Fig. 1. Vapour units and cooling unit in plant (A)

Symbol	Part Name
A	Boiler no (1)
B	Boiler no (2)
C	Cooling unite no (1)
D	Distribution battery no (1)
E	Two boiler feeding lines

includes vapour line no. (1) which divided in to [sub vapour line no.(1) and sub vapour line no. (2)] and vapour line no. (2). the saturated hot vapour at on a temperature 162 °C in distribution lines.

Vapour line no (1)

This line extend vertically and horizentally and divided in to lines called sub line no.(1) and sub line no.(2) fig. 1.

Sub vapour line no (1)

This line extend vertically and horizentally providing the vapour to part no (2) which including plate heat exchanger no. (1), plate heat exchanger no. (2), CIP (cleaning in place) device no. (1) and ultra height temmperature device and fig. 2.

Sub vapour line no. (2)

This line extend vertically and horizontally providing the vapour to part no (3) which including plate heat exchanger no (3), plate heat exchanger no. (4)and CIP dvice no. (2) fig. 3.

Vapour line no. (2)

This line extend vertically and horizontally providing the vapour to the distribution battery no. (2). this battery is responsible of provide the vapour to part no.(4) fig. 1.

Cooling unite no. (1)

It consists of many parts and its responsible for feeding all production lines with requirments of ice water range (4~8 °C) and this units is responsible of providing part no. (1, 2and 3) of the plant fig. 1.

Distribution battery no. (2) illustrated in fig. 4

The distribution battery no. (1) providing the vapour to the distribution battery no. (2) through vapour line no. (2). This battery is responsible of providing part no. (4) of the plant with vapour and its include four distribution vapour lines with its requirements of vapour. The distribution battery number (2) includes vapour line no. (3), vapour line no.(4), vapour line no. (5) and vapour line no. (6) the saturated hot vapour at on a temperature 162°C in distribution lines.

Vapour line no. (3)

This line extend vertically and horizontaly providing the vapour to plate heat exchanger no. (5) and ultra filtration device no. (1) fig. (4).

Part no. (2): Milk and juice production lines

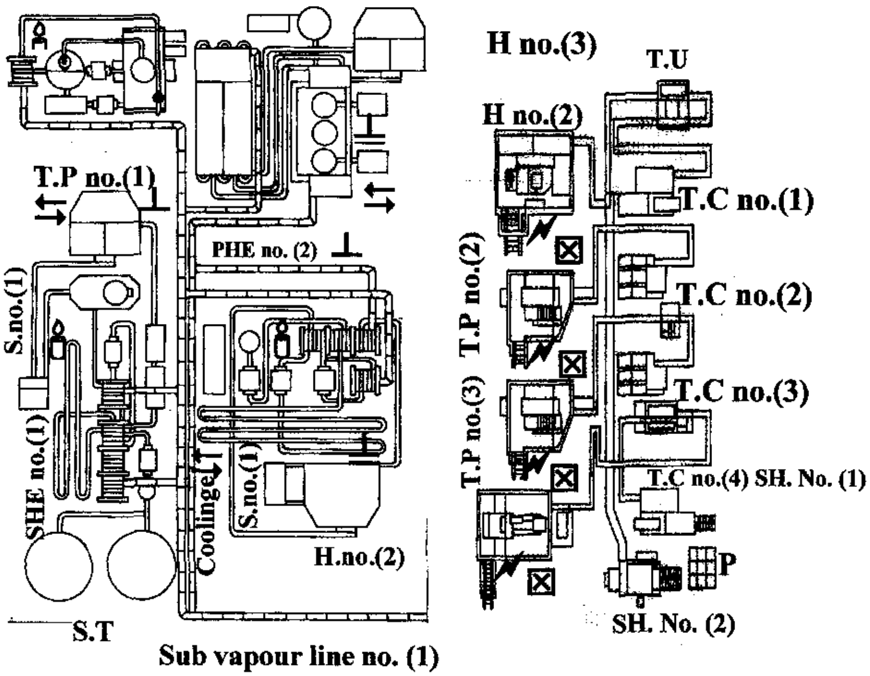

Fig. 2. Distribution of steam lines and cooling lines in plant (A)

Symbol	Part Name	Symbol	Part Name
PHE	Plat heat exchanger device no.(1and 2)	T.C	Tetra cardboard packer no.(1, 2, 3 and 4)
UHT	Ultra heigh temperature device	TU	Tubex straw applicator
H	Homogenizer no.(1,2and 3)	SH.	Shrink no.(1 and 2)
S	Separator no.(1and 2)	P	Product
S.T	Storage tanks	CIP	Cleaning in place device no.(1)
P.T	Packaging tanks		
T.P	Tetra brick aseptic packaging no.(1,2,3 and 4)		

Part no. (3): Butter production line

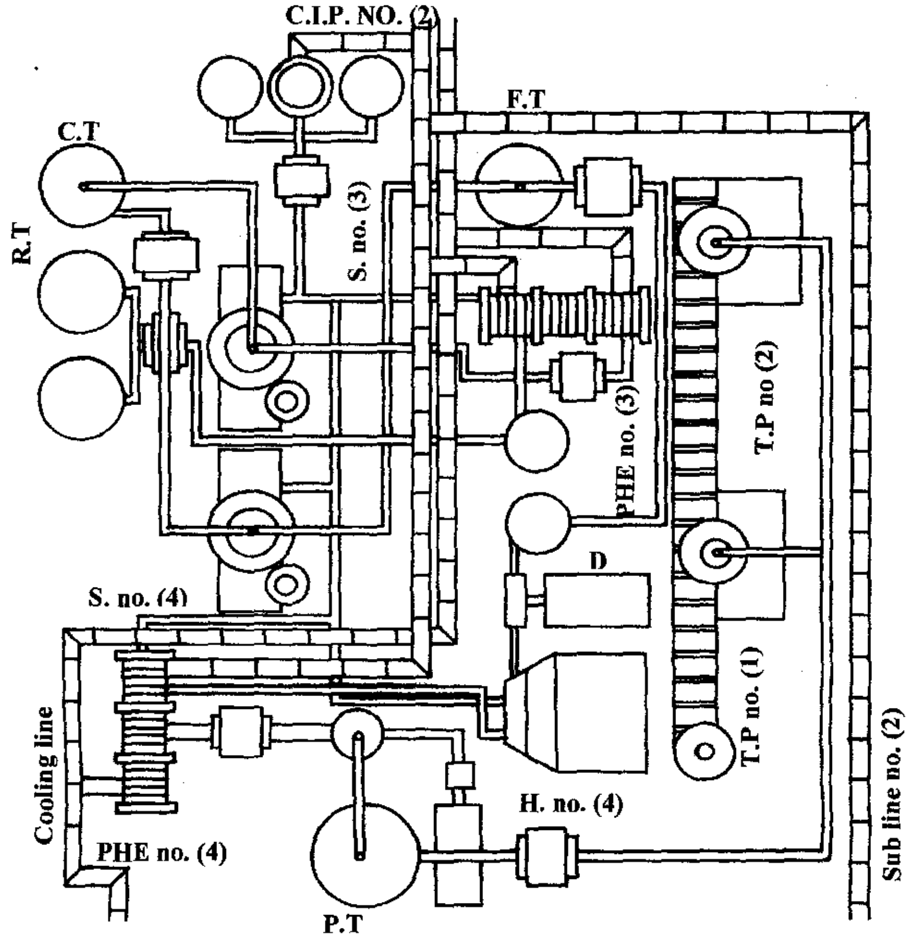

Fig. 3. Distribution of steam lines and cooling lines in plant (A)

Symbol	Part Name	Symbol	Part Name
PHE	Plat heat exchanger device no.(3 and 4)	C.T F.T	Churning tank
		P.T	First stage reception tank
H	Homogenizer no.(4)	U	Packaging tank
S	Separator no.(3 and 4)	T.P	Ultra violet device
D	Gear pump	CIP	Tin packages (1Kg and 20Kg)
R.T	Reception tanks		Cleaning in place device no.(2)

Vapour line no. (4)

This line extend vertically and horizontally providing the vapour to plate heat exchanger no. (6), ultra filtration device no. (2) and Ro device which filtrated the curd fig. 4.

Vapour line no. (5)

This line extend vertically and horizontally providing the vapour to concentrate plate heat exchanger no. (7) plate heat exchanger no. (8) and plate heat exchanger no. (9) fig. 4.

Vapour line no. (6)

This line extend vertically and horizontally providing the vapour to CIP device no. (3) fig. 4.

Cooling unit no. (2)

As explained in cooling unit no. (1) fig. 4.

Part No. (2) milk and juice production lines:

It includes two production lines for produce pure milk, milk mixed with fruit, mango juice and orange juice.

Part No. (3) butter production line:

It includes butter production line for produce (tin packages butter 2 Kg and tin packages butter 20 Kg).

Part No. (4) Feta chess production line and cooling unite no. (2):

It includes Feta cheese production line for produce (feta cheese 250g and Feta cheese 500g) and cooling unite no. (2).

In this research different insulation materials used to discover the best insulation material and less cost .energy losses from steam pipes by convection and radiation were calculated and comparing after insulation and before used three insulation materials with a different thickness. in this study three types of insulation material was used (compressed fiberglass covered with aluminum slab with a thickness 2 inch, commercial fiberglass covered with aluminum foil with a thickness 2 inch and commercial fiberglass covered with aluminum foil with a thickness 1inch) this materials reduce the temperature of steam pipes surface from 170C^{o} to 47°C, 58°C and 70°C while the exhausted pipes insulated by compressed fiberglass covered with aluminum slab with a thickness 2 inche this material reduce the temperature of steam pipes surface from 184°C to 60°C.

Part no. (4): Feta cheese production line

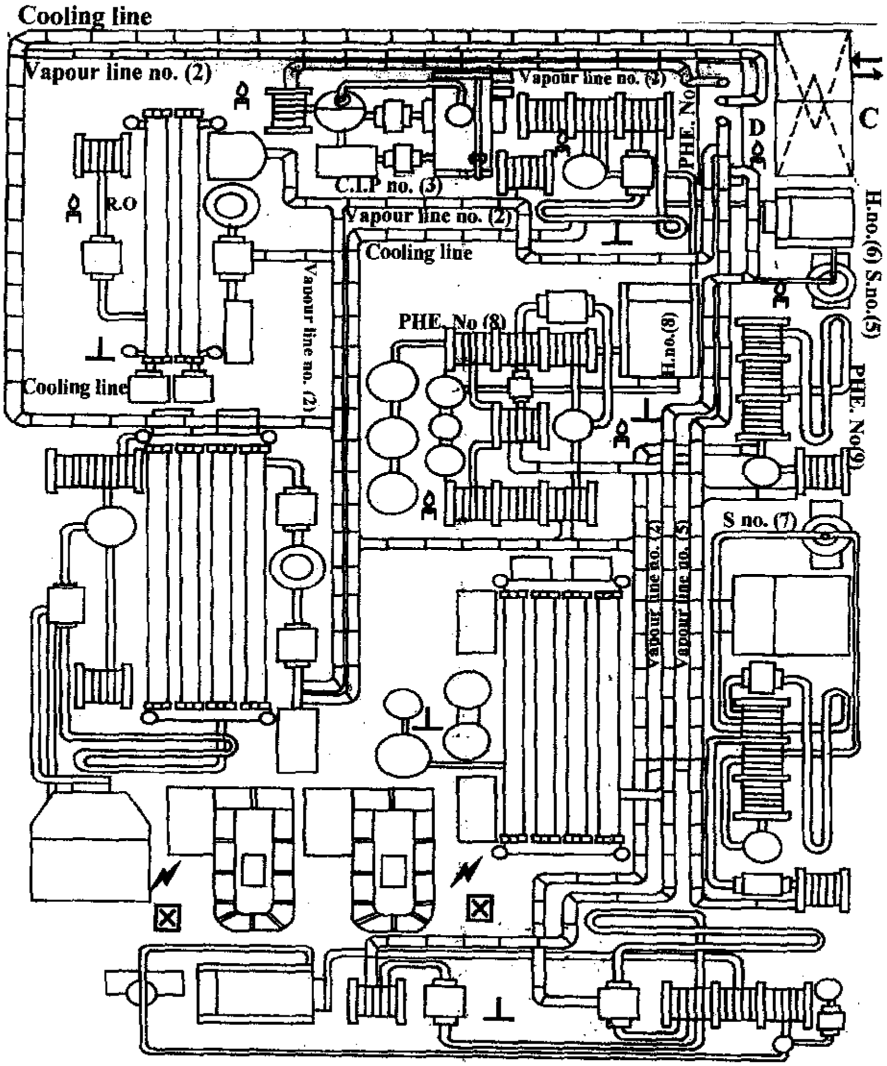

Fig. 4. Distribution of steam lines and cooling lines in plant (A)

Symbol	Part Name	Symbol	Part Name
PHE	Plat heat exchanger device no (5, 6, 7, 8 and 9)	*T.P*	Tetra brick aseptic pack.(250 gm and 500 gm)
		D	
H	Homogenizer no.(5, 6, 7, 8 and 9)	*C*	Distribution battery no. (2)
S	Separator no.(5, 6 and 7)	*CIP*	Cooling unite no (2)
U.F	Ultra filtration device no.(1and 2)		Cleaning in place device no. (3)
R.O	Curd filtration device		

Measuring Instruments

Were used to measure temperature, dimensions, diameter, steam flow rate, flow rate, steam pipes (vertical or horizontal) heat loses by (convection and radiation), cylinder or square device surface(vertical or horizontal), condensate hot water and discarded hot water including.

Temperature instruments

Digital multimeter 1000 Model MY60 series hand held DMM Instruments. with a thermocouple was used for monitoring temperature with an accuracy of (±1.0%) and at raange(-20 °C ~ 1000 °C) by reading liquid crystal display (LCD).

Dimension instruments

1- Metal and leather strip meter for measuring pipes and divice lengths.

2-Tridimensional measurement somet (caliper) for measuring pipes outer diameter.

Flow rate counter

Flow rate counter, programmable logic controller system (PLC_S) model A/B. Lund. Sweden with an accuracy of (±0.4%). It was used for measure product flow rate.

Vapor rate counter

was differential pressure (D/P) cell foxboro with an accuracy of (±0.5%). It was used for measure steam flow.

Measured Points:

Vapor pressure at point (℗)

Vapor flow rate at point (ю)

Condensate vapor at point (💧)

Temperature at point (🌡)

Product flow rate at point (⏚)

Energy Calculation

Yunus (2007) and Mills (2002) calculated Heat losses from steam pipes and equipment surfaces.

Convection heat losses from steam pipes

$$Q_C = \overline{h}_c A(T_s - T_e) \rightarrow (1)$$

$$Ra_L = Gr_L\, Pr = Pr\, \frac{\beta \Delta T g L^3}{\nu^2}$$

$$T_r = \frac{T_s + T_e}{2}$$

$$\beta = 1/T_r$$

Heat losses from a vertical steam pipes or cylinder

Laminer natural convection:

$$\overline{Nu}_L = 0.68 + 0.670\, (Ra_L\, \Psi)^{1/4}$$

$Ra_L \leq 10^9 \rightarrow (2)$

Turbulent natural convection:

$\overline{Nu_L} = 0.68 + 0.670\,(Ra_L \Psi)^{1/4}$

$(1 + 1.6 \times 10^{-8})$

$10^9 \leq Ra_L \leq 10^{12} \rightarrow (3)$

$\Psi = [1 + (\frac{0.492}{pr})^{9/16}]^{-16/9}$

$\overline{h_c = \frac{k}{L}\overline{Nu_L}}$

Heat losses from a horizontal steam pipes or cylinder

Laminer natural convection:

$\overline{Nu_D} = 0.36 + \frac{0.518 R_{aD}{}^{1/4}}{1 + (0.559/pr)^{9/16\,4/9}}$

$10^{-6} \leq Ra_D \leq 10^9 \rightarrow (4)$

Turbulent natural convection:

$\overline{Nu_L} = \left\{0.60 + 0.387\left[\frac{R_{aD}}{1 + (0.559/pr)^{9/16\,16/9}}\right]\right\}^{9/16 2}$

$Ra_L \geq 10^{12} \rightarrow (5)$

Heat losses from a horizontalal plated devices.

Facing down cooled air.

$\overline{Nu_L} = 0.82\, Ra_L{}^{1/5}$

$10^5 \leq Ra_L \leq 10^{10} \rightarrow (6)$

$\overline{N}$

$u_L = 0.58\, Ra_L{}^{1/5}$

$10^{10} \leq Ra_L \leq 10^{11} \rightarrow (7)$

Facing UP cooled air

$\overline{Nu_L} = 0.54\, Ra_L{}^{1/4}$

$10^5 \leq Ra_L \leq 2 \times 10^7 \rightarrow (8)$

$\overline{Nu_L} = 0.58\, Ra_L{}^{1/3}$

$2 \times 10^7 \leq Ra_L \leq 10^{10} \rightarrow (9)$

Radiation heat losses

$Q_R = A\,F\,(\sigma T_s^4 - \sigma T_a^4) \rightarrow (10)$

Total thermal energy losses

$q_{conduction} = q_{convection} + q_{radiation}$

Thermal energy losses in condensat water and cooling

$q = mc\,(Tin - Tout) \rightarrow (11)$

The unite operation analyzed were heat unit, square units, cylinder units and discarded hot water.

RESULTS AND DISCUSSION

Total Energy Losses From Steam Pipes and Units Operation in Plant (A):

The thermal energy losses by convection and radiation from steam pipes, exhausted pipes, units operation, cleaning and cooling for processing milk, juice, butter and feta chess in plant A using steam infusion a high temperature short time (HTST) pasteurization processed were determined and compared. From Table 1 and Fig. 5 it can be noticed that the energy losses from steam pipes were 897.86 MJ/h. The percentage of energy losses for steam pipes formed about 34.09% of total energy and 25.83% for cooling of the total energy. The high of energy losses in this units compared to others may be due to that a heat unit and cooling consider the great part of thermal heat losses in plant A, Looking for convection and radiation energy losses Table. 1, it can be noticed that the energy losses by radiation is low compared represents to convection ones. Thermal energy losses by convection represents a percentage of 51.10% and 56.92% while radiation thermal energy losses represents 48.90% and 43.08% of total thermal energy losses for horizontal units and vertical units respectively. The comparison between the different units operation systems for milk, juice, butter and feta chess processing inside plant A was also conducted. These systems were (HTST) and (UHT) it was noticed from Fig. 5 that the great thermal energy losses from UHT device were 57.36 MJ/h in square units and from product pipes were 166.43 MJ/h in cylinder units with percentages of 2.57% and 6.32% respectively.

Thermal Energy Losses Input Distribution

Thermal energy losses distribution for different processes inside the system of milk, juice, butter and feta chess processing including heat unit, square units, cylinder units and discarded hot water table 1 and Fig. 6.

Heat unit

The thermal energy losses from conducting heating unit in plant A presented in Table 1 and Fig. 6. The data can be indicated that the highest value of thermal energy losses of 897.86 MJ/h was accompanied with steam pipes, while the lowest one with boiler compared to other value of 70.45 MJ/h. These mentioned values formed percentages of 74.36% and 5.84% of the total thermal energy losses for each unit.

Square units

The thermal energy losses from conducting square units in plant A presented in Table 1 and Fig. 6. The data can be indicated that the highest value of thermal energy

Table 1. Comparison between heat losses from heat unit, square units, cylinder and discardedhot water in plant (A)

Units types / Units name		Horizontal pipes heat losses (MJ/h)			Vertical pipes heat losses (MJ/h)			Q Total conduction (MJ/h)
		Q Convection	Q Radiation	Q Conduction	Q Convection	Q Radiation	Q Conduction	
Heat unit	Boiler no. (1&2)	18.10	52.35	70.45	—	—	—	70.45
	Exhausted pipes	47.68	128.26	175.94	24.21	38.94	63.15	239.09
	Planet steam pipes	447.52	390.82	838.34	31.68	27.84	59.52	897.86
Square units	UHT	14.58	10.57	25.15	21.05	11.16	32.21	57.36
	PHE	4.85	2.51	7.36	21.03	11.17	32.20	39.56
	UF (PHE)	0.72	0.44	1.16	3.17	1.48	4.65	5.81
	Homogenizer	0.63	0.38	1.01	1.28	0.64	1.92	2.93
Cylinder units	Products pipes	103.57	38.27	141.84	16.66	7.93	24.59	166.43
	UF (pipes)	65.49	49.84	115.33	0.99	0.35	1.34	116.67
	Device tanks	—	—	—	27.92	14.25	42.17	42.17
	CIP tanks	3.24	2.92	6.16	7.75	4.10	11.85	18.01
Discarded hot water	Cooling	—	—	—	—	—	—	680.40
	Cleaning	—	—	—	—	—	—	297.50
Total		706.38	676.36	1382.74	155.74	117.86	273.60	2634.24
Percent of T.E		51.10	48.90	100 %	56.92	43.08	100 %	

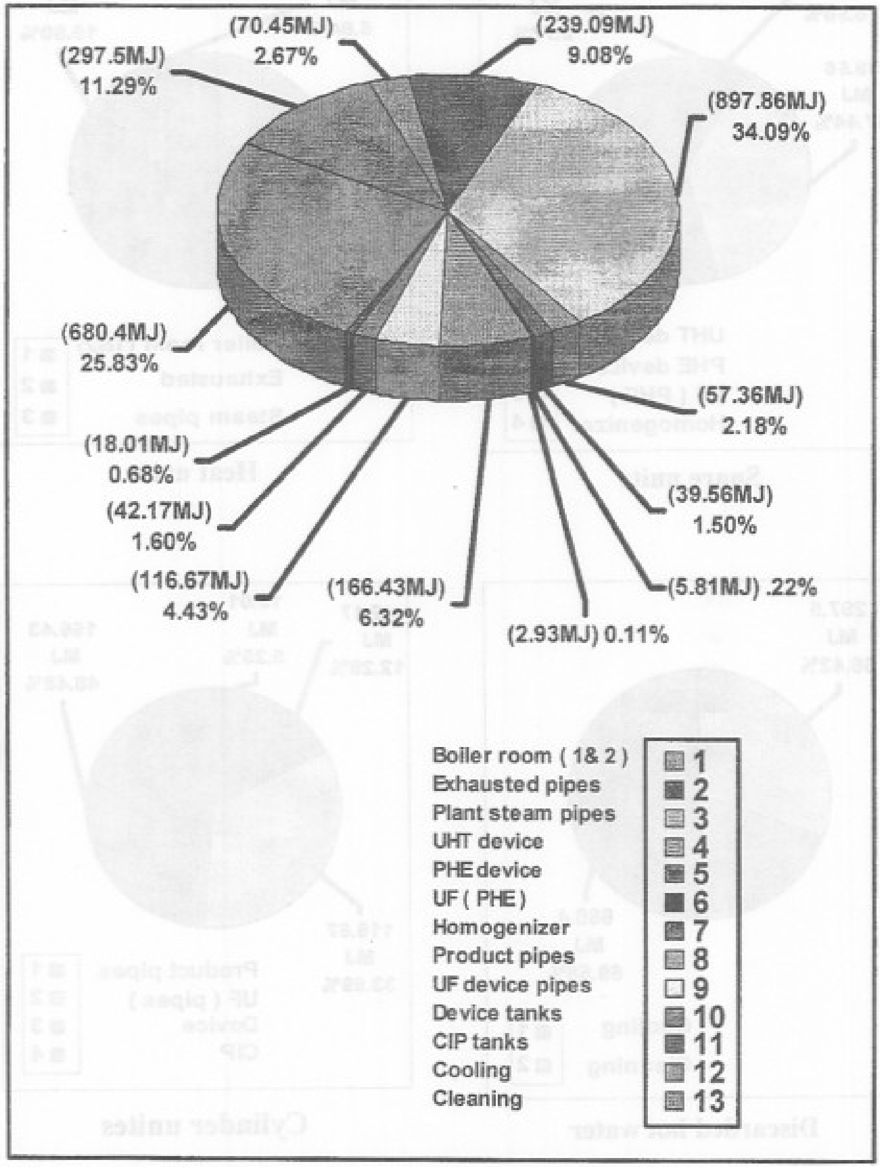

Fig. 5. Heat losses from diffrent units operation in plant (A)

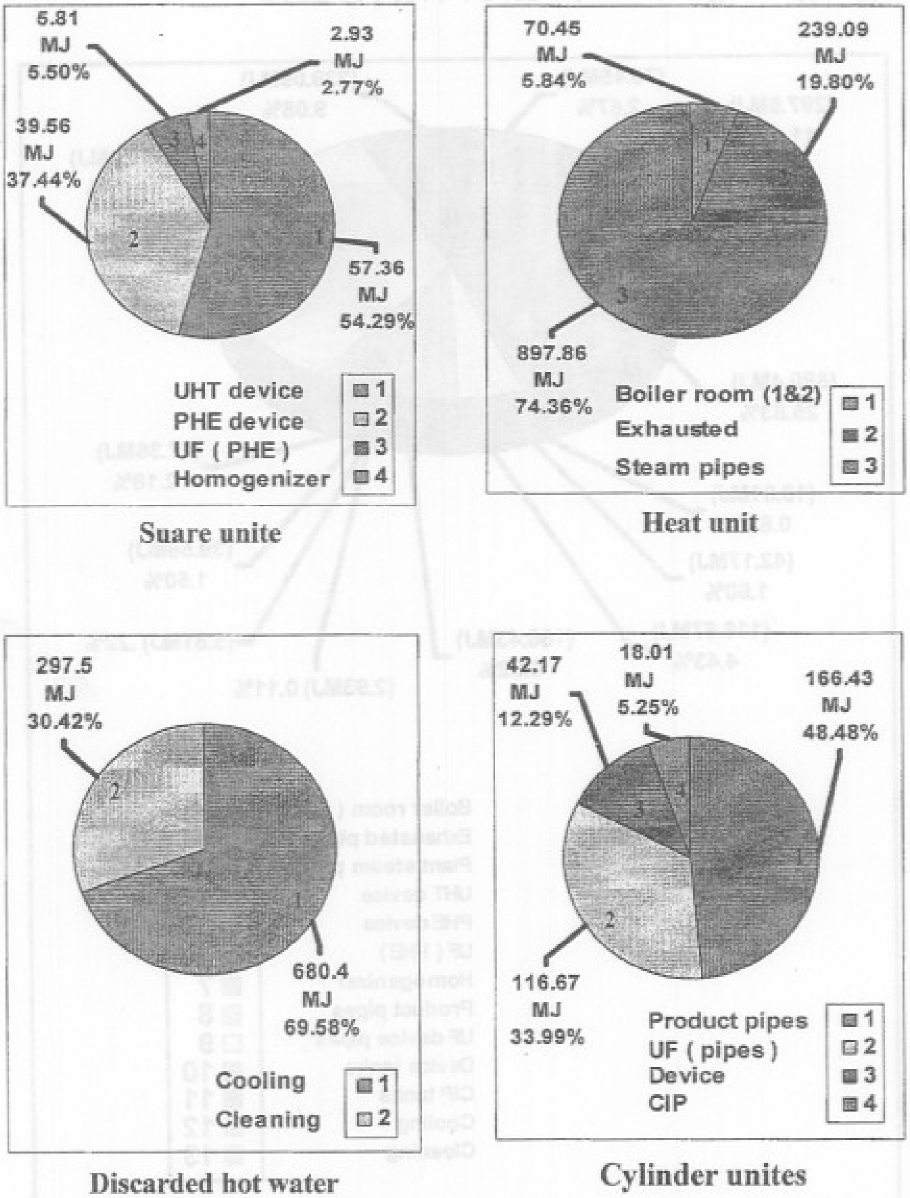

Fig. 6. Comprison bettwen the thermal losses energy distribuation in heat unit, square units, cylinder units and discarded hot water in plant (A)

losses of 57.36 MJ/h was accompanied with UHT device, while the lowest one with homogenizer compared to other value of 2.93 MJ/h. These mentioned values formed percentages of 54.29% and 2.77% of the total thermal energy losses for each unit.

Cylinder units

The thermal energy losses from conducting cylinder units in plant A presented in Table 1 and Fig. 6. The data can be indicated that the highest value of thermal energy losses of 166.43 MJ/h was accompanied with product pipes, while the lowest one with CIP tanks compared to other value of 18.01MJ/h. These mentioned values formed percentages of 48.48% and 5.25% of the total thermal energy losses for each unit. the reason of energy increase in the case of product pipes may be returned to the lengthy distance of pipes extended compared to the other which have small surface.

Discarded hot water

The thermal energy losses from conducting discarded hot water in plant A presented in Table 1 and Fig. 6. The data can be indicated that the highest value of thermal energy losses of 680.40 MJ/h was accompanied with cooling packages and bottles, while the lowest one with cleaning compared to other value of 297.50 MJ/h. These mentioned values formed percentages of 69.58% and 30.42% of the total thermal energy losses for each unit. The reason of energy increase in the case of cooling may be returned to the height quantity of product needs cooling to the other which have less amount.

Total Energy Losses From Steam Pipes, Exhausted Pipes and Insulation Materials in Plant (A)

The thermal energy losses by convection and radiation from steam pipes and exhausted pipes in plant A were determined and compared. From Table 2 and Figs 7 and 8 it can be noticed that the energy losses from steam pipes were 897.89 MJ/h after insulation. Looking for horizontal pipes and vertical pipes total energy losses Table. 2, it can be noticed that the energy losses from vertical steam pipes is low compared to horizontal steam pipes ones. Thermal energy losses from horizontal steam pipes represents a percentage of 93.37% while vertical steam pipes

Table 2. Comparison between heat losses from steam pipes , exhausted pipes and different insulation materials in plant (A)

Pipes types / Pipes insulation	Horizontal pipes heat losses (MJ / h) Convection and radiation				Vertical pipes heat losses (MJ / h) Convection and radiation				Q T.C. (MJ/h)	Total Saving ratio
	Q Conv.	Q Rad.	Q Conduction	Saving ratio	Q Conv.	Q Rad.	Q Conduction	Saving ratio		
Plant steam pipes	447.52	390.82	838.34	---	31.68	27.84	59.52	---	897.86	---
Un insulated steam pipes	435.14	376.11	811.25	96.77%	20.70	10.15	30.85	51.83%	842.10	93.78%
Insulation material no (1)	95.89	7.34	103.23	87.27%	5.30	0.38	5.68	81.59%	108.91	87.07%
Insulation material no (2)	149.05	19.03	168.08	79.28%	8.40	1.01	9.41	69.59%	177.49	78.92%
Insulation material no (3)	165.20	19.14	184.34	77.28%	8.61	1.02	9.63	68.78%	193.97	76.96%
Exhausted pipes	47.68	128.26	175.94	---	24.21	38.94	63.15	---	239.09	---
Insulated exhausted pipes (2)	8.53	0.98	9.51	94.60%	4.04	0.30	4.34	93.13%	13.85	94.21%

(1) Compressed fiberglass covered with aluminum slab with a thickness 2 inches (2) Commercial fiberglass covered with aluminum foil with a thickness 2 inches (3) Commercial fiberglass covered with aluminum foil with a thickness 1 inch.

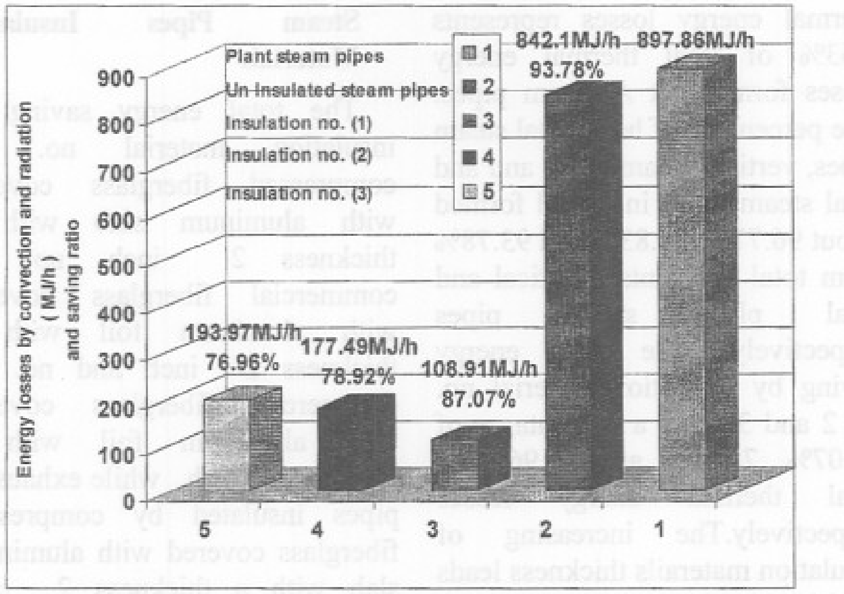

Fig. 7. Comprison bettwen plant steam pipes, un insulated steam pipes and three different insulation materials in plant (A).

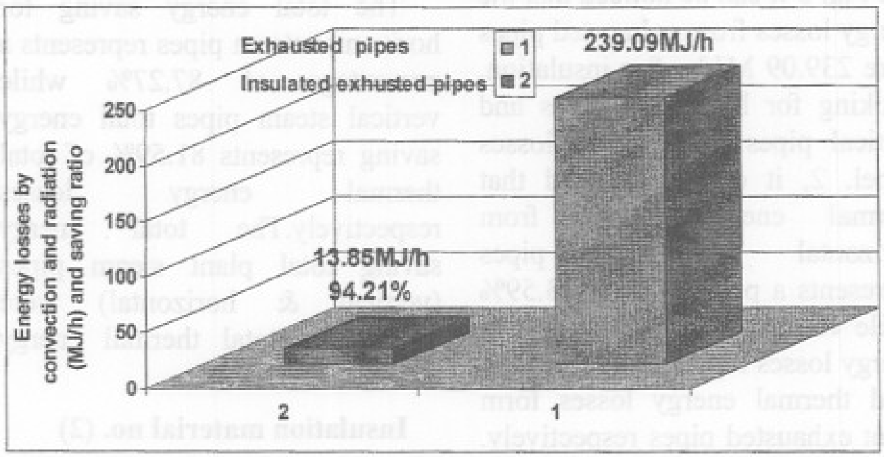

Fig. 8. Comprison bettwen uninsulated exhausted pipes and insulated exhausted pipes in plant (A)

thermal energy losses represents 6.63% of total thermal energy losses form plant A steam pipes. The percentage of horizontal steam pipes, vertical steam pipes and and total steam pipes insulated formed about 96.77%, 51.83% and 93.78% from total horizontal, vertical and total plant steam pipes respectively. The total energy saving by insulation material no. (1, 2 and 3) with a percentages of 87.07%, 78.92% and 76.96% of total thermal energy losses respectively.The increasing of insulation materails thickness leads to rising the thermal heat losses as a result of exceed the surface exposed to still air.From Table 2 and Fig. 3 it can be noticed that the energy losses from exhausted pipes were 239.09 MJ/h after insulation, Looking for horizontal pipes and vertical pipes total energy losses Tabel. 2, it can be noticed that thermal energy losses from horizontal exhausted pipes represents a percentage of 73.59% while vertical steam pipes thermal energy losses represents 26.41% of total thermal energy losses form plant exhausted pipes respectively. The total energy saving by insulation material with a percentage 94.21% of total thermal energy losses

Steam Pipes Insulation Materials

The total energy saving by insulation material no. (1) compressed fiberglass covered with aluminum slab with a thickness 2 inch, no. (2) commercial fiberglass covered with aluminum foil with a thickness 2 inch and no. (3) commercial fiberglass covered with aluminum foil with a thickness 1 inch, while exhausted pipes insulated by compressed fiberglass covered with aluminum slab with a thickness 2 inch represented in Table 2 and Fig. 8.

Insulation material no. (1)

The total energy saving for horizontal steam pipes represents a percentage of 87.27% while vertical steam pipes total energy saving represents 81.59% of total thermal energy losses respectively.The total energy saving total plant steam pipes (vertical & horizontal) were 87.07% of total thermal energy losses.

Insulation material no. (2)

The total energy saving for horizontal steam pipes represents a percentage of 79.28% while vertical steam pipes total energy saving represents 69.59% of total thermal energy losses respectively. The total energy saving total plant steam pipes (vertical & horizontal) were 78.92% of total thermal energy losses.

Insulation material no. (3)

The total energy saving for horizontal steam pipes represents a percentage of 77.28% while vertical steam pipes total energy saving represents 68.78% of total thermal energy losses respectively. The total energy saving total plant steam pipes (vertical & horizontal) were 76.96% of total thermal energy losses.

Exhausted pipes insulation material

The total energy saving for horizontal exhausted pipes represents a percentage of 94.60% while vertical exhausted pipes total energy saving represents 93.13% of total thermal energy losses respectively. The total energy saving total plant exhausted pipes (vertical & horizontal) were 94.21% of total thermal energy losses.

CONCLUSION

1- Thermal energy losses form heat unit; square units, cylinder units and discarded hot water in plant A were (1207.40, 105.66, 343.28 and 977.99 MJ/h). The reason of energy increase in the case of heat unite compared to other units may be to it consider the great part of thermal energy losses in the plant.

2- The Thermal energy losses form steam pipes and exhausted pipes were 897.86 MJ/h and 239.09 MJ/hr with percentage of 74.36% and 19.80% of the total thermal energy losses from heat unit exhausted pipes inside heat unit. The reason of energy losses increased in the case of steam pipes because of the height temperature of its surface and its long distance extended to the others units operation.

3- The Thermal energy losses form Ultra-Height-Temperature (UHT) device were 57.29 MJ/h with percentage of 54.29% of the total thermal energy losses from square units. The reason high energy losses accompanied with this device returned to the height temperature of and its extensive large surface exposed to air compared to other units operation.

4- The Thermal energy losses form product pipes and UF device pipes were 166.43 MJ/h and 116.67 MJ/hr with percentage of 48.48% and 33.29% of the total thermal energy losses from cylinder units. The height energy losses with product pipes may be returned to the lengthy distance of pipes extended compared to others units operation.

5- The thermal energy losses in cooling product and cleaning device & equipment joint with discarded hot water were 680.40 MJ/hr and 297.50 MJ/hr with percentage of 69.58% and 30.42% of the total thermal energy losses from discarded hot water. The height value of energy losses in cooling consider the great part of thermal heat losses and the great quantity of product need cooling comparing to other operation.

6- The percent of thermal energy saving due to insulated the steam pipes by using three different insulation materials were compressed fiberglass covered with aluminum slab with a thickness 2 inch, commercial fiberglass covered with aluminum foil with a thickness 2 inch and commercial fiberglass covered with aluminum foil with a thickness 1 inch saving 87.07%, 78.92% and 76.96% of the total thermal energy losses from steam pipes and the compressed fiberglass covered with aluminum slab with a thickness 2 inch consider the best material saving the energy losses.

7- The percent of thermal energy saving due to insulated the exhausted pipes saving 94.21% of the total thermal energy losses from exhausted pipes.

REFERENCES

Ahmed, K.A. 1992. "Energy Consumption Determination in Dairy Plants" Unpublished M.Sc. Thesis, Fac. of Agric., Alex. Univ..

Bertsch, R. 2007. Energy Savings in Dairy Factories. Energy Costs are Becoming an Important Cost Factor in Dairy Factories. DMZ,-Lebensmittelindustrie-und-Milchwirtschaft, 128 (16) :26-29.

Boardman, J. 1986. Effecting Efficient Energy Usage.Food Process, May,: 29-31.

Mills, A.F. 2002. Basic Heat and Mass Transfer. Prentice Hall. L.A., Chapt. (8): 649-743.

Pagan, R. and N. Price. 2008. Good Housekeeping Procedures to Improve the Efficiency of Water Use in Food Processing Plants. Handbook-of-water-and-energy-management-in-food-processing : 335-366.

Ranjan-Sarkar. 1998. Energy Management in Dairy and Food Processing Industry. Indian-Dairy-man, 50 (8): 21-22.

Rao, M.A., J. Katz, J.F. Kenny and Downing. 1976. Thermal Energy Losses in Vegetable Canning Plants. Food Technology, 30 (12): 44-47.

Rao, M.A. and J. Katz. 1976. Computer Estimation of Heat Losses in Food Processing Plants. Journal of Food Technology, March : 36-42.

Sadasivam, V. 1990. Energy Management in Dairy Plant. Indian-Dairy-Man, 42 (3): 124-126.

UNIDO. 1995. Handy Manual in Food Processing Industry, Out put of Seminar on Energy Conservation in Food Processing Industary. Sponsored by Japan and organized by India and Pakistan: 12-13 and 21-38.

Vasanthi-Sethu, and V.A. Viramuthu. 2008. Water Recycling in the Food Industry. Handbook-of-water-and-energy-management - in – food - processing. Cambridge, UK: Wood Head Publishing Ltd.,: 647-662.

Walshe, N. 1993. Power Saving. Dairy Industries International, 58 (3): 20-21.

Yunus A. Gengel. 2006. Heat and Mass Transfer. Copyright by MC-Grow Hill Education, Third Edition (si unites), Chapt. (9): 503-561 and Chapt. (12): 663-707.

الطـــــاقـــــة المفقــودة فى التصنيـــع الغـــــذائى

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استهدف هذا البحث تقدير كمية الطاقة الحرارية المفقودة من بعض وحدات تصـنيع الألبان وذلك من خلال حساب كمية الطاقة الحرارية المفقودة في كل منها ومقارنـة ثلاثـة انواع من المادة العزلة لموا سير البخار واختيار افضلها و ذلك بأحد مصانع منتجات الألبان بمدينة العاشر من رمضان .

و قد تبين من النتائج المتحصل عليها كل مما يأتي :

- كانت الطاقة الحرارية المفقودة من وحدة الحـرارة و الوحـدات المربعـة و الوحـدات الأسطوانية والماء السـاخن هـي ١٢٠٧,٤٠و ١٠٥,٦٦و٣٤٣,٢٨و٩٧٧,٩٩ ميجـا جول/الساعة علي الترتيب.
- الطاقة الحرارية المفقودة من مواسير البخار هي ٨٩٧,٨٦ ميجا جول / الساعة.
- الطاقة الحرارية المفقودة من مواسير العادم هي ٢٣٩,٠٩ميجا جول / الساعة.
- الطاقة الحرارية المفقودة من مواسير البخار الأفقية تمثل٩٣,٣٧٪ بينما المواسير الأفقية كانت ٦,٦٣٪ من الطاقة الحرارية الإجمالية المفقودة من مواسير البخار بالمصنع.
- نسبة مواسير البخارالكلية التي تم عزلها بالمصنع تمثل ٩٣,٧٨٪ من مواسـير البخـار الأجمالية بالمصنع.
- نسبة مواسير البخار الأفقية و الرأسية التـي تـم عزلهـا بالمصـنع هـى ٩٦,٧٧٪ و٥١,٨٣٪ من مواسير البخار المواسير الأفقية و الرأسية الأجمالية بالمصنع.
- نسبة التوفير في الطاقة الحرارية نتيجة عملية عزل مواسير البخار بأستخدام ثلاثة أنواع من المادة العازلة هي الصوف الزجاجى المضغوط بقطر ٢ بوصة و الصوف الزجـاجى التجارى بقطر ٢ بوصة و الصوف الزجاجى التجارى بقطر ١ بوصـة كانـت ٨٧,٠٧٪ و٧٨,٩٢٪ و٧٦,٩٦٪ من اجمالى الطاقةالحراريـة المفقـودة مـن مواسـير البخـار بالمصنع علي الترتيب.
- نسبة التوفير في الطاقة الحرارية نتيجة عملية عزل مواسير العادم هـي ٩٤,٢١٪ مـن اجمالى الطاقة الحرارية المفقودة من مواسير العادم بالمصنع.