

سامية محمد مصطفى



شبكة المعلومات الجامعية

بسم الله الرحمن الرحيم



سامية محمد مصطفى



شبكة المعلومات الجامعية



شبكة المعلومات الجامعية التوثيق الالكتروني والميكروفيلم



سامية محمد مصطفى



شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات



يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار



سامية محمد مصطفى



شبكة المعلومات الجامعية



بعض الوثائق الأصلية تالفة



سامية محمد مصطفى



شبكة المعلومات الجامعية



بالرسالة صفحات لم ترد بالأصل



**Cairo University
Faculty Of Engineering**

**EXPERIMENTAL INVESTIGATION OF TURBULENT
HEATED FLOW IN AN ANNULAR
SECTOR DUCT**

Presented By

Amr Yehia Abdo El Sayed
B.Sc. in mechanical power engineering

In partial fulfillment of
master of science degree
in mechanical engineering

SUPERVISED BY ;

PROF. A.S. EL ASFOURI
Mechanical Power Depart.
Faculty of Engineering
Cairo University

PROF. A.S. HANAFI
Mechanical Power Depart.
Faculty of Engineering
Cairo University

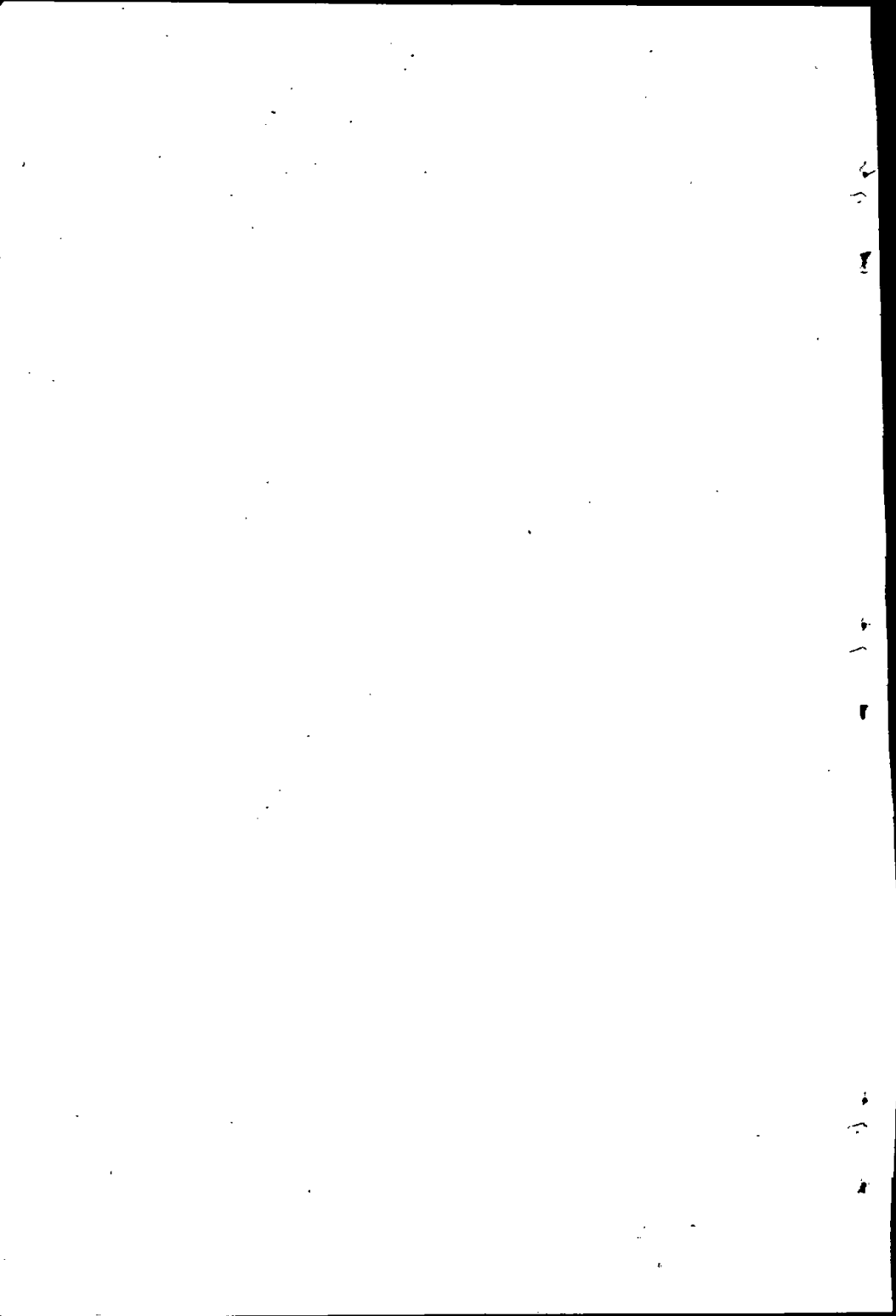
ASSO.PROF. M.A. RIZK
Mechanical Power Depart.
Faculty of Engineering
Cairo University

1996

B

17-11





ACKNOWLEDGEMENTS

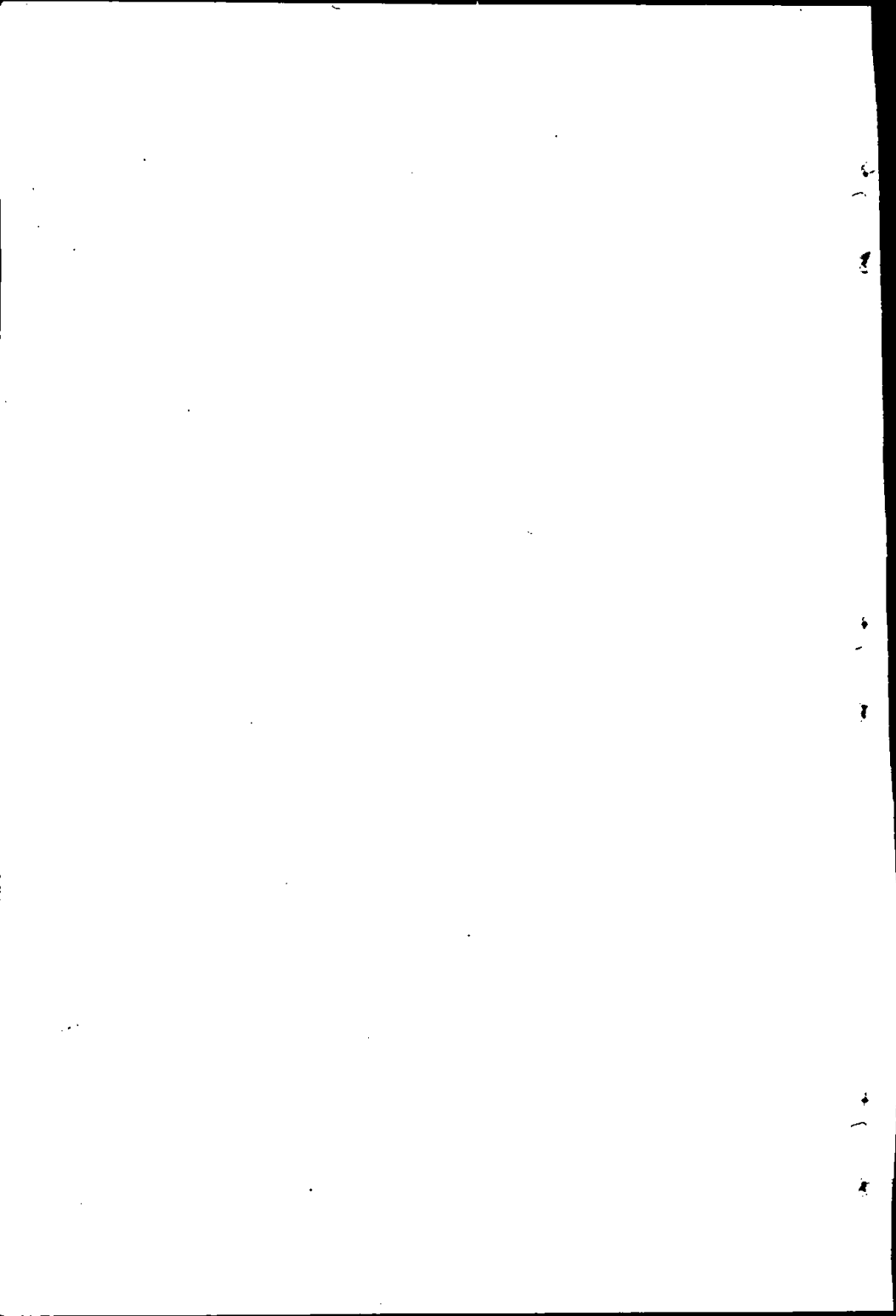
The author would like to thank his supervisors , Prof. Ahmed El-Asfour , Prof. Abdalla Hanafi and Dr. Moustafa Rizk , for their precious guidance and sincere help through the completion of the thesis .

Special thanks for Prof. Mohsen Abou-Ellail for his great help .

The author would like to express his deep gratitude and appreciation to his family in general and specially to his parents , and he would like to offer this work to them .

The author would like to thank all the Cairo University , Faculty Of Engineering, Mechanical Power Department staff because of their contribution at various times to the successful completion of this work and till now .

Special acknowledge to "The Egyptian company of iron and steel" because of its help in the manufacturing of the test rig duct , which has a very difficult geometrical shape .



ABSTRACT

The continuing interest in compact heat exchangers has created the need for studying the effect of heat transfer parameters for different passage shapes . It has been recognized that generally circular tubes results are not applicable to non-circular passages even when the hydraulic diameter (D_h) is used as the characteristic dimension , therefore , design data should be generated for each passage shape individually . The new flow passage shape under investigation in the present work is the annular sector duct which is a non circular passage .

The major difference between the annular sector duct and non circular ducts of other geometry is that , the annular sector duct has both concave and convex boundaries . The combination of these combined boundaries would significantly affect the secondary flow pattern in the centrifugal force field .

In the current research , an annular sector duct of diameter ratio of 0.5 and a sector angle of 60 degrees is studied experimentally . The experimental test rig was of total length of $113 D_h$, designed to have a starting unheated length of $65 D_h$ in order to ensure hydrodynamically fully developed flow in the downstream passage. It is followed by $48 D_h$ heated length to ensure thermally fully developed flow at the exit of the test section .

Twelve experimental runs were performed for measuring wall temperature , air mixing cup temperature and air velocity at several locations along the test section . Fluid velocity was measured at three axial locations , namely , at lengths equal to $48 D_h$, $65 D_h$ (before the entrance to the test section) and $113 D_h$ (at the exit of the test section) .

Temperatures were measured at lengths equal to $66 D_h$, $70 D_h$, $76 D_h$, $81 D_h$, $86 D_h$, $92 D_h$, $97 D_h$, $103 D_h$ and $113 D_h$ from the beginning of the annular sector duct .

Experimental runs correspond to Reynolds number , 22875 , 35329 , 37834 , 44404 , 49065 , 54631 , 59424 , 62965 , 66086 , 66965 , 68015 and 73766 . Results were carried out to obtain relation between local or average Nusselt numbers and Reynolds number.

The average Nusselt number is correlated with Reynolds number according to the relation ;

$$\overline{N}_{Nu} = 0.055 * (N_{Re})^{0.71}$$

Comparison between heat transfer characteristics in annular sector duct and that in other shaped ducts (such as circular , triangular , rectangular , square and trapezoidal ducts) indicated an improvement in heat transfer characteristics , even the heat transfer has been improved in annular sector ducts by an average value of 50% approximately more than the annular duct passage shape .

The resulting increase in heat transfer from the annular duct could be explained as a result of two main phenomena , The first is due to the corner regions , those are resulted in the new shape , which produce secondary flows , converting part of the main flow velocity to eddies which improve the heat transfer between the duct wall and the fluid , and the second is due to that the partitions act as fins to which the heat is conducted , and then convected to the fluid . The later mechanism improves the heat transfer between the heated wall and the flowing fluid , especially at low fluid velocities .

LIST OF CONTENTS

	Page
Acknowledgements	ii
Abstract	iii
List of Contents	v
List of Figures	vii
Nomenclature	ix
 <u>Chapter 1 Introduction</u>	
1.1. Motivation	1
1.2. Objective of the present work.....	3
 <u>Chapter 2 Literature Review</u>	
2.1. Introduction	4
2.2. Review of previous experimental work.....	5
2.3. Review of theoretical work.....	9
2.4. Conclusion	12
 <u>Chapter 3 Experimental Work</u>	
3.1. The test rig	13
3.2. Test section	16
3.2.1. General description.....	16
3.2.2. Measuring locations.....	16
3.2.3. Traversing mechanism.....	26

	Page
3.3. Manufacturing of the test rig.....	26
3.3.1. Annular sector duct.....	26
3.3.2. Heater , guard heater and insulation.....	28
<u>Chapter 4 Results , Discussion and Conclusion</u>	
4.1. Introduction	32
4.2. Experimental results	33
4.2.1. Static pressure distribution.....	33
4.2.2. Air velocity profiles	36
4.2.3. Air temperature profiles	36
4.2.4. Average Nusselt number	36
4.2.5. Local Nusselt number	55
4.2.6. Local heat transfer coefficient	59
4.2.7. Air mixing cup temperature	61
4.2.8. Heated wall temperature	63
4.3. Conclusion	67
4.4. Recommendation for future work.....	68
References	70
Appendix -A Calibration of Orifice meter	75
Appendix -B Calibration of Three hole probe.....	81
Appendix -C Experimental Error Analysis	88

LIST OF FIGURES

Figure	Page
3.1 Experimental test rig	14
3.2 Cross section of the flow channel	15
3.3 Heater and insulation construction	17
3.4 Measuring stations along the test section	18
3.5 Static pressure tap and connection	22
3.6 Static pressure tap locations along the test rig.....	23
3.7 Selector switch	24
3.8 Wall-thermocouple distribution	25
3.9 Traversing mechanism	27
3.10 Lead layer	29
3.11 Heater construction	31
4.1 Static pressure distribution for low Reynolds number range	34
4.2 Static pressure distribution for high Reynolds number range	35
4.3 - 4.14 Velocity contours for different Reynolds number	37-39
4.15 - 4.62 Temperature contours for different Reynolds number	40-51
4.63 Comparison of average Nusselt number for different duct geometry	52
4.64 Local Nusselt number for different Reynolds number	56
4.65 Comparison of local Nusselt number for different duct geometry 1	57

Figure	Page
4.66 Comparison of local Nusselt number for different duct geometry 2	58
4.67 Local heat transfer coefficient for different Reynolds number	60
4.68 Experimental mesh for velocity and temperature profiles	62
4.69 Local fluid mixing cup temperature for different Reynolds number.....	64
4.70 Local heated wall temperature for different Reynolds number	65
4.71 Local difference between heated wall and fluid mixing cup temperatures	66
A.1 Orifice-meter construction	76
A.2 Pressure drop across the orifice plate for different average air velocity..	79
A.3 Orifice-meter discharge coefficient for different Reynolds number	80
B.1 Three-hole probe construction	82
B.2 Variation of pressure on each hole of the probe with the attack angle....	84
B.3 Variation of probe coefficients with the attack angle 1	86
B.4 Variation of probe coefficients with the attack angle 2.....	87