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Project 1592

CALUMET AND HECLA, INCORPORATED
WOLVERINE TUBE DIVISION
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ABSTRACT

This report contains a summary of the operations of the research group and work completed during the year 1957. The status of the work of the project is reviewed and discussed. Recommendations as to the future research program are presented.

INTRODUCTION

The Wolverine Tube heat transfer project at the Engineering Research Institute is entering its eighteenth year of operation. The activities of the research project were considerably expanded during the past year. During the year nine men were normally employed on the project on a part time basis. At the close of the year eight men were employed on a part time basis and one man was employed on a full time basis.

The research group has always had more prospective investigations than could be handled simultaneously. The investigations which were carried out during the year were those which were given priority status as a result of conferences held with the Technical Manager, New Products Division, of Wolverine Tube.

PROJECT STATUS AS OF JANUARY, 1957

In January of 1957 the research group was working on the following investigations, with priority in the order presented:

1. Determination of the influence of cyclic operation on bond resistance.
2. Development of an improved bi-metal bond-resistance measurement apparatus.
3. Measurement of the Freon condensing capacity of several coaxial finned tube coils.
4. A study of the performance of corrugated tubes in steam condensing with water flowing through the inside of the tubes at high velocity.

In addition to the above items the priority list also included four items on which the project group was not then working. These were:

5. Revision of the Williams-Katz report entitled "Performance of Finned Tubes in Shell and Tube Heat Exchangers", issued in January, 1951, to bring the report up to date.
6. Further boiling studies with finned tubes to determine maximum heat flux for nucleate boiling.
7. Determination of the heat transfer and pressure drop characteristics of internal finned tubes.

8. Extension of earlier natural convection studies with finned tubes for correlation purposes.

In addition to the above eight items, four prospective investigations were also under discussion at the start of the year. These were:

1. A study of the performance of storage tank hot water heaters using finned tubes.

2. A study of the performance of shell and finned tube units in gas cooling applications.

3. The use of electrode potential and eddy current techniques for determining tightness of bond in duplex tubes, i.e., measuring bond resistance indirectly.

4. The use of vibrational dampening characteristics of duplex tubes as an indirect measure of bond resistance to heat transfer.

At the start of the 1957 year the following personnel were employed on a part time basis as research assistants:

James R. Wall (Group Leader)
Marvin L. Katz (Graduate Student)
Jack Alcalay (Graduate Student)
James R. Fleming (Graduate Student)
Byron S. Gottfried (Graduate Student)
Harry Hsiung (Graduate Student)
Robert H. Cherry (Graduate Student)
William F. Conroy (Senior)
Walter R. Gutchess (Senior)
Larry D. Wheaton (Senior)
Jean A. Storms (Typist)

CHANGE OF STATUS DURING THE YEAR

Changes in Priority:

During the year four technical reports were issued. The titles of the reports are listed in a later section of this report. The reports were issued in January, February, July, and August respectively.

Since the work on priority item number three above was completed by the technical report issued in February, the priority list was revised on February 22nd to include the following:

1. Influence of cycling operation on bond resistance.
2. Development of an improved bi-metal bond resistance measurement apparatus.
3. Determination of the heat transfer and pressure drop characteristics of corrugated tubes in steam condensing.

Following the issuance of technical reports during July and August, the priority list was changed on September 23rd to:

1. Investigation of the influence of cycling operation on bond resistance.
2. Determination of the heat transfer and pressure drop characteristics of corrugated tubes in steam condensing.
3. The heat transfer and pressure drop characteristics of corrugated tubes in a 9 foot long concentric pipe heat exchanger with water to water flow conditions.
4. The investigation of the heat transfer and pressure drop performance of tube banks in a wind tunnel.
5. Investigation of the heat transfer and pressure drop performance of internal finned tubes.
6. Revision of the Williams-Katz report entitled "Performance of Finned Tubes in Shell and Tube Heat Exchangers".
7. Vibrational testing of bond resistance.

The above priority list was in effect at the end of the 1957 year.

Technical Conferences:

Technical conferences concerning the research program were held with representatives of Wolverine Tube on various occasions during the year.

At the invitation of the American Society of Refrigerating Engineers (ASRE), Prof. E. H. Young attended a committee meeting of the ASRE Task Force on "Refrigerant Heat Transfer Inside of Tubes" on November 13, 1957. The Research Committee of the American Society of Refrigerating Engineers established this task force to:

1. "Counsel the Research Committee in the making of research grants."

2. "Coordinate the work being done by all known workers in the field, both in university and company laboratories, making sure that the work done under research grants is in useful areas and that it does not overlap work being done by industry which will be published, and to help disseminate available information from companies which are willing to publish their findings, and the areas in which they expect to publish future work. The intent of this phase is to focus attention on areas which need investigation, and to avoid needless and wasteful work in areas which have already been explored."

At the November meeting of the ASRE Task Force Committee, suggestions were presented by the various members and a number of recommendations were formally put together. The preliminary meeting is to be followed by the appointment of a permanent Task Force Group sometime in the early part of 1958.

Prof. E. H. Young and Mr. M. L. Katz of the project group and Mr. J. S. Rodgers of Wolverine Tube attended the afternoon heat transfer session of the American Society of Mechanical Engineers annual meeting in New York City on December 3, 1957. The same group attended a conference on December 4, 1957, at the Naval Engineering Experiment Station, Annapolis, Maryland, and conferences on December 5, 1957, with the Nuclear Power Branch and with the Heat Transfer Division of the Bureau of Ships, Department of the Navy, in Washington, D. C. Copies of Report No. 47 entitled "Progress Report on the Steam Condensing Performance on Corrugated Tubes", were distributed and discussed at these conferences.

Wolverine Trufin Fellowship:

Mr. Dennis J. Ward, the project group leader in 1956, had submitted a thesis proposal to the Department of Chemical and Metallurgical Engineering in February of 1956. Mr. Ward proposed to study the "effect of finned tube geometry on the heat transfer and pressure drop of air in forced convection across finned tube banks". At that time a letter was forwarded to Wolverine Tube requesting that Wolverine Tube support this doctoral research by reopening the Wolverine Trufin Fellowship. Pursuant to this request, the fellowship was granted by Wolverine Tube to the University of Michigan for the amount of \$4,000. The University appointed Mr. Ward "Wolverine Trufin Fellow" from September 20, 1956, to September 20, 1957.

The Director of the Engineering Research Institute made available to the research project a wind tunnel for the study of air cooling units. The project made this wind tunnel available to Mr. Ward for his thesis investigation.

Mr. Ward completed his doctoral research investigation and prepared a thesis on his findings. The results of his research will be presented in the form of a technical paper to the American Institute of Chemical Engineers—American Society of Mechanical Engineers joint conference on Heat Transfer at Northwestern University in Evanston, Illinois, in August of 1958.

The results obtained by Mr. Ward will be very useful in the design of air cooled heat exchangers. The research group is currently using the wind tunnel to check the performance of finned tube banks having large fin tip clearances to see if the air film coefficient correlation obtained by Mr. Ward has any limitations.

Use of Digital Computer Facilities:

A large amount of experimental data was analyzed by use of the digital computer available on the University of Michigan campus. The computer enables the group to better correlate the results of various investigations.

Changes in Project Personnel:

During the year Mr. W. F. Conroy, Mr. W. R. Gutchess, and Mr. L. D. Wheaton completed the requirements for their degrees and accepted employment in industry. In June, Mr. Dale E. Briggs was added to the project group. In September, Mr. Gordon D. Towell and Mr. Henry C. Lim were added to the group. Also in September, Mr. James R. Wall left the group to work on the manuscript for the book on Heat Transfer Through Finned Tubes. In November, Mr. J. D. Hellums joined the project group on a full time basis until the start of the spring, 1958, semester.

SUMMARY OF TECHNICAL REPORTS SUBMITTED TO WOLVERINE TUBE IN 1957

- A. Report No. 45, "Annual Report for 1956", issued January, 1957.
- B. Report No. 46, "Condensation of Freon-12 in 11-Fins-Per-Inch and 19-Fins-Per-Inch Coaxial Coils", issued February, 1957.
- C. Report No. 47, "Progress Report on Steam Condensing Performance of Corrugated Tubes", issued July, 1957.

- D. Report No. 48, "Development of an Apparatus for the Measurement of Low Bond Resistances in Finned and Bare Duplex Tubes", issued August, 1957.

PREPARATION OF MANUSCRIPT ON HEAT TRANSFER THROUGH FINNED TUBES

Professor Donald L. Katz, Chairman of the Department of Chemical and Metallurgical Engineering and Professor Edwin H. Young, Project Supervisor, are coauthoring a book entitled Heat Transfer Through Finned Tubes. The book is to be published by John Wiley and Sons of New York. The preparation of the manuscript is being supported by a grant from Wolverine Tube.

RECOMMENDATIONS CONCERNING FUTURE RESEARCH WORK

Discussions with the Technical Manager, New Products Division, of Wolverine Tube indicate that there exists a number of fundamental investigations that should be undertaken. In addition to the investigations currently in progress and the prospective investigations listed on page 2, the following should be considered:

1. Shell and Tube Investigations.

a. Liquid-Liquid. An investigation of the relative performance of 19 fin-per-inch tubes (Type S/T), laid out on a square pitch arrangement rotated 45°, to plain tubes of the same arrangement should be undertaken. Also, data should be obtained on the equilateral triangular pitch arrangement without the shell-circle arrangement.

b. Gas Coolers. The use of Type S/T low-finned tubes in shell and tube gas coolers represents an ideal application for this tube. Relative pressure-drop and heat transfer data for finned and plain tubes in identical shell arrangements with gas flow are needed.

c. Partial Condensers. Low-finned tubes of Type S/T can be used to definite advantage in partial condenser applications. A laboratory investigation for measuring experimental coefficients with plain and finned tubes in identical shell arrangements should be undertaken.

2. Unbaffled Shell and Tube Heat Exchangers.—Interest is developing in the possibility of using unbaffled finned tube shell and tube units for liquid-to-liquid and liquid-to-gas heat transfer applications. No studies of the shell side performance of such units has as yet been undertaken.

3. Tube-Baffle Leakage.—The helical fin of the low fin tube permits fluid to leak around the tube through the baffle hold. The influence of this leakage on the tube-baffle orifice coefficient is unknown. Some preliminary studies have been made but further investigation is needed.

4. Fouling of Corro-Tubes.—The performance of the Corro-Tube in fouling heat transfer applications is unknown.

5. Steam in Hydrocarbon Condensation.—Recent developments indicate that more information is needed concerning the influence of water vapor on the condensation of hydrocarbons on finned tubes.

6. Natural-Convection Heat Transfer.—Studies of the heat transfer from finned tubes to air by natural convection should also be undertaken. An investigation of this nature, using baseboard-type heaters was initiated in 1953, but was discontinued due to the pressure of other important investigations. Data of this type would be of great value in preparing a natural-convection correlation.



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