AIN-SHAMS UNIVERSITY
FACULTY OF ENGINEERING

INVESTIGATION OF PULSATING FLOW ON THE PERFORMANCE OF A DOUBLE CONCENTRIC TUBE HEAT EXCHANGER

By

SAMIR SAAD ZAGHLOUL SALEH
B. Sc. (Mech. Eng.) 1975

Submitted in partial fulfillment of the requirements for the degree of Master of Science in Mechanical Engineering
Power Departement

Supervisors

1. Prof. Dr. Hussein Z. Barakat
Professor , Mech. Engineering Power Department
Faculty of Engineering Ain Shams University.

2. Dr. Raouf N. Abdel-Messih
Associate Professor, Mech. Engineering Power Department
Faculty of Engineering, Ain Shams University.

3. Dr. Gamil W. Younan
Lecturer, Mech. Engineering Power Department
Faculty of Engineering, Ain Shams University.

الله

بسم الله الرحمن الرحيم

وما أوتيتم من العلم إلا قليلا

صدق الله العظيم

بسم الله الرحمن الرحيم

EXAMINERS COMMITEE

The undersigned certify that they have read and recommend to the faculty of engineering. Ain Shams university for acceptance a thesis entitled

"**Investigation of pulsating flow on the performance of a double concentric tube heat exchanger**".

Submitted by Eng. **Samir Saad Zaghloul Saleh**. in partial fulfilment of the requirements for the degree of master of science in Mechanical Power.

1. Prof. Dr. Abdel Latief Abdel Mohssen
Professor , Mech. Engineering Power Department
Faculty of Engineering Assyout University.

2. Prof. Dr. Samir M. Abdel Ghanie
Professor , Mech. Engineering Power Department
Faculty of Engineering Ain Shams University.

3. Prof. Dr. Hussein Z. Barakat
Professor , Mech. Engineering Power Department
Faculty of Engineering Ain Shams University.

4. Dr. Raouf N. Abdel-Messih
Associate Professor, Mech. Engineering Power Department
Faculty of Engineering, Ain Shams University.

TO MY PARENTS WHO GAVE AND ARE STILL GIVING WITHOUT ASKING ANYTHING IN RETURN.

AND TO MY WIFE WHO FORMED AND IS STILL FORMING MY FANTASTIC GROUP.

STATEMENT

The work included in this thesis was carried out by the author in the Mechanical Power Engineering Departement, Ain Shams University from 1991 to 1996

No part of this work has been submitted for a Degree or a Qualification at any other University or Institute .

ACKNOWLEDGEMENT

The author would like to acknowledge with the help and advice given to me by **Prof. Dr. Hussein Z. Barakat, Dr. Raouf N. Abdel Messih and Dr. Gamil W. Younan** for their help and advice which they gave during the work on this thesis and their continued interest in the problems involved.

The author also appreciates the assistance given by the Staff of Refrigeration and Air Conditioning Laboratory and the Workshops of the Ain Shams University, Faculty of Engineering.

ABSTRACT

The study of pulsting flow, is of special interest in industrial applications, such as chemical processes and heat exchangers. In spite of its considerable importance, limited researches about the pulsed flow in heat exchangers. could be found .

Some investigators stressed their work on the results they had found from the experimental tests. These results show that there is some improvement in the heat transfer when pulsed flow is being applied. However they did not satisfy a suitable correlation to these results, due to the difficulty of finding an accurate relation having all the variations of the parameters affecting the heat transfer enhancement .

In the present work, experiments are carried out, covering a wide range of Reynolds number and the frequency of pulsation to invesigate their effects on the enhancement of the heat transfer coefficient, In these experiments Reynolds number ranges from 10^4 to 8×10^4 while the pulsating frequency ranges from 0.5 Hz to 8 Hz. As for the inlet hot water trmperature, only two values are investigated, namely 50°C and 60°C for either the parallel or the counter flow heat exchangers .

From the test results it was found that, pulsating flow heat exchangers show an improvement in the overall heat transfer coefficient .

In general the enhancement of heat transfer in case of counter flow, using pulsed flow, is much higher than of the corresponding parallel flow heat exchanger. also the results show that, making the inner hot flow in pulsating mode produces higher improvement in heat transfer

coefficient than making the cold fluid in pulsating mode. As for the variation of the inlet hot water temperature, the results indicate that the absolute values of the maximum enhancement increases as the hot fluid temperatures is reduced and this maximum occurs at lower values of frequency and this improvement depends on the applied frequency of pulsation .

The effectiveness of the heat exchanger gets better if the pulsating flow is used rather than the steady state flow, and a pulsating flow of 1.5 Hz in counter flow results in the best effectiveness. However, in parallel flow, all frequencies show also improvement of the effectiveness over the steady flow operation, and this improvement is dependant on the applied frequency .

The improvement obtained in the absolute valuse of the enhancement, when both the hot and cold streams are in pulsation, is found to be negligible, compared to the enhancement found by making only the inner stream in pulsating mode .

Finally, correlating formulae are obtained to relate the changes in the enhancement with the Reynolds number, Prandtl number and the applied frequency of pulsation .

NOMENCLATURE :

A	: area	[m^2]
Cp	: specific heat at constant pressure	[J/kg.K]
E	: enhancement	[-]
F	: frequency (Hz)	[1/s]
$\dot{m}$	: mass flow rate	[kg/s]
NTU	: number of transfer unit	[-]
Nu	: Nusselt number	[-]
Q	: heat transfer rate	[W]
Re	: Reynolds number	[-]
Pr	: Prandtl number	[-]
T	: temperature	[K]
U	: overall heat transfer coefficient	[W/m^2.K]
ΔT	: temperature difference	[K]
ΔE	: increment of enhancement	[-]
L	: Heat exchanger's length	[m]
V	: volume flow rate	[m^3/s]
f_o	: the ratio between oscillating velocity and mean velocity of flow	[-]
d	: tube diameter	[m]

Fu	: function	[-]
C	: coefficient	[-]
h	: convective heat transfer coefficient.	[W/m^2.K]
t	: The time of the complete cycle.	[s]
Cc	: heat capacity of cold air .	[W/K]
k	: thermal conductivity	[W/m.K]
ε	: effectiveness	[-]
υ_m	: mean velocity of flow	[m/s]
μ	: dynamic viscosity	[N.s/m^2]
ρ	: density	[kg/m^3]

Subscript :

c	: cold fluid	h	: hot fluid or high
i	: inner	ln	: logarithmic mean
o	: out	max	: maximum
p	: pulsating mode	m	: mean
ex	: experimental	s	: steady state mode
w	: wall	cal	: calculated
L	: low		

CONTENES

INTRODUCTION