International Journal of Mechanical, Industrial and Aerospace Sciences
ISSN: 2517-9950
Vol:1, No:8, 2007

Optimizing of Gas Consumption in Gas-burner Space Heater

Saead Negahdari, and Davood Jalali Vahid

***Abstract*—**Nowadays, the importance of energy saving is clearance to everyone. By attention to increasing price of fuels and also the problems of environment pollutions, there are the most efforts for using fuels littler and more optimum in everywhere. This essay studies optimizing of gas consumption in gas-burner space heaters. In oven of each gas-burner space heaters there is two snags to prevent the hot air (the result of combustion of natural gas) to go out of oven of the gas-burner space heaters directly without delivering its heat to the space of favorite environment like a room. These snags cause a excess circulating that helps hot air deliver its heat to the space of favorite environment. It means the exhaust air temperature will be decreased then when there are no snags. This is the aim of this essay to use maximum potential energy of the natural gas to make heat. In this study, by the help of a finite volume software (FLUENT) consumption of the gas-burner space heaters is simulated and optimized. At the end of this writing, by comparing the results of software and experimental results, it will be proved the authenticity of this method.

***Keywords*—**FLUENT, Heat transfer, Oven of Gas-burner space heaters, Simulation.

I. INTRODUCTION

FOR the sake of increasing price of all kind of fuels and prevention of petering their reservoirs, the efforts of all scientists and governments is fewer and optimum consumption of fuels like oil and natural gas. One of the gas consumers is gas space heater or gas-burner space heaters.

There are two methods for optimizing of natural gas consumption of gas-burner space heaters: 1- Theoretical methods 2- Experimental methods. Experimental methods are so accurate and expensive and need so many times to use. It means this method is not the exclusive method for analyzing; besides, the theoretical methods in spite of their inexpensiveness and shortness are not accurate as experimental methods. Then to use both advantages of these to methods, after simplifying and simulation of the phenomenon, the results will be compared with the experimental results to prove the authenticity of the theoretical method. Gas-burner space heaters are some systems to warm environment by burning fuels like natural gas and converting the potential energy of fuels to heat. There are some activities to simulate the gas-burner space heaters in other countries by some other softwares like Fire [1]. But because of their different methods this study is new as an innovation. There are so suggestions for changing some parts or all parts of the gas-burner space heaters to optimize their consumptions on the base of the Fourier's law [2] and Newton's chilling law [2] for conduction and convection like: 1- Changing substances of gas-burner space heaters body by a better conductive substance like cupper instead of the steel (increase the conductivity coefficient of the equation no. 1). 2- Adding fins on the body of gas-burner space heaters or it's oven to increase the area of convection on the base of equation no. 2 3- Adding some fans for better convection on the base of equation no. 2 4- etc .By the reason of high prices it is recommended that do something that don't negative affect on the total price of product. In this essay, at the first, one of products of an Iranian factory[1] is simulated by the control volume software, FLUENT, and then by changing the shape of the snags in the oven of gas-burner space heaters it will be a lower temperature in exhaust air that mean there will be more heat transfer to the space of favorite environment like a room. The snags in the oven of gas-burner space heaters are a short metal band in front of balcony of the oven. These snags cause a excess circulating that helps hot air deliver its heat to the space of favorite environment more than when they are not in their seated. Making and changing these snags are very simple and inexpensive.

II. GEOMETRICAL CHARACTERISTICS, ASSUMPTIONS AND SOLVING METHOD

First simplify is changing the problem from 3D to 2D environment. The shape of the oven before optimization is conforming to Fig. 1. Instead of simulation of combustion, there is a velocity inlet with value of 0.01 m/s and temperature of 1000 K. In the other hand the stage of after combustion is simulated and there was no necessity to having combustion. As it is seen outlets are two holes in the upper part of the oven. The stream of the air in the oven is slow and quiet then the thermodynamic properties are constant. The density is constant on the base of Nelson-Obert generalized compressibility charts [3] for nitrogen instead of air in these conditions. The problem is solved in steady state – steady flow condition because the time of unsteady condition can be

F. Saead Negahdari, M.S. Student, Department of Mechanical Engineering, Sahand University of Technology, P.O. Box 51335-1996, Tabriz, Iran (phone: +98-9123993451; e-mail: saead_neg@yahoo.com).

S. Davood Jalali Vahid, Assistant Professor, Department of Mechanical Engineering, Sahand University of Technology, P.O. Box 51335-1996, Tabriz, Iran (e-mail: davoodjalali@yahoo.co.uk).

[1] Ghaynar Khazar Tabriz Industrial Co.

ignored in front of steady state- steady flow condition because of shortness. The temperature of software is conforming to these conditions (300 K and 1 atm). The only parameter that is changed is the pair of snags. The conditions of FLUENT are "Solver: Segregated, Space: 2d, Gradient option: Cell-based, Time: Steady". There are $\rho = 1.225\, kg/m^3$ and $c_p = 1.006$ j/kg.K $\mu = 1.7894 * 10^4$ kg/m.s for the air in the software. The mesh properties are "Tri","Pave" with the distance of 0.2.

III. The Governing Equations

In Fig. 1 and 4, the ovens are showed in 2D environment. All the walls have convection heat transfer. But the snags because of little area have not convection heat transfer. The equations of Fourier's law, Fourier's chilling law, continuity, momentum and energy for a two dimensional, quiet and constant thermodynamic properties are as below:

$$q = -k\left(\frac{\partial T}{dx} + \frac{\partial T}{dy}\right) \quad (1)$$

$$q = hA\Delta T \quad (2)$$

Continuity:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \quad (3)$$

Momentum in course of x:

$$\frac{\partial (uu)}{\partial x} + \frac{\partial (uv)}{\partial y} = -\frac{1}{\rho}\frac{\partial P}{\partial x} + \frac{\mu}{\rho}\left[\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right] \quad (4)$$

Momentum in course of y:

$$\frac{\partial (uv)}{\partial x} + \frac{\partial (vv)}{\partial y} = -\frac{1}{\rho}\frac{\partial P}{\partial y} + \frac{\mu}{\rho}\left[\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2}\right] + g\beta (T - T_{room})$$

Energy:

$$\frac{\partial (uT)}{\partial x} + \frac{\partial (vT)}{\partial y} = \alpha\left[\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right] \quad (5)$$

TABLE I
Units for Fluids and Heat Transfer Properties

Symbol	Quantity	unit
A	area	m^2
g	Gravity acceleration	m/s^2
h	Convection Heat Transfer Coefficient	W/m^2 K
k	Thermal conductivity	W/m. K
P	Pressure	Pa
T	Temperature	K
v,u	Velocity	m/s
x	distance	m
β	Heat bulk expansion coefficient	K^{-1}
μ	Dynamic viscosity	Kg/m.s
ρ	density	Kg/m^3

IV. Results

After simulation of oven of gas-burner space heaters the temperature of outlet stream is 517 K in software that its error is about 1%. Meantime CO_2 of the result is 6.4%. Then according to the references [4, 5, 6], the total efficiency is 69%. But after changing the snags the best shape of snags is "~" that its result in software is temperature 486 K and the results of experimental test is 506 K that the error of software is about 4%. The percentage of CO_2 is 6.6. The growth of CO_2 shows more O_2 is consumed it means the combustion is more complete than the previous stage. It is proved by achieving the total efficiency that is 74%. It is necessary to state the instrument that is used to measuring the real temperature of exhaust air is CE MultiTester (model: MI 2094) that is so accurate. [7]

TABLE II
Measured Properties of Exhaust Air for Two Different Snags

Error of software in percent	Percentage. of CO_2	Output air temp. in lab	Output air temp. in software	Room temp. (Velocity inlet)	Snag shape
1	6.4	524	517	22	Straight snags
4	6.6	506	486	22	Accolade snags

Comparing the two figures (3 and 7) shows in the case of snags of "~" more heat can achieve to upper wall of the oven. Then the heat can be transferred better than previous case. In velocity contours (figures no 4 , 8 , 5 , 9) show that hot air before going out of oven has high velocity. This mean this shape is caused that hot air in second case used more space than first case this is because of higher velocity in second case.

V. Conclusion

Because of remaining of hot air in second case that is more than first case there is more heat transfer from oven to favorite space. This longer time causes longer distance that it means a bigger area for convection. Meantime because the most of heat transfer is by upper wall (because hot air goes up) the second case will help this condition, too.

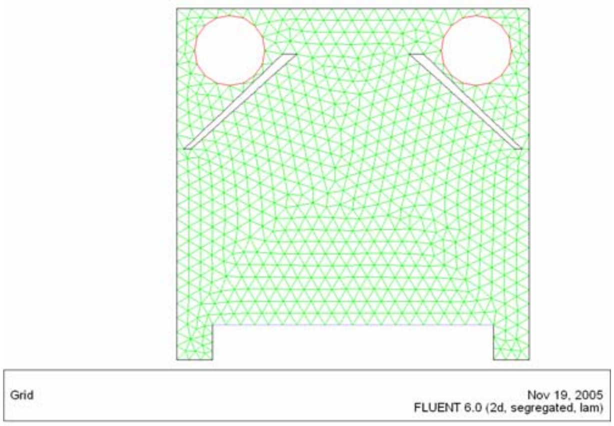

Fig. 2 Schematic figure of 2D oven that shows the meshes for 1st case. The input edge is blue and output holes are red

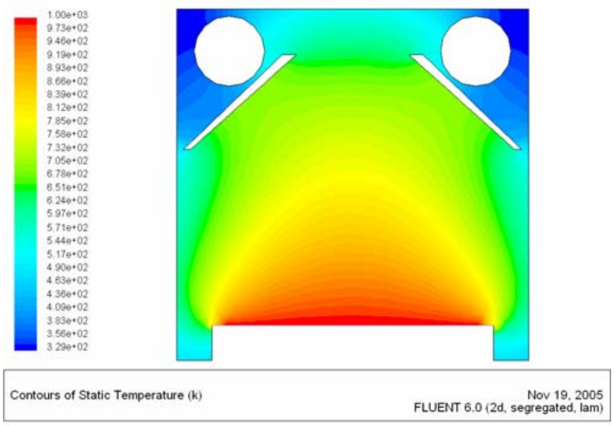

Fig. 3 Temperature contours for 1st case

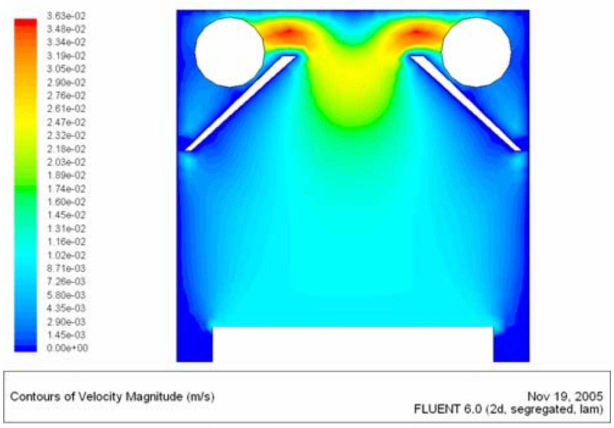

Fig. 4 Velocity contours for 1st case

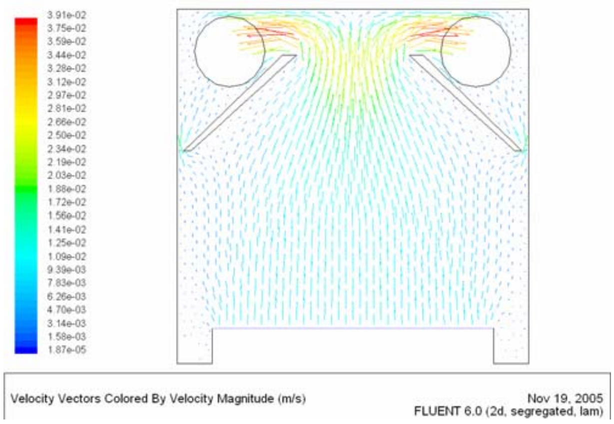

Fig. 5 Velocity vectors for 1st case

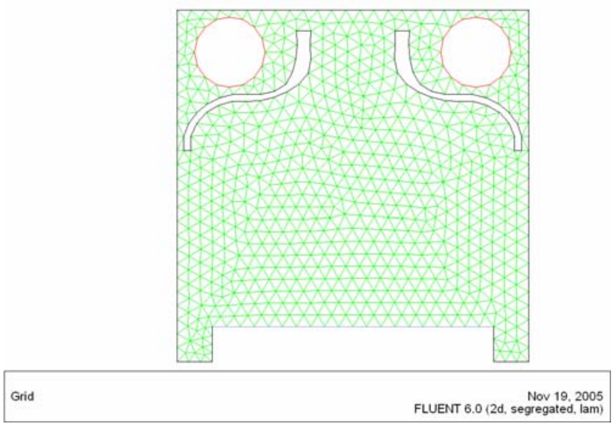

Fig. 6 Figure of 2D oven that shows the meshes for 2nd case

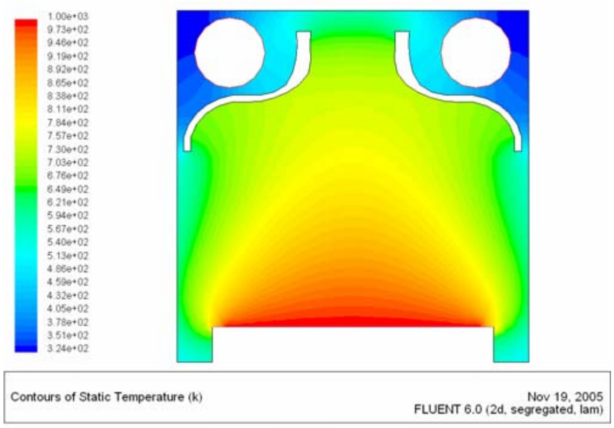

Fig. 7 Temperature contours 2nd case

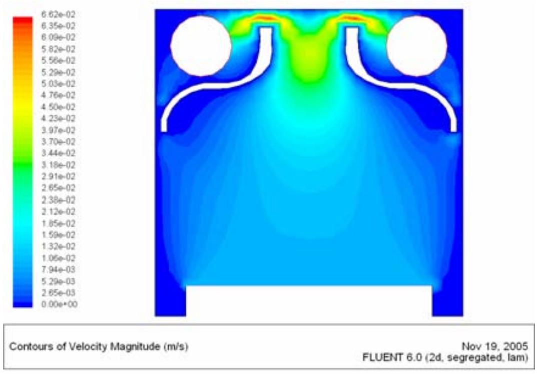

Fig. 8 Velocity contours 2nd case

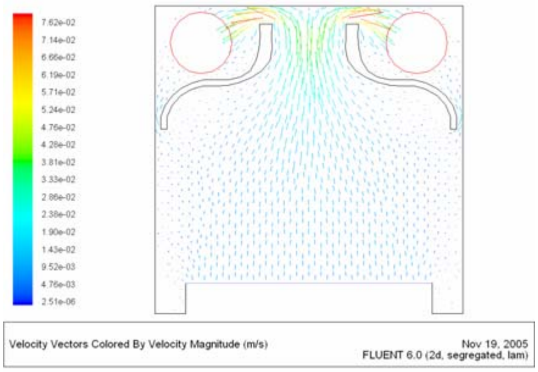

Fig. 9 Velocity vectors 2nd case

ACKNOWLEDGMENT

Authors would like to thank Mr. Jafar Najafi, manager of Ghaynar Khazar Tabriz Industrial Co. because of his efforts and supports.

REFERENCES

[1] [Online]. Available: http://www.avl.com.
[2] F. P. Incropera, Introduction to Heat Transfer Approach (Book style). Industrial Esfahan University, Iran, publishing, 1995 (Translated version), Appendix A, page 695.
[3] Y.A. Cengel, M.A. Boles, Thermodynamics: an Engineering Approach (Book style). Elm-o-Sanat Iran University publishing, 2000 (Translated version), first chapter.
[4] Institute of Standards and Industrial Research of Iran, ISIRI number 1220, Gas fired vented room heaters, fourth edition.
[5] Institute of Standards and Industrial Research of Iran, ISIRI number, 1220-2, Gas space heating appliances Test method for energy consumption and energy labeling instruction, 1st Edition.
[6] American national Standard for Gas-Fired, Vented room heaters, (ANSI21.111.1974 Z).
[7] [Online]. Available: http://www.mehreganpaya.com.
[8] N. Jamshidi, D. Afkari, Teaching FLUENT and GAMBIT, Amirkabir University Publishing, Iran, 2003.
[9] R. Rahimiasl, M. Soltani, CFD by FLUENT, Tarrah Publishing, Iran, 2004.

Saead Negahdari: birthplace: Tehran, Iran, birth date: 02/05/1981. BSc. in Mechanical engineering (Fluids) in Ferdowsi of Mashhad of Iran in 2005 and MSc in Mechanical engineering (Energy Exchanger) Sahand University of Technology in Iran in 2007.

He is engaged in Ghaynarkhazar Co. for two years till now as R&D master. He has 3 essays as below:

1- A Research on Solar Collectors, Bafgh Yazd student conference, 2006.
2- A Research on the renewable fuels instead of gasoline and gas, 1st conference on Optimizing Energy, Mashhad, Iran, 2007.
3- Optimizing the gas heater for Label E to D, 1st conference on Optimizing Energy, Mashhad, Iran, 2007.

He interested in new and renewable energy like solar, wind, fusion, fission and etc energies. He is familiar with most Mechanical engineering softwares like AutoCAD, SolidWorks and MATLAB and FORTRAN programming language.

Saead Negahdari is with Industrial University of University of Sahand Tabriz (e-mail: s_negahdari@sut.ac.ir).

Davood Jalali Vahid is engaged in Sahand University of Technology.