World Academy of Science, Engineering and Technology
International Journal of Chemical and Molecular Engineering
Vol:5, No:9, 2011

Thermodynamic Study of Seed Oil Extraction by Organic Solvents

Zhila Safari, Ali Ashrafizadeh, and Najaf Hedayat

***Abstract*—**Thermodynamics characterization Sesame oil extraction by Acetone, Hexane and Benzene has been evaluated. The 120 hours experimental Data were described by a simple mathematical model. According to the simulation results and the essential criteria, Acetone is superior to other solvents but under certain conditions where oil extraction takes place Hexane is superior catalyst.

***Keywords*—**Liquid-solid extraction, seed oil, Thermodynamic Study.

I. Introduction

ENERGY conservation law is similar to first thermodynamic law is explanatory of non-fading energy. While second thermodynamic law states that under normal environmental conditions all the energy source can not be used.

Thermodynamic engineers have recently introduced new quality of energy called exergetic. This means that the amount of energy in each process is preserved. The second law introduce entropy, free energy of Helmholtz and free enthalpy (Gibbs free energy and give us them in the form of thermodynamic functions and give us ability that computing irrevocability amount of process. Recently more new concept of energetic is used instead of using entropy [1].

Analysis of the second law means that entropy is generated from heat. In this respect, Stodula and Gouyare based on Gibbs and Keenon introduced availability concept. Bonsnjankovic was a pioneer in using irrocabilitry concepts. Rant was the first in appliying the exergetic concept [2]. Bejan established new concepts relating to entropy generation because of link between heat transfer, fluids mechanic and thermodynamic[3].

Usually meal or medicinal oils are obtained from vegetal or animal fats. Vegetal fats are liquid in room temperature which are often derived from vegetable oils, plants, fish, and plant seeds. Sesame seed contains almost 50% oil which may have numerous applications particularly in medicine.

Sesame seed also contains proteine and vitamine ،F، E, D, B and Lysytyn. Sesame oil has 70% unsaturated fatty acids such as Linoleic acid as well as saturated fatty acids like Palmitic acid and Ashydylic acid.

Zhila Safari is with Department of Chemistry, Dezful Branch, Islamic Azad University, Dezful, Iran (e-mail: zhilasafari@iaud.ac.ir).

Ali Ashrafizadeh is with Department of Engineering Chemistry, Dezful Branch, Islamic Azad University, Dezful, Iran (e-mail: ashrafi@iaud.ac.ir).

N. Hedayat is with Water Engineering Department, Dezful Branch, Islamic Azad University, Dezful, Iran (e-mail: n.hedayat@yahoo.com).

According to definitions of standard institute and industrial researches of Iran, there are three kinds of sesame oils : 1-row oil with meal usage ability without passing filtration stage, 2- almost filtered oil, 3- entirely filtered oil.

There are three methods for extracting oil from seeds namely compact extraction, solvent extraction, and the combination of two.

Various researches were conducted on the application of organic solvents as a method of extracting oil from the seeds such as sesame oil [4]. Recent recearch by M. V. Reshma, C. Balachandran, C. Arumughan, A. Sunderasan, D. Sukumaran, S. Thomas and S. S. Saritha are on the use of solid liquid extraction process [5].

M. P. Corso et al. applied compressed propane and super saturation carbon dioxide for oil extraction given the energy resources limitation and bioenvironmental challenges. However, there is an emerging trend towards optimal production which needs the minimum resources while ensuring higher environmental safety [6]. Thermodynamic analysis of the process and comparison of available methods suggest that this is the most effective tool in this respect. Given the visibility of applying various solvents for oil extraction process regarding oily seeds each method can realistically be applied depending on circumstances and condition upon which the process take place. Based on the aforementioned parameters, it can be stated any research should focus on the circumstances at characteristics of the oil seeds under consideration which the sesame seed extraction process is not an exception. The present research aims at identifying appropriate extraction technique for general application in Iranian industry.

II. Materials and Methods

System that used in conducting testa was solid- liquid extraction device made in Deltalab Company of France (MP1035 model) that its total diagram shared in Fig. 1.

Sesame put in its special bed in amount of one kilogram in milling form (particles dimensions 0.1 to 0.6 ml). After starting the system the boiling activity takes place and the solvents are poured on the sesame bed at an speed which can regulated by the boiler and its tower reflection ratio. After loading sesame bed by solvent and using connecting pipe lines the oil obtained from seeds are poured towards boiler from the sesame bed. This solvent is than evaporated again and the process continues with every loading. This results in more oil entering the boiler which is than separated from the solid phase.

In this stage with changing solvent route, sesame guided toward solvent storing containers, the recycling operation is performed. The solvents which are used in this experiment consist of Hexane, Acetone and Benzene. Three different powers of boiler and three different numbers for reflux ratio of distillation tower were examined for each solvent.

A. Exergetic Analysis of Used System

Exergetic resources loss can be estimated by the following methods:

1. Boiler Exergetic Loss in Extraction Stage

$$EL_{Bioler\ 1} = q_B\left(1-\frac{T_0}{T}\right) \tag{1}$$

Where. q_B is the speed of heat transfer in boiler and T, T_0 : Temperature of boiler，reference temperature.

2. Condencer Exergetic Loss in Extraction Stage

$$EL_{Cond\,1} = q_C\left(1-\frac{T_0}{T_{LM\,1,2}}\right) \tag{2}$$

Where, q_c is the speed of heat transfer in condenser which is derived from (3) and $T_{LM1,2}$ consist of mean logarithm temperature of cooling water condenser in entry and exit from condenser.

$$q_C = \dot{m}_{H\,2O}CP_{H\,2O}\left(T_{out}-T_{in}\right) \tag{3}$$

3. Exergetic Loss of Distillation Tower Due to Changing Concentration in Extraction Stage

$$EL_{dis1C} = \left[\sum_{j=1}^{Z} RT_0 \sum_{i=1}^{2} nij \ln\frac{1}{x_{ij}}\right]_{in} - \left[\sum_{j=1}^{Z} RT_0 \sum_{i=1}^{2} nij \ln\frac{1}{x_{ij}}\right]_{out} \tag{4}$$

Where, Z is times number that solvent and oil poured from sesame bed in to boiler，also x_i , n_i are number of mole and mole ratio of available solvent and oil in solution，respectively.

4. Exergetic Loss of Distillation Tower Due to Changing Temperature in Extraction Stage

$$EL_{dis1T} = \sum_{j=1}^{Z}\sum_{i=1}^{2} m_{ij}Cp_{ij}\Delta T_{ij}\left(1-\frac{T_0}{T_{LM\,1,2,i,j}}\right) \tag{5}$$

Where，q_B is the speed of heat transfer in boiler and T and T_0 are reference temperatures and boiler temperature，respectively.

5. Exergetic Loss in Sesame Column Due to Changing Concentration

$$EL = \left[\sum_{j=1}^{Z} RT_0 \sum_{i=1}^{2} nij \ln\frac{1}{x_{ij}}\right]_{in} - \left[\sum_{j=1}^{Z} RT_0 \sum_{i=1}^{2} nij \ln\frac{1}{x_{ij}}\right]_{out} \tag{6}$$

Where，Z is times number of loading sesame bed.

6. Boiler Exergetic Loss in Recycling Stage
Sesame extraction stage can be written:

$$EL_{Boiler2} = q_B\left(1-\frac{T_0}{T}\right) \tag{7}$$

Used parameters in expression (7) are same as in expression (1).

7. Condeser Exergetic Loss in Recycling Stage
The same method can be used for extraction stage:

$$EL_{Cond\,2} = q_C\left(1-\frac{T_0}{T_{LM\,1,2}}\right) \tag{8}$$

Parameters used in (8) are the same as (2).

8. Exergetic Loss in Distillation Tower Due to Changing Concentration in Recycling Stage

$$EL_{dis2C} = +RT_0\left[\sum_{i=1}^{2} ni2\ln\frac{1}{x_{i2}} - \sum_{i=1}^{2} ni1\ln\frac{1}{x_{i1}}\right] \tag{9}$$

In this equation，1 and 2 indexes are first and last states of recycling stage.

9. Exergetic Loss Due to Changing Temperature of Recycled Solvent in Recycling Condenser

$$EL_{Condrec} = \left(m.Cp.\Delta T\right)_{Sol} \times \left(1-\frac{T_0}{T_{LM\,1,2,Sol}}\right) \tag{10}$$

Where, Sol is recycling solvent. Comparison of laboratory data such as temperature, concentration and time of performing test can help determining the rate of exergetic losses in the process.

III. Data Analysis

Fig. 2 shows changes of exergetic loss changes for the three solvents in different reflux ratio of distillation tower at about 750V power.

As can be observed from Fig. 2, generally acetone shows minimum exergetic losses than Hexane and Benzene. But Hexane can have 30% lower exergetic loss than acetone in reflux ratio.

Fig. 3 shows changes of exergetic loss changes for the three solvents in different percents from maximum boiler power of 1500V.

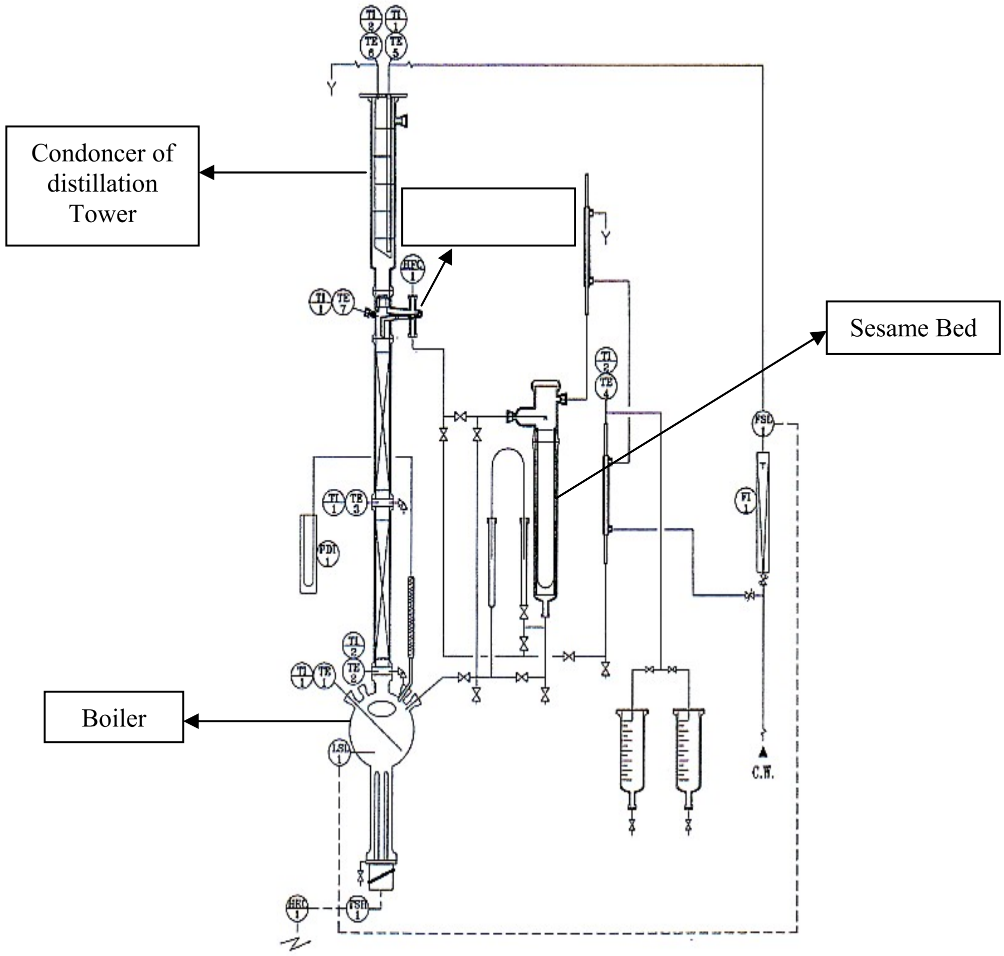

Fig. 1 Solid-Liquid extraction device made in Deltalab company of France(MP1035 model)

As can be observed from Fig. 3, acetone has generally lower exergetic losses while Hexane shows lower exergetic losses at about 55% of maximum boiler power.

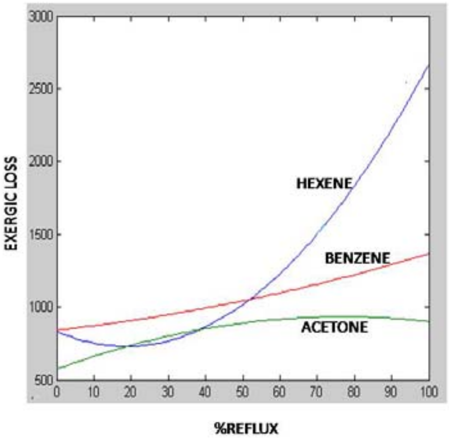

Fig. 2 Changes of exergetic loss for each three solvents in different numbers of reflux ratio of distillation tower

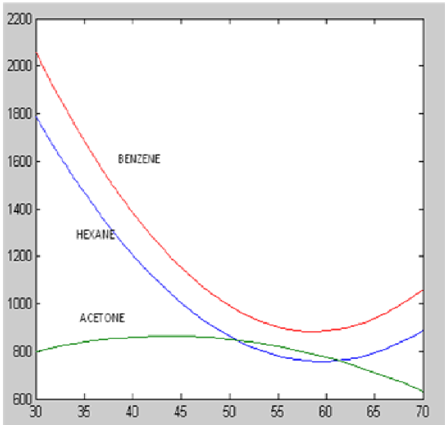

Fig. 3 Changes of exergetic loss for each three solvents in different boiler temperature

IV. CONCLUSION

It can be concluded from Fig. 2 and 3, if parameters are exactly controlled the application of Hexane solvent in reflux ratio of 30% and 825V power for one kilogram sesame there will be the least exergetic loss in oil extraction process from sesame grains.

However, because of the volatility and unwanted reactions Acetone is inappropriate. Furthermore the Benzene is also inappropriate because it is toxic. For this reason Hexane is preferred.

REFERENCES

[1] Nario santo, Chemical energy and exergy, Elsevier, 2004, PP:149.
[2] Gouy G, About available energy.Jphysique II, 1998, 8: 105-18.
[3] A. BEJAN, Entropy generation through heat and fluid flow, John Wiley and sons, New York, 1982.
[4] C.M.Cater, K. C. Rhee, R. D. Hagenmaier & K. F. Mattil, “Aqueous extraction- An alternative oil seed milling process “, Journal of the american oil chemists’ society, Sprinnger Berlin/ Heidelberg, Volume 510 No. 4, April, 1974, P. P. 137- 141.
[5] M.V.Reshma, C. Balachandran, C. Arumughan, A. Sunderasan, D. Sukumaran, S. Thomas and S. S. Saritha, “ Extraction, Separation and characterisation of sesame oil lignan for nutraceutical applications”, Food Chemistry, Vol. 120, Issu 4, 15 June 2010, PP. 1041- 10460.
[6] M. P. Corso, M. R. Fagundes- Klen, E. A. Silva, L. C. Filho, J. N. Santos, L. S. Freits and C. Dariva, “Extracting of sesame seed (sesamum indicum L.) oil using compressed propane and supercritical carbon dioxide, Journal of supercritical fluides, Vol. 52 Issue 1, Feb. 2010, PP. 56- 61.