RESEARCHING AND CALCULATING THE ECONOMIC EFFICIENCY ABOUT USING OF NATURAL CONVECTION TOBACCO DRYER IN VIET NAM

Dr. Nguyen Hay - Faculty of Engineering and Technology - Nong Lam University
Ho Chi Minh City - Viet Nam
Email : nguyenhay@hcm.fpt.vn

SUMMARY

Various heat exchangers have various technical parameters, such as: cost of fuel, quality of tobacco after drying by each heat exchanger. Besides, different dryer walls also have different technical parameters in some things : time used, wasteful fuel, construction cost of each dryer wall. These differences lead to differences in economic efficiency. Thus, it is essential to determine the economic efficiency of every heat exchanger as well as every dryer wall. On those backgrounds, we can find the heat exchanger that has the most effective.

The method of determining the economic is used here bases on the verifying method on the economic effect of a certain economic object. There are three important economic effect criteria are used:

- Net Present Value NPV.
- Internal Rate of Return IRR
- Pay-back Period PBP.

Through the analysis and comparison the economic effect, we can see: when we replace the 2nd, 3rd, 4th heat exchanger by the 1st one that is researched, manufactured, and has been using. So, its efficiency is the best. NPV from fuel saving and quality of dried tobacco of the 1st heat exchanger is higher than the others. In addition, PBP is the shortest. Considering dryer walls, the brick wall is also the best. In case of low investment, we should choose straw-clay wall, its efficiency is less than brick wall slightly. We shouldn't invest in steel sheet – rice husk, fibrocement, and carton wall.

I. BASIC THEORY

Various heat exchangers have various technical parameters, such as: cost of fuel, quality of tobacco after drying by each heat exchanger. Besides, different dryer walls also have different technical parameters in some things: time used, wasteful fuel, construction cost of each dryer wall. These differences lead to differences in economic efficiency. Thus, it is essential to determine the economic efficiency of every heat exchanger as well as every dryer wall. On those backgrounds, we can find the heat exchanger that has the most effect.

The method of determining the economic is used here bases on the verifying method on the economic effect of a certain economic object (a project, a policy or a new technology). This method uses a targets-system to evaluate. When an evaluated object reaches these target criteria, it'll be accepted. In a series of evaluated objects, in this case is the kind of heat exchangers or kind of dryer walls, if the object is more dominant than the others about these evaluated criteria, it'll be range in the high economic efficiency.

In there, we use three criteria that are the most commonly used. They are:

*** Net Present Value NPV :**

Formula: $$NPV = \sum_{i-1}^{n} \frac{(B_i - C_i)}{(1+r)^i}$$

B_i : receiving cash flow at i^{th} year.

C_i : expenditure cash flow at i^{th} year.

n: the years that object acts.

($B_i - C_i$) : gross benefit of object.

- If NPV > 0: having efficiency.
- If NPV $\leq$ 0 : not having efficiency, not be accepted.

When we compare a lot of heat exchangers and dryer walls, the ones that has high NPV, it'll have high economic efficiency.

*** Internal Rate of Return IRR:**

IRR is the highest interest rate that an object will pay for the investor who used it.

Formula:

$$f(x) = \sum_{i=1}^{n} \frac{(B_i - C_i)}{(1+x)^i}$$

When f(x) = 0 is x = IRR.

f(x) is the n^{th} degree function, it will be solve by Financial function in Excel 5.0.

The larger IRR, the more effective object.

*** Pay-back period PBP:**

PBP is the period that the invested capital is recovered for investor in form of interest rate and deduction.

The formula can be calculated by deducted method.

$K_i = \Delta_i (1+r)$

$\Delta_i = K_i - P_i$

When $\Delta_i \rightarrow 0$ is $i \rightarrow$ PBP

Where:

K_i :the remained invested capital that attributed to i^{th} year. Δ_i :remained investment capital after being recovered P_i : gross adds deduction in i^{th} year.

r: discount rate.

The smaller PBP, the more effective object.

2. ECONOMIC EFFICIENCY OF HEAT EXCHANGERS

In order to evaluate the economic efficiency of heat exchangers, we proceed to make experiments on dryers that are different only on heat exchanger, the rest parts of dryers are similar, such as: chamber wall, chamber measurement, the quantity of tobacco in dryer. There are 4 kinds of heat exchangers. When calculating the economic effect we do not mind the same parts, we just calculate:

- The cost of manufacturing heat exchanger.
- The cost of fuel in a batch of tobacco leaf.
- Collective value from dryer tobacco leaf (because of dryer tobacco leaf is different from different heat exchangers).

2.1. Calculating the cost for investment of heat exchanger:

A heat exchanger can be used in about 4 years, and it has approximately 12 batches per year. There is a summary table of cost for investment of a heat exchanger:

Table 1: Cost of investment for a heat exchange

Kind of heat exchanger	Cost of investment for a heat exchanger (Unit: VND)
First head exchanger	7,168,900
Second heat exchanger	7,258,900
Third heat exchanger	7,009,000
Fourth heat exchanger	7,057,900

These data isn't enough to evaluate exactly the economic effect of each heat exchanger. To understand more clearly, we need study about the fuel cost for a drying batch of each heat exchanger.

2.2. The fuel cost for a drying batch on heat exchangers

The fuel cost for a drying batch is different for each heat exchanger. And then, table 2 below reveals the average fuel cost for each heat exchanger.
Where:

Briquette: VND380 per kg.
Fired-wood: VND120, 000 per ster.

Table 2: Fuel cost for a drying batch.

Kind of heat exchanger	Cost of fuel
First heat exchanger	980,160
Second heat exchanger	1,036,060
Third heat exchanger	1,046,880
Fourth heat exchanger	1,231,400

2.3. Obtained value from quality of tobacco leaf

After drying, the quality of tobacco leaf is very important, it is directly influence to calculate benefit in commerce. Normally, the quality of tobacco leaf is divided into 4 types:

The 1st:	VND18, 500 per kg
The 2nd:	VND17, 000 per kg
The 3rd:	VND13, 000 per kg
The 4th:	VND 9,000 per kg

From the experimental resulted table, we can see the dried tobacco that is dried on different heat exchangers is different. As a result, they have various economic values.

From the calculated data, we establish the table to compare the value of tobacco after drying in different heat exchangers:

Table 3: Product income after drying

Kind of heat exchanger	Product income (VND per drying batch)
The 1st	6,421,205
The 2nd	6,011,025
The 3rd	5,773,215
The 4th	5,916,450

2.4.Evaluating the heat exchangers

In order to calculate the effect criteria above for the heat exchangers, firstly, we need definite the cash flow of B_i, C_i , and horizontal time.

+ Determining the n^{th} horizontal time:

Used time of heat exchangers are 3 years, kind of dryer wall is brick. Therefore, we chose n = 10.

+Determining deduction rate r:

r is a deduction of value follows the time which ratio r. r commonly is chosen on the occasion cost of capital. This chosen occasion cost depend on interest rate that borrowed from bank to invest for tobacco dryer with rate 1.2%/month or 14.4%/year.

+Determining the received cash flow B_i:

After researching the different heat exchanger, product and out-turn quality of tobacco have variation (table 3). For this reason, B_i among the kind of heat exchangers also varied. Whereas, in the same type, i^{th} year is a constant.

$$B_1 = B_2 = B_3 = \dots = B_{10}$$

+Determining the cost cash flow C_i:

Cash flow C_i includes two main components

- Primary invested cost includes: Invested cost for a heat exchanger (table 1); cost for construct dryer wall (brick wall) , and cost for constructing layers, tobacco leaf sticks (invariable).
- Annual production expenditure includes: input materials cost (fresh tobacco: 1200VND/kg)

Table 4: Investment cost and production cost

1st heat exchanger	Dryer wall cost	6,711.0										
	Other investment cost	5,483.0					5,483.0					
	Heat exchanger cost	7,168.9				7,168.9				7,168.9		
	Fresh tobacco		49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0
	Labor		1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0
	Fuel		9,938.0	9,938.0	9,938.0	9,938.0	9,938.0	9,938.0	9,938.0	9,938.0	9,938.0	9,938.0
	Ci	19,362.9	60,626.0	60,626.0	60,626.0	67,794.9	66,109.0	60,626.0	60,626.0	67,794.9	60,626.0	60,626.0
2nd heat exchanger	Dryer wall cost	6,711.0										
	Other investment cost	5,483.0					5,483.0					
	Heat exchanger cost	7,258.9				7,258.9				7,258.9		
	Fresh tobacco		49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0
	Labor		1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0
	Fuel		10,563.1	10,563.1	10,563.1	10,563.1	10,563.1	10,563.1	10,563.1	10,563.1	10,563.1	10,563.1
	Ci	19,452.9	61,251.1	61,251.1	61,251.1	68,510.0	66,734.1	61,251.1	61,251.1	68,510.0	61,251.1	61,251.1
3rd heat exchanger	Dryer wall cost	6,711.0										
	Other investment cost	5,483.0					5,483.0					
	Heat exchanger cost	7,009.0				7,009.0				7,009.0		
	Fresh tobacco		49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0
	Labor		1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0
	Fuel		11,452.8	11,452.8	11,452.8	11,452.8	11,452.8	11,452.8	11,452.8	11,452.8	11,452.8	11,452.8
	Ci	19,203.0	62,140.8	62,140.8	62,140.8	69,149.8	67,623.8	62,140.8	62,140.8	69,149.8	62,140.8	62,140.8
4th heat exchanger	Dryer wall cost	6,711.0										
	Other investment cost	5,483.0					5,483.0					
	Heat exchanger cost	7,057.9				7,057.9				7,057.9		
	Fresh tobacco		49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0
	Labor		1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0
	Fuel		10,738.6	10,738.6	10,738.6	10,738.6	10,738.6	10,738.6	10,738.6	10,738.6	10,738.6	10,738.6
	Ci	19,251.9	61,426.6	61,426.6	61,426.6	68,484.5	66,909.6	61,426.6	61,426.6	68,484.5	61,426.6	61,426.6

Table 5: Cash flow of heat exchangers

Kind of heat exchanger	Criteria	Year									
		0	1	2	3	4	5	6	7	8	9	10
1st heat exchanger	Received (Bi)		77054	77054	77054	77054	77054	77054	77054	77054	77054	77054
	Cost (Ci)	19363	60626	60626	60626	67795	66109	60626	60626	67795	60626	60626
	Bi - Ci	-19363	16428	16428	16428	9259	10945	16428	16428	9259	16428	16428
2nd heat exchanger	Received (Bi)		72132	72132	72132	72132	72132	72132	72132	72132	72132	72132
	Cost (Ci)	19453	61251	61251	61251	68510	66734	61251	61251	67795	61251	61251
	Bi - Ci	-19453	10881	10881	10881	3622	5398	10881	10881	4337	10881	10881
3rd heat exchanger	Received (Bi)		69278	69278	69278	69278	69278	69278	69278	69278	69278	69278
	Cost (Ci)	19203	62141	62141	62141	69150	67624	62141	62141	69150	62141	62141
	Bi - Ci	-19203	7137	7137	7137	128	1654	7137	7137	128	7137	7137
4th heat exchanger	Received (Bi)		70997	70997	70997	70997	70997	70997	70997	70997	70997	70997
	Cost (Ci)	19252	61427	61427	61427	68485	66910	61427	61427	68485	61427	61427
	Bi - Ci	-19252	9570	9570	9570	2512	4087	9570	9570	2512	9570	9570

this cost is constant for every heat exchanger and every year; fuel cost (coal and fired-wood : table 2), this cost is various in all of heat exchangers, but in the same type is not changed for every year; Labour cost is also unvaried for each year and each heat exchanger. Investment and production cost are showed in table 4.

- Summary table about the cash flow B_i, C_i is performed in table 5.

From table 4 and 5, we determine the Pay-back Period (PBP):

Table 6: Determining the PBP (Pay-back Period)

	Kind of heat exchanger			
Criteria	1st	2nd	3rd	4th
Constant investment cost	19363	19453	19203	19252
Motion capital	5880	5985	6133	6014
Sum of investment cost	25243	25438	25336	25266
Benefit + Deduction	16428	10881	7137	9570
Pay-back period (PBP)				
+ a month	1.54	2.34	3.55	2.64
+ a year	18.4	28	43	32

From table 5 and time flow n = 10. Base on calculating result from Financial function of Excel, we have the comparative table of economic efficiency of heat exchangers:

Table 7: Economic effect of heat exchangers.

Criteria	Kind of heat exchangers			
	1^{st}	2^{nd}	3^{rd}	4^{th}
NPV	49756	24442	7517	18566
IRR	80%	49%	26%	41%
PBP(month)	18	28	43	32

From table 7 we can see the 1^{st} heat exchanger have the most effective, because NPV = 49756 is much higher than NPV of 2^{nd}, 3^{rd}, 4^{th}. Furthermore, IRR is also higher than the others. Next, PBP = 18 months is the shortest Pay-back Period of all. The next is 2^{nd} because it has NPV = 24442, IRR = 49% and PBP = 28 months. 3^{rd} is the lowest type, however, 3^{rd} and 4^{th} have high effects if compared to other investment.

3. ECONOMIC EFFICIENCY OF DRYER WALLS

Designing different walls of tobacco leaf dryers creates the different technology parameters. Therefore, economic effects are also different. Hence, it is necessary that we must choose the most economic effective wall to the future invest.

3.1.Cost of each dryer wall

Table 8 : Constructive wall cost

Kind of dryer wall	Cost (VND)	Used period (year)
Straw-clay wall	3,872,000	3
Brick wall	6,711,000	10
Fibrocement wall	11,576,000	5
Steel sheet and rice husk wall	14,292,700	5
Carton with 2 layers	8,575,600	4

3.2. Fuel cost for a drying batch of dryer walls

According to the experiment results, dried cost of dryer walls is different:

Table 9: Average cost of a drying batch for dryer walls.

Kind of dryer walls	Average cost (VND/drying batch)
Straw-clay wall	846,400
Brick wall	828,160
Fibrocement wall	991,560
Steel sheet and rice husk wall	759,760
Carton with 2 layers	775,340

Table 10: Investment cost and production cost

Straw-olay	Dryer wall cost	3,872.0			3,872.0			3,872.0			3,872.0	
	Other investment cost	5,483.0					5,483.0					
	Heat exchanger cost	7,168.9				7,168.9				7,168.9		
	Fresh tobacco		49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0
	Labor		1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0
	Fuel		11,069.0	11,069.0	11,069.0	11,069.0	11,069.0	11,069.0	11,069.0	11,069.0	11,069.0	11,069.0
	Ci	16,523.9	61,757.0	61,757.0	65,629.0	68,925.9	67,204.0	65,629.0	61,757.0	68,925.9	65,629.0	61,757.0
Brick	Dryer wall cost	6,711.0										
	Other investment cost	5,483.0					5,483.0					
	Heat exchanger cost	7,168.9				7,168.9				7,168.9		
	Fresh tobacco		49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0
	Labor		1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0
	Fuel		9,938.0	9,938.0	9,938.0	9,938.0	9,938.0	9,938.0	9,938.0	9,938.0	9,938.0	9,938.0
	Ci	19,362.9	60,626.0	60,626.0	60,626.0	67,794.9	66,109.0	60,626.0	60,626.0	67,794.9	60,626.0	60,626.0
Fibrocement	Dryer wall cost	6,157.6					6,157.6					
	Other investment cost	5,483.0					5,483.0					
	Heat exchanger cost	7,168.9				7,168.9				7,168.9		
	Fresh tobacco		49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0
	Labor		1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0
	Fuel		12,815.0	12,815.0	12,815.0	12,815.0	12,815.0	12,815.0	12,815.0	12,815.0	12,815.0	12,815.0
	Ci	18,809.5	63,503.0	63,503.0	63,503.0	70,671.9	75,143.6	63,503.0	63,503.0	70,671.9	63,503.0	63,503.0
Steel sheet – rice husk	Dryer wall cost	14,292.7					14,297.7					
	Other investment cost	5,483.0					5,483.0					
	Heat exchanger cost	7,168.9				7,168.9				7,168.9		
	Fresh tobacco		49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0	49,248.0
	Labor		1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0
	Fuel		9,117.1	9,117.1	9,117.1	9,117.1	9,117.1	9,117.1	9,117.1	9,117.1	9,117.1	9,117.1
	Ci	26,944.6	59,805.1	59,805.1	59,805.1	66,974.0	79,585.8	59,805.1	59,805.1	66,974.0	59,805.1	59,805.1
Carton	Dryer wall cost	8,576				8,576				8,576		
	Other investment cost	5,483					5,483					
	Heat exchanger cost	7,169				7,169				7,169		
	Fresh tobacco		49,248	49,248	49,248	49,248	49,248	49,248	49,248	49,248	49,248	49,248
	Employment		1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440
	Fuel		9,765	9,765	9,765	9,765	9,765	9,765	9,765	9,765	9,765	9,765
	Ci	21,228	60,453	60,453	60,453	76,198	65,936	60,453	60,453	76,198	60,453	60,453

Table 11: Cast flow of dryer wall

Kind of dryer wall	Criteria										
		1	2	3	4	5	6	7	8	9	10
Straw-olay	Received (Bi)	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054
	Cost (Ci)	61,757	61,757	65,629	68,926	67,204	65,629	61,757	68,926	65,629	65,629
	Bi - Ci	15,297	15,297	11,425	8,182	9,814	11,425	15,297	8,182	11,425	11,425
Brick	Received (Bi)	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054
	Cost (Ci)	60,626	60,626	60,626	67,795	66,109	60,626	60,626	67,795	60,626	60,626
	Bi - Ci	16,428	16,428	16,428	9,259	10,945	16,428	16,428	9,259	16,428	16,428
Fibrocement	Received (Bi)	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054
	Cost (Ci)	63,503	63,503	63,503	70,672	75,144	63,503	63,503	70,672	63,503	63,503
	Bi - Ci	13,551	13,551	13,551	6,382	1,910	13,551	13,551	6,382	13,551	13,551
Steel sheet – rice husk	Received (Bi)	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054
	Cost (Ci)	59,805	59,805	59,805	66,974	79,586	59,805	59,805	66,974	59,805	59,805
	Bi - Ci	17,249	17,249	17,249	10,080	(2,532)	17,249	17,249	10,080	17,249	17,249
Carton	Received (Bi)	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054	77,054
	Cost (Ci)	60,453	60,453	60,453	76,198	65,936	60,453	60,453	76,198	60,453	60,453
	Bi - Ci	16,601	16,601	16,601	856	11,118	16,601	16,601	856	16,601	16,601

3.3. Received value from quality of tobacco

Quality of tobacco after drying is very important, it influences directly to consider the benefit in commerce. When making experiments, we chose 1^{st} heat exchanger and install with the different walls. Thus, quality of dried tobacco is the same and their value is 6.421.205 VND per drying batch.

3.4. Calculating the effect of dryer walls

In order to calculate the effect criteria above for the heat exchangers, firstly, we need definite the cash flow of B_i, C_i , and horizontal time.

+ Determining the n^{th} horizontal time:

The used period of dryer walls is various, there are: 3; 10; 6; 5; 4 years. We elect n = 10, because brick wall have the longest used period (10 years). The others could be considering 2 or 3 long-life, this is equivalent to 10 years.

+ Determining the deductive rate r: r was chosen equally to 14%.

+ Determining the received cash flow B_i:

When researching the difference of dryer walls, yield and quality output of dried tobacco (making experiment only on 1st heat exchanger) is a constant because B_i among heat exchangers and ith years are constant ($B1 = B_2 = ... = B_{10}$)

+ Determining the expenditure cash flow C_i:

Cash flow C_i includes two main components:

- Primary investment cost includes: Constructive cost for dryer wall (Table 8) and cost for 1st heat exchanger (fixed).
- Annual production cost includes: input materials cost (fresh tobacco: VND 1,200 per kg), this cost is constant for every heat exchanger and every year; fuel cost (coal and fired-wood: table 9), this cost is changed in every heat exchanger, but in the same type is unchanged for all year; Labor cost is also unvaried for each year and each heat exchanger. Investment cost and production cost are showed in table 10.
- Summary table about the cash flow B_i, C_i is performed in table 11.

Table 12: Determining the Pay-back Period.

Criteria	Kind of dryer walls				
	Straw-clay	Brick	Fibrocement	Husk	Carton
Constant investment cost	16524	19363	18810	26945	21228
Motion capital	6069	5880	6360	5743	5851
Sum of investment cost	22593	25243	25170	32688	27079
Benefit + Deduction	15297	16428	13551	17249	16601
Pay-back period (PBP)					
+ A month	1.47	1.54	1.86	1.89	1.63
+ A year	17.7	18.4	22.3	22.7	19.6

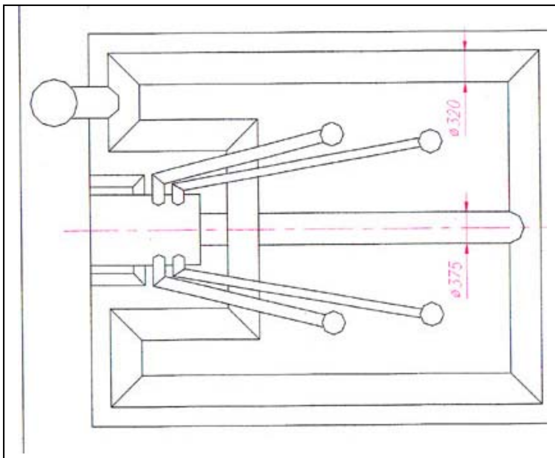
From table 11 and time flow n = 10. Base on calculating results from Financial function of Excel, we have the comparative table of economic efficiency of heat exchangers:

Table 13: Economic efficiency of dryer walls

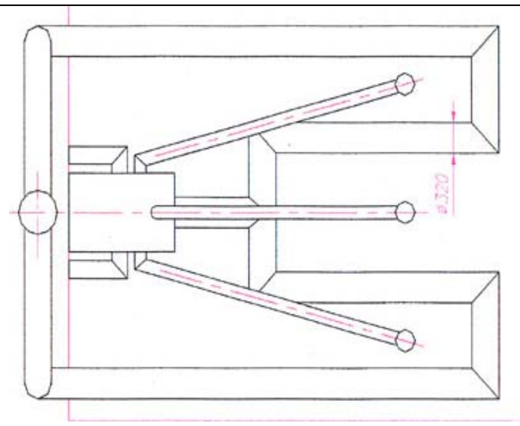
Criteria	Kind of dryer wall				
	Straw-clay	Brick	Fibrocement	Rice husk	Carton
NPV	42187	49756	34272	40348	41820
IRR	84%	80%	64%	56%	70%
PBP (month)	12	18	22	23	20

From table 13 we can see in 5 kinds of dryer wall, brick and straw-clay wall have NPV and IRR are much higher than Fibrocement, rice husk and carton ones. Besides, PBP of them are less than the others. So, in all of them, using the brick wall and straw-clay wall is more effective than the others.

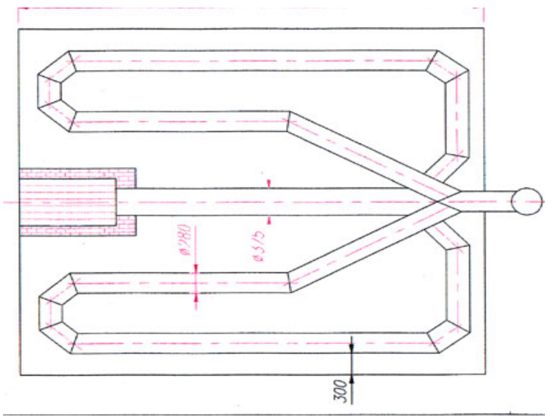
When comparing between straw-clay wall and brick wall, we can see: NPV ‘s brick is higher than one of former, IRR s’ brick is less than one of former, and PBP are the same. Because of this, their economic efficiency is quite similar, and brick dryer wall is more slightly effective. The materials stations of government or rich farmers, which have big investment, should use brick dryer wall. The farmers that have a small investment should use straw-clay dryer wall because it is cheaper.



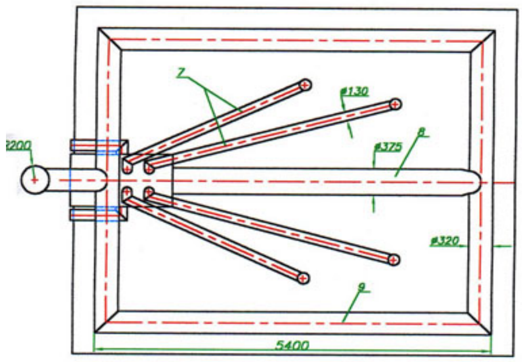
Picture 2: 3-pipes heat exchanger with chimney in one side.



Picture 3: 4-pipes heat exchanger.



Picture 4: 5-pipes heat exchanger.



Picture 5: 3-pipes heat exchanger.

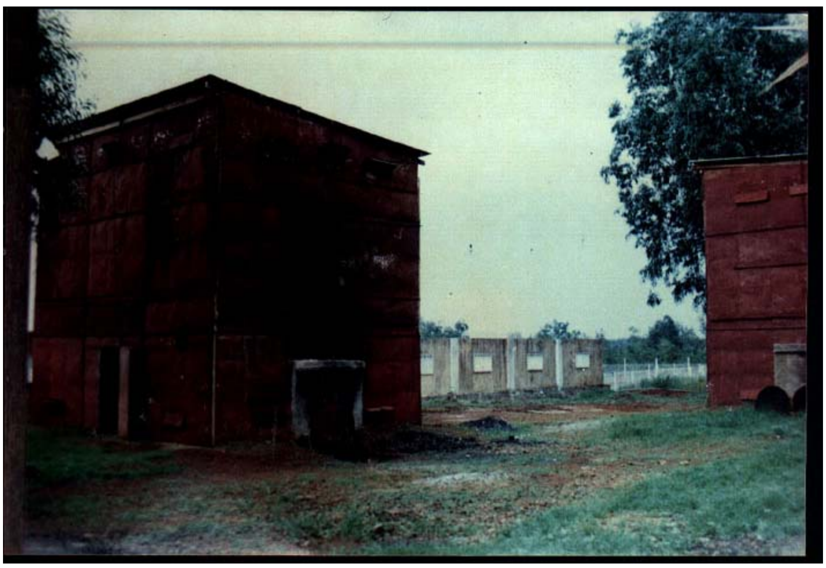
CONCLUSION

Through the analysis and comparison the economic effect, we can see: when we replace the 2nd, 3rd, 4th heat exchanger by the 1st one which are researched, manufactured, and has being using. So, its efficiency is the best. NPV from fuel saving and quality of dried tobacco of the 1st heat exchanger is higher than the others. In addition, PBP is the shortest. If we calculate in one thousand of dryers, who have being used per year, benefit from this change is billions.

Considering dryer walls, the brick wall is also the best. In case of low investment, we should choose straw-clay wall, its efficiency is less than brick wall slightly. We shouldn’t invest in steel sheet – rice husk, fibrocement, carton wall.

Picture 6: Tobacco leaf dryer has straw-clay wall

Picture 7: Tobacco leaf dryer has brick wall



Picture 8: Tobacco leaf dryer has steel sheet – rice husk wall

REFERENCES

1. PHAM LE DAN – **System of supplying heat** –Polytechniques University HaNoi City – 1991.
2. ĐOAN DU, BUI HUY HAN, VO VAN MAN – **The Handicraft Dryer** – Technology and Science Publisher – 1966.
3. BUI HAI, TRAN QUANG NHA – **Thermotechnics** - The University and Vacational Publisher – 1987.
4. TRAN VAN PHU – **Introduce to design dryer devices** – University of Technology.
5. HOANG DINH TIN, LE QUE KY – **Thermo-transfer base,** *book two* - University of Technology, HCMC. – 1989.
6. HOANG DINH TIN – **Transfering heat and calculating thermo – exchangeable devices** – Centre of reseaching thermo – devices and new energy – University of Technology – 1996.
7. A. HIRUN AND A. PROMWUNGKWA – **Flue Cured Tobacco** – Department of Mechanical Engineering Chaing Mai University, Chaing Mai 500002 ThaiLand – 1981.
8. JESSIEC ELAURIA – **Optimization of Fluidized–bed Burner of semirara Coal** – University of the Philippines Diliman, Quezon City July – 1993.
9. M.H. MAWHINNEY – **Burner Furnaces**.
10. M.DM SCHLESINGER – **Fuels** .
11. T.SIRATANAPANTA, P.RERKKRIANG AND P. TERDTOOL – **Tobacco drying** - Department of Mechanical Engineering Chaing Mai University, Chaing Mai 500002 ThaiLand – 1981.
12. W.K.COLLINS AND S.N.HAWKS, JR – Principles of Flue – **Cured Tobacco Production** – N.C State University box 7620 Raleigh, NC 2769 – 7620. First Edition – 1993.