DEPARTMENT OF CHEMICAL AND METALLURGICAL ENGINEERING

Heat Transfer Laboratory
The University of Michigan
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Report No. 54

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Project 1592

WOLVERINE TUBE
Division of
CALUMET AND HECLA, INCORPORATED
ALLEN PARK, MICHIGAN

January 1963

ABSTRACT

This report contains a summary of the operations of the research group and the work completed during the year 1962. The status of the work of the project is reviewed and discussed.

INTRODUCTION

The heat transfer project sponsored by Wolverine Tube Division of Calumet and Hecla, Incorporated within the Department of Chemical and Metallurgical Engineering at The University of Michigan is in its twenty-third year of operation. During the past year the project employed three men on a part-time basis. Of these, one was an instructor in the Department of Chemical and Metallurgical Engineering and the other two were students in the department. Part-time secretarial help was also employed. The project's laboratory facilities are located in the Fluids Building on the North Campus of The University as indicated in Figure 1. The project director maintains an office in the East Engineering Building where many of the files are kept.

During 1962, there were many more prospective investigations listed than could be handled simultaneously or could be completed. The investigations were, therefore, undertaken in accordance with the current priority status set as a result of conferences held with the Director of Research and Development Division of Wolverine Tube. The prospective projects were separated into two categories. One consisted of projects requiring laboratory facilities and the others consisted of projects requiring the use of technical information available in the literature to effect a desired design or analysis of heat transfer data in an effort to abstract information of value to Wolverine Tube.

In January 1962, the equipment (laboratory) projects in order of priority were:

1. Study of the heat transfer characteristics of boiling refrigerants and investigation of internal fin configurations on boiling refrigerant heat transfer coefficients.

2. Determination of the optimum fin height and fin spacing for refrigerant condensing.

3. Investigation of the steam condensing characteristics of titanium tubes.

4. Investigation of the steam condensing characteristics of corrugated tubes.

5. Determination of the air film heat transfer and pressure drop correlations for banks of finned tubes using the wind tunnel.

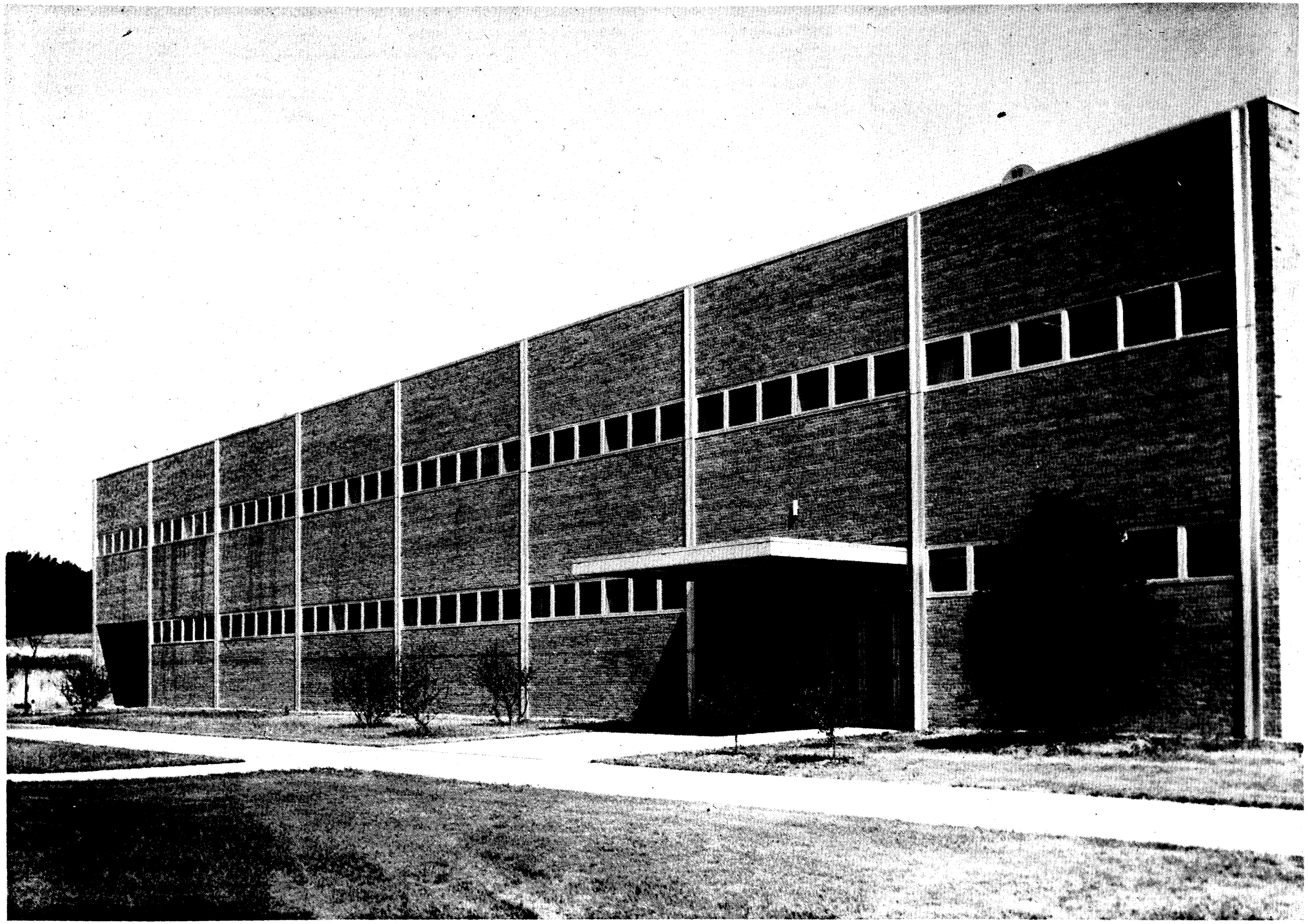

Figure 1. Fluids Laboratory Located on the North Campus of The University of Michigan

6. Study of the performance of Type S/T tubes in large shell and tube heat exchangers. Liquid and gas cooling. The effect of longitudinal unbaffled flow.

7. Study of natural convection heat transfer from plate fins and finned tubes.

Non-laboratory studies in order of priority were:

1. Revision of the Ward-Young air cooling heat transfer correlation to include data obtained on additional banks of tubes.

2. Revision of the Williams-Katz report on the performance of Type S/T tubes in shell and tube heat exchangers.

Several small projects of higher priority than those mentioned above were added to the project work list during the year. Work on these additional projects were coordinated with existing projects through conferences held with representatives of Wolverine Tube.

At the beginning of the year, the following personnel were employed on the project on a part-time basis:

1. Dale E. Briggs (one-half time)
2. Ardis R. Vukas (one-quarter time)

Mr. Briggs is an Instructor in the Department of Chemical and Metallurgical Engineering and was the acting director of the project until February 3, 1962.

The project director, Professor E. H. Young, returned to the project on February 3, 1962, having taken a sabbatical leave from The University of Michigan for the fall semester of the 1961-1962 academic year.

On February 12, 1962, Mr. Boris Taruntaev and Mr. William D. Hancock were added to the project staff. Both men are students in the Department of Chemical and Metallurgical Engineering. Mr. Taruntaev is working toward a master's degree and Mr. Hancock is working toward a bachelor's degree.

At the end of 1962, the following persons were employed on the project:

1. Dale E. Briggs (one-half time)
2. Ardis R. Vukas (one-half time)
3. Boris Taruntaev (one-half time)
4. William D. Hancock (one-half time)

LABORATORY INVESTIGATIONS

Wind Tunnel Investigation

Air film convective heat transfer data were taken on two tube banks in the wind tunnel during the year. Figure 2 shows a view of the wind tunnel. One tube bank contained four rows of 2 inch O.D. monometallic aluminum tubes on a 2-3/16 inch equilateral triangular pitch and the other contained six rows of 3/4 inch O.D. monometallic copper tubes on a 15/16 inch equilateral triangular pitch. The data were analyzed to obtain the air film heat transfer coefficient as a function of the maximum air velocity through the tube bank. Isothermal pressure drop data were taken on seven wind tunnel tube banks. Three banks contained six rows of 2-1/4 inch O.D. Type L/C tubes placed on an equilateral triangular pitch. The tube pitches for those banks were 2.700, 3.375, and 4.500 inches. The remaining four banks contained six rows of 1-1/2 inch O.D. Type L/C tubes (Banks 22, 23, 24 and 25) that were placed on 1.930, 1.687, 2.450, and 3.375 inch equilateral triangular pitches. These data were analyzed and pressure drop correlations were obtained which presented the effect of tube pitch on pressure drop for the tubes studied. Figure 3 gives the pressure drop in inches of water per row as a function of the maximum air velocity through the tube bank for the 1-1/2 inch O.D. tubes and Figure 4 gives the pressure drop in inches of water as a function of the tube pitch with the maximum air velocity as a parameter.

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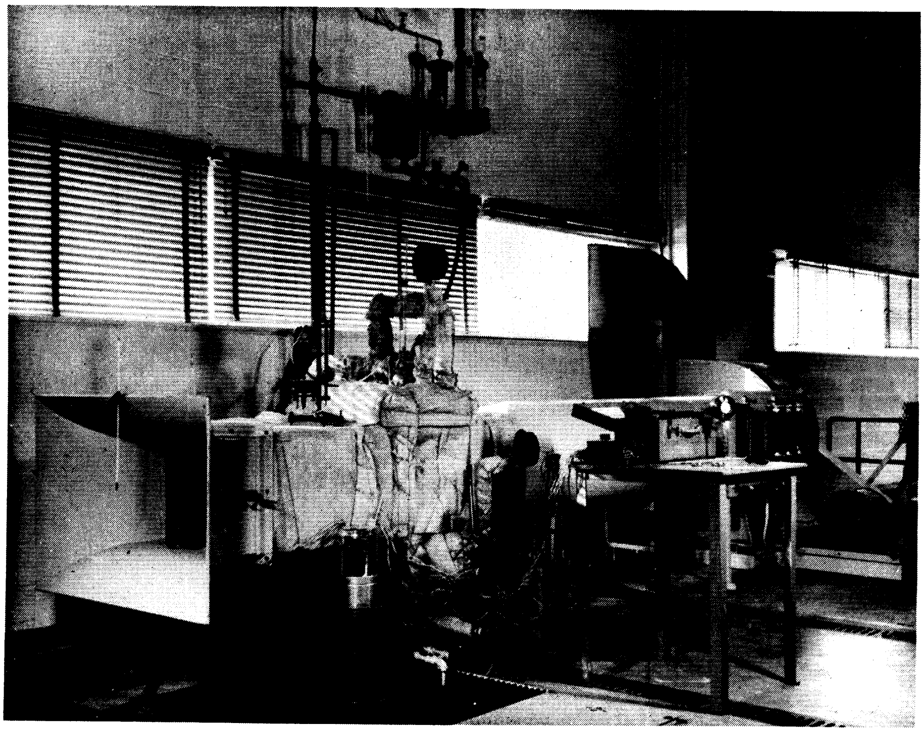

Figure 2. Overall View of Wind Tunnel with Test Section Insulated.

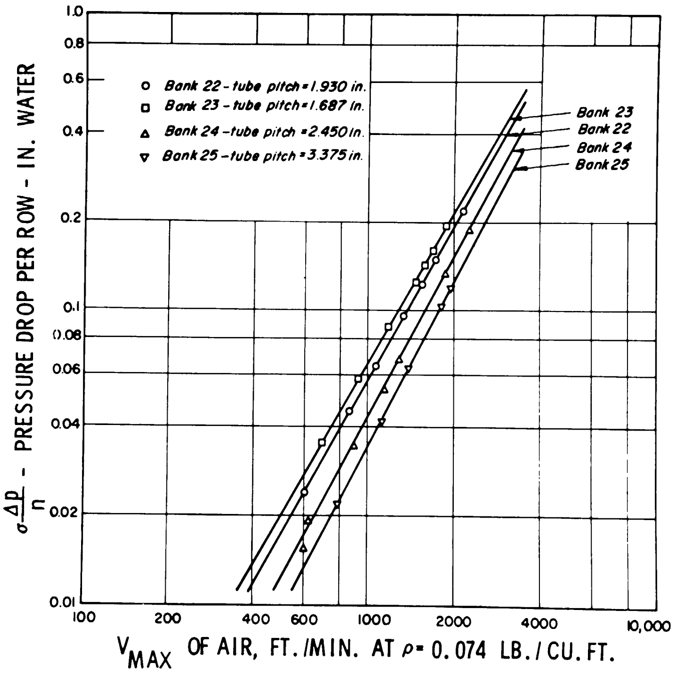

Figure 3. Pressure Drop Data for Banks 22, 23, 24, and 25.

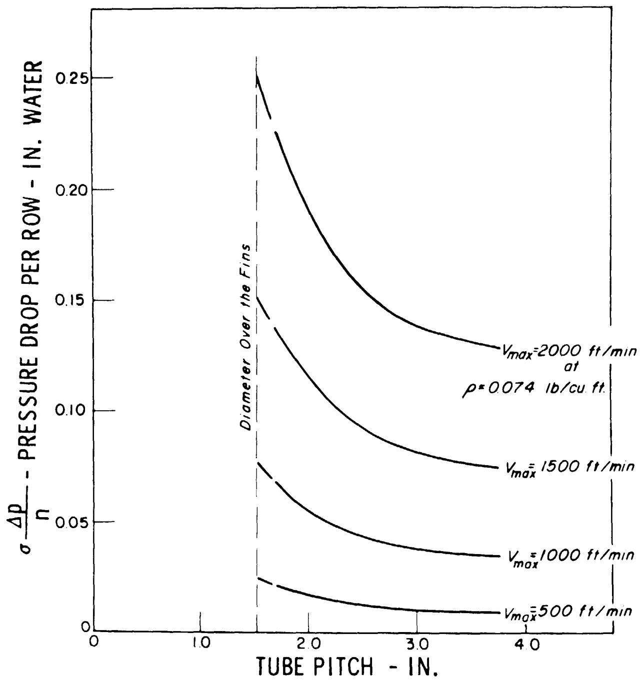

Figure 4. Comparison of Pressure Drop Data for Banks 22, 23, 24, and 25 at Various Constant Air Velocities.

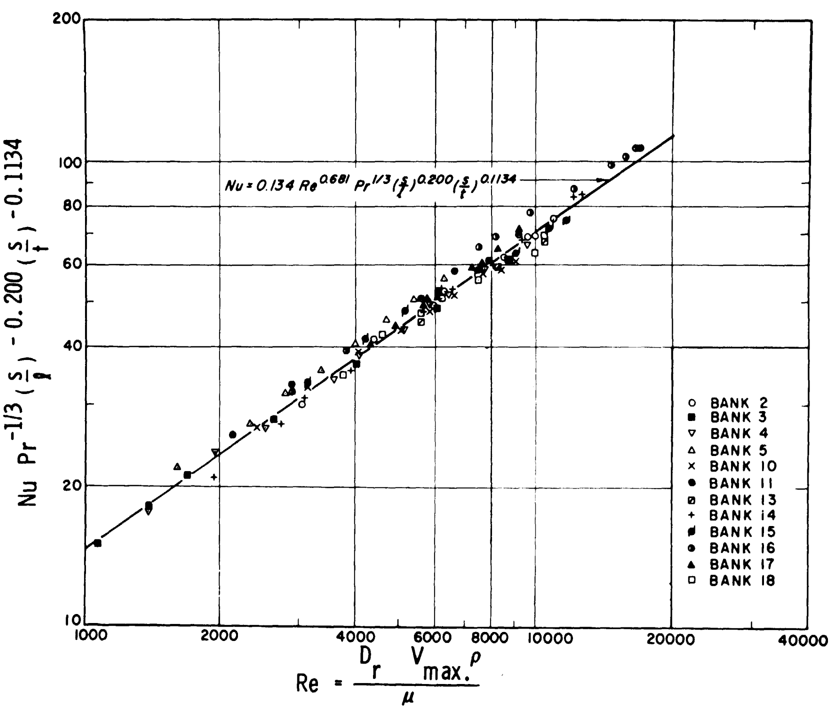

Figure 5. Comparison of Finned Tube Heat Transfer Data with the Correlation Obtained by a Regression Analysis.

Investigation of the Steam Condensing Characteristics of Corrugated Tubes

An investigation to predict the steam condensing capabilities of an internally grooved tube and two corrugated tubes was started in January 1962 and completed in February 1962. Sections of the three tubes were photographed and the photographs were used to obtain accurate measurements of inside and outside heat transfer surface areas. Modified tube-side Wilson plot data were taken in the concentric pipe heat exchanger shown in Figure 6 with hot water flowing in the annulus and cold water flowing through the tubes. Using the calculated values of the heat transfer areas, the data were processed with the IBM 709 digital computer and the inside heat transfer coefficient constants obtained for the Sieder and Tate Equation. Figure 7 gives the calculated Wilson plot results for corrugated tube 489. Tube-side pressure drop data were also taken and processed. A comparison of the anticipated low pressure steam condensing capabilities of the three tubes with those of plain tubes was then made, [redacted]

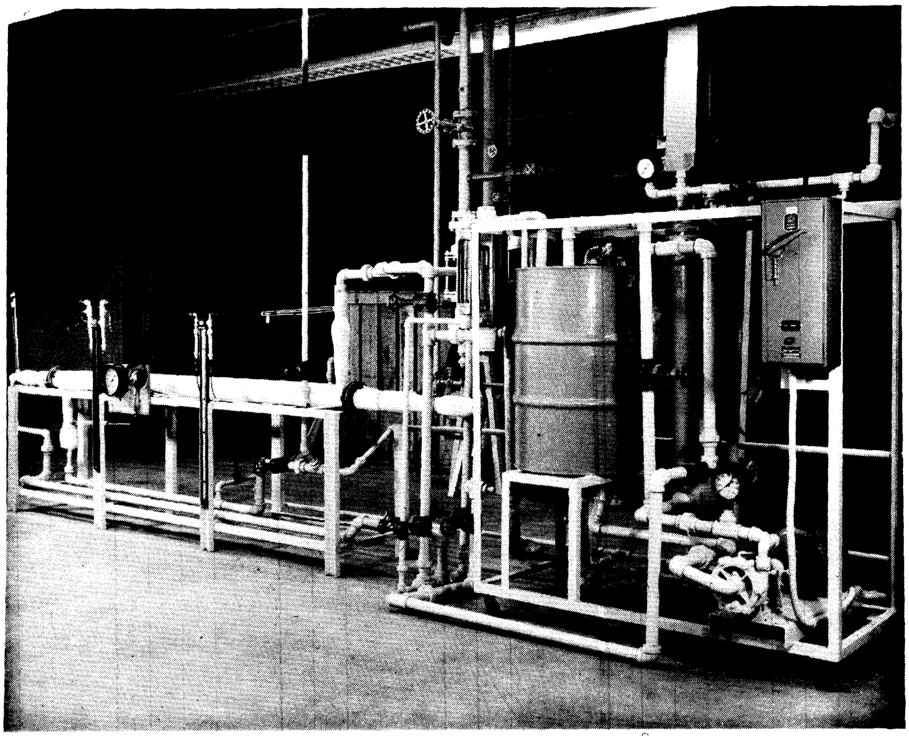

Figure 6. View of the Concentric Pipe Heat Exchanger Located in Fluids Building.

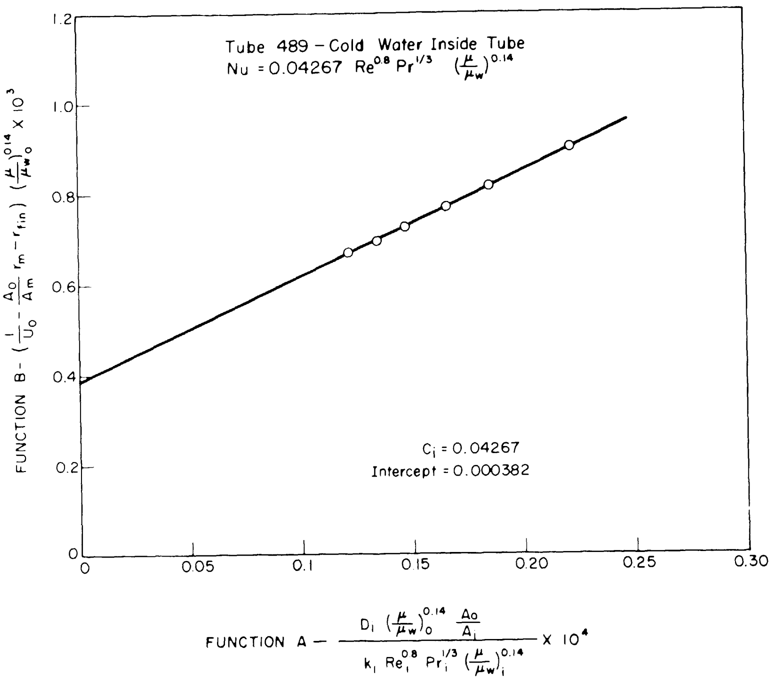

Figure 7. Modified Wilson Plot for the Inside Heat Transfer Coefficient of a Corrugated Tube - Tube 489.

tank. Cooling water will be heated to the desired temperature in a preheater and will pass through the tubes under study. Steam will be generated inside a reboiler by condensing steam inside horizontal S/T type tubes. The steam will then pass through an 8 inch pipe to the overhead condenser where it will be condensed on the outside of the horizontal titanium tubes. The condensate will return to the reboiler by a condensate return line. A steam jet ejector will be used to remove non-condensibles and a make-up tank will be used as necessary to maintain a sufficient water level in the reboiler.

Measurements of the inlet and outlet water temperature and the water flow rate in each tube will permit the determination of the amount of heat transferred by each tube. Wilson plot techniques will be used to evaluate the inside heat transfer coefficient and the condensing coefficients will be obtained by difference from the overall heat transfer coefficient.

The fabrication of the laboratory experimental equipment was nearing completion at the end of the year.

THEORETICAL AND NON-LABORATORY INVESTIGATIONS

Heat Transfer from Plate Fin Units

A mathematical investigation was begun in January 1962 to determine a satisfactory fin spacing, fin thickness, and fin height for plate fin units used in refrigeration systems utilizing thermoelectric cooling. Heat was to be removed from the refrigerated system by natural convection to plate fins on the cold side and heat was to be transferred from the plate fins on the hot side to the ambient air by forced convection. The heat transfer correlations required in this investigation were obtained from the literature. A conference was held with personnel from Wolverine Tube to discuss the significance of the findings upon completion of the investigation in February 1962.

Revision of Report on Performance of Finned Tubes in Shell and Tube Heat Exchangers

A re-correlation of the heat transfer and pressure drop data in a University of Michigan Engineering Research Institute Report entitled, "Performance of Finned Tubes in Shell and Tube Heat Exchangers," by R. B. Williams and D. L. Katz (1951) was begun in September 1962. After writing an IBM 7090 computer program to obtain the inside heat transfer coefficient constant for the Sieder and Tate equation from Wilson plot data, all the original data were processed and the constants obtained. Table I shows the tabulated computer output results for bundle 1, runs 2A - 2D. The original correlation was prepared by hand calculations.

A computer program has been written to analyze all the heat transfer and pressure drop data. The calculated values of the inside heat transfer coefficient constants will be used in the computer program. The analysis will include the development of shell-side heat transfer coefficient and pressure drop correlations by both the Donohue and Bell methods. Comparisons of the correlations for the finned tube bundles with the correlations for the plain tube bundles will be made to obtain the relative performance of finned tube bundles to plain tube bundles over a wide range of Reynolds numbers. Table II shows representative computer output results for plain tube bundle No. 1.

Table I. Modified Wilson Plot Data and Results Calculated by an IBM 7090 Digital Computer for the Inside Heat Transfer Coefficient for Bundle 1.

WILSON PLOT DETERMINATION OF THE INSIDE HEAT-TRANSFER COEFFICIENT FOR BUNDLE 1 , NUMBER OF RUNS IS 4

SHELL SIDE FLUID IS WATER

TUBE SIDE FLUID IS WATER

RUNS	BUND	TEMP	ITER	XAO	XAI	XAM	RM	CI
4	1	0	4	38.2500	32.9500	35.5800	.6250E-04	.2400E-01

NO	K	L	M	NN	O	P	Q
1	.10124896E 01	-.46678063E-03	.58540867E-05	-.32721741E-07	.72640616E-10	-.00000000E 00	-.00000000E 00
2	.10124896E 01	-.46678063E-03	.58540867E-05	-.32721741E-07	.72640616E-10	-.00000000E 00	-.00000000E 00
3	.30377927E 00	.25267360E-03	.92050520E-05	-.75847219E-07	.17507457E-09	-.00000000E 00	-.00000000E 00
4	.30377927E 00	.25267360E-03	.92050520E-05	-.75847219E-07	.17507457E-09	-.00000000E 00	-.00000000E 00
5	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00
6	-.21968737E 01	.54722744E 03	-.41363282E 05	.16141324E 07	-.24764542E 08	-.00000000E 00	-.00000000E 00
7	-.21968737E 01	.54722744E 03	-.41363282E 05	.16141324E 07	-.24764542E 08	-.00000000E 00	-.00000000E 00
8	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00

DIAS	AFS	AFT	DIAT
.62500E-01	.50800E-01	.56800E-01	.53800E-01

NOTE - INPUT TEMPERATURES ARE IN FAHR.

RUN	TSIF	TSOF	TTIF	TTOF	W SHELL	W TUBE	Q SHELL	Q TUBE	LMTD	F
2A	177.600	165.510	148.750	157.680	35343	46530	428327	415818	18.295	.944
2B	177.690	165.560	152.460	158.860	35491	65043	431547	416653	15.792	.945
2C	177.300	165.110	153.700	158.850	35739	83340	436690	429610	14.649	.949
2C	177.290	164.980	155.050	159.330	35780	103455	441491	443240	13.551	.949

RUN	Q AVG	PER DEV	LMTDC	UO	RE SHELL	RE TUBE	PR SHELL	PR TUBE
2A	422072	-1.482	17.263	639.204	49095	43348	2.296	2.662
2B	424100	-1.756	14.930	742.659	49326	61772	2.294	2.607
2C	433150	-.817	13.895	814.964	49522	79530	2.302	2.594
2C	442366	.198	12.863	899.101	49554	99429	2.303	2.574

Table I. (continued)

AFTER 4 ITERATIONS, INTERCEPT IS .56427354E-03 , CI IS .02440117

RUN	FUNCTICN A	FUNCTION B
2A	.22584083E-04	.14861342E-02
2B	.17147771E-04	.12697446E-02
2C	.14043770E-04	.11508752E-02
2C	.11782061E-04	.10370004E-02

RUN	TSAV	TWALL O	TWALL I	TTAV
2A	171.555	164.246	163.504	153.215
2B	171.625	164.255	163.510	155.660
2C	171.205	163.604	162.843	156.275
2D	171.135	163.594	162.817	157.190

RUN	HI PRIME	RFIN IN	HI	HO PRIME	RFIN OUT	HO	NU SHELL	NU TUBE	RE SHELL	NU/PR-VISC
2A	1244.935	.0000E 00	1244.935	1770.549	-.0000E 00	1770.549	286.139	175.215	49095	218.536
2B	1639.515	.0000E 00	1639.515	1750.462	-.0000E 00	1750.462	282.880	230.384	49326	216.098
2C	2001.366	.0000E 00	2001.366	1724.647	-.0000E 00	1724.647	278.784	281.120	49522	212.796
2D	2385.695	.0000E 00	2385.695	1790.690	-.0000E 00	1790.690	289.472	334.908	49554	220.902

VISCOSITIES LB/FT-HR

RUN	VISC. SHELL	VISC SH WALL	VISS/VISSW	VISC. TUBE	VISC TU WALL	VIST/VISTW
2A	.8857	.9341	.9481	1.0167	.9385	1.0833
2B	.8852	.9341	.9477	.9973	.9388	1.0624
2C	.8879	.9386	.9460	.9926	.9436	1.0519
2C	.8883	.9387	.9464	.9855	.9439	1.0441

WILSCN PLOT CONSTANT EQUALS .02440117 , INTERCEPT EQUALS .56427354E-03

Table II. Representative Shell-side Heat Transfer Coefficient and Pressure Drop Friction Factor Results Calculated with an IBM 7090 Digital Computer for Bundle 1.

HEAT TRANSFER AND PRESSURE DROP ANALYSIS OF THE WILLIAMS - KATZ DATA

BUNDLE	1
NO. RUNS	4
SHELL-SIDE FLUID	WATER
TUBE-SIDE FLUID	WATER
TEMPERATURES	FAHRENHEIT
TUBE ID - IN	.6460
TUBE OD - IN	.7510
TUBE RD - IN	.7510
TUBE DEQ - IN	.7510
TUBE PITCH - IN	.9400
SHELL MEAN FLOW AREA (DONOHUE) - SQFT	.05150
SHELL MEAN FLOW AREA (BELL) - SQFT	.0655
WINDOW AREA - SQFT	.04160
AFLOW C/L MIDDLE - SQFT	.05140
AFLOW C/L ENDS - SQFT	.09570
AFLOW TUBE - SQFT	.05680
TUBE OUTSIDE AREA - SQFT	38.250
TUBE INSIDE AREA - SQFT	32.920
TUBE METAL AREA - SQFT	35.580
NO. BAFFLES	9
BAFFLE SPACING MIDDLE - IN	3.9300
BAFFLE SPACING END - IN	7.3200
NO. RESTRICTIONS FROM CENT. TO CENT.	3.1100
NO. RESTRICTIONS FROM CENT. TO SHELL	.8900
NO. RESTRICTIONS (BELL)	2.420
NO. RESTRICTIONS IN WINDOW	1.580
INSIDE COEFFICIENT CONSTANT	.02440
WINDOW VOL. EQ. DIA. - FT	.1132
HL/HNL	.8281
DPL/DPNL	.6580
PHI	1.0630
CHI LAMINAR FLOW	1.3380
CHI TURBULENT FLOW	.9150
XI PRESSURE DROP LAMINAR	.2620
XI PRESSURE DROP TURBULENT	.3220
XI HEAT TRANSFER	.6890
METAL RESISTANCE WALL/K	.0000625

NO	K	L	M	NN	O	P	Q
1	.10124896E 01	-.46678063E-03	.58540867E-05	-.32721741E-07	.72640616E-10	-.00000000E 00	-.00000000E 00
2	.10124896E 01	-.46678063E-03	.58540867E-05	-.32721741E-07	.72640616E-10	-.00000000E 00	-.00000000E 00
3	.30377927E 00	.25267360E-03	.92050520E-05	-.75847219E-07	.17507457E-09	-.00000000E 00	-.00000000E 00
4	.30377927E 00	.25267360E-03	.92050520E-05	-.75847219E-07	.17507457E-09	-.00000000E 00	-.00000000E 00
5	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00
6	-.21968737E 01	.54722744E 03	-.41363282E 05	.16141324E 07	-.24764542E 08	-.00000000E 00	-.00000000E 00
7	-.21968737E 01	.54722744E 03	-.41363282E 05	.16141324E 07	-.24764542E 08	-.00000000E 00	-.00000000E 00
8	.63129999E 02	-.11700000E-01	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00	-.00000000E 00

Table II. (continued)

RUN	TTI	TTC	W TUBE	TSI	TSO	W SHELL	PRESSURE DROP
	F	F	LB/HR	F	F	LB/HR	PSI
2A	148.750	157.680	46530	177.600	165.510	35343	3.150
4A	149.200	159.220	46100	177.510	167.970	49100	5.810
5A	148.860	159.640	45800	177.160	168.850	60600	8.850
6A	149.290	156.700	46100	177.080	162.880	25000	1.540

RUN	Q SHELL	Q TUBE	Q AVG	PER DEV	LMTD	F	LMTDC	UO	RE TUBE
	BTU/HR	BTU/HR	BTU/HR		F		F	B/H-SF-F	
2A	428327	415818	422072	-1.482	18.295	.944	17.263	639.204	43375
4A	469611	462293	465952	-.785	18.529	.952	17.635	690.786	43313
5A	504889	494122	499506	-1.078	18.728	.956	17.901	729.522	43045
6A	355790	341847	348819	-1.999	16.756	.933	15.641	583.029	42899

RUN	TSAV	T WALL O	T WALL I	TTAV	PR TUBE	NU TUBE	HI	DE SHELL	PR SHELL	HO	RFIN	HO PRIME
	F	F	F	F			B/H-SF-F	LB/CUFT		B/H-SF-F	H-SF-F/B	B/H-SF-F
2A	171.555	164.256	163.515	153.215	2.662	175.303	1244.786	61.123	2.296	1773.568	-.000000	1773.568
4A	172.740	166.424	165.606	154.210	2.639	174.803	1242.044	61.109	2.275	2247.412	-.000000	2247.412
5A	173.005	167.395	166.517	154.250	2.638	174.076	1236.912	61.106	2.270	2745.669	-.000000	2745.669
6A	169.980	162.207	161.594	152.995	2.667	173.557	1232.210	61.141	2.324	1418.350	-.000000	1418.350

VISCOSITIES LB/FT-HR

RUN	VISC. SHELL	VISC SH WALL	VISS/VISSW	VISC. TUBE	VISC TU WALL	VIST/VISTW
2A	.8857	.9341	.9482	1.0167	.9384	1.0834
4A	.8783	.9192	.9555	1.0087	.9238	1.0920
5A	.8766	.9127	.9605	1.0084	.9175	1.0991
6A	.8957	.9485	.9444	1.0185	.9523	1.0695

Table II. (continued)

HEAT TRANSFER RESULTS BASED ON THE METHOD OF DONOHUE

RUN	RE SHELL	NU SHELL	NU/PR-VISC	FUNCTION C	FUNCTION D	FUNCTION E	LN RE SH	LN PR SH	LN VIS RAT	LN NU S
2A	48492.6	287.009	219.192	219.192120	5.389948	10.789166	10.789166	.831035	-.053171	5.659513
4A	67937.8	363.409	278.082	278.082031	5.627916	11.126348	11.126348	.821986	-.045567	5.895529
5A	84007.4	443.901	339.654	339.654160	5.827928	11.338660	11.338660	.819970	-.040334	6.095601
6A	33916.5	229.758	174.861	174.860924	5.163991	10.431656	10.431656	.843149	-.057222	5.437027

PRESSURE DROP RESULTS BASED ON THE METHOD OF DONOHUE

RUN	DP SHELL PSI	VEL WINDOW FT/SEC	DP WINDOW PSI	DP CROSSFLOW PSI	RE CL ENDS	RE CL CENTER	FRICTION FACTOR BASED ON RE CL CENTER
2A	3.150	3.861	1.804	1.346	26095.8	48586.9	.189258
4A	5.810	5.365	3.483	2.327	36560.1	68070.0	.169707
5A	8.850	6.622	5.306	3.544	45207.7	84170.8	.169795
6A	1.540	2.730	.902	.638	18251.8	33982.5	.179141

HEAT TRANSFER RESULTS BASED ON THE METHOD OF BELL

RUN	HOP LEAK B/H-SF-F	HOP NO LEAK B/H-SF-F	RE C/L	J IDEAL	NU IDEAL	LN RE	LN PR	LN VIS-RAT	LN NU
2A	1773.568	2141.732	38127.8	.008545	432.993	10.548697	.831035	-.053171	6.070723
4A	2247.412	2713.937	53416.8	.007754	548.254	10.885880	.821986	-.045567	6.306738
5A	2745.669	3315.625	66051.6	.007671	669.687	11.098191	.819970	-.040334	6.506811
6A	1418.350	1712.776	26667.2	.009735	346.622	10.191188	.843149	-.057222	5.848236

PRESSURE DROP RESULTS BASED ON THE METHOD OF BELL

RUN	DP LEAK PSI	DP NO LEAK PSI	VZ ENDS FT/SEC	VZ CENTER FT/SEC	DP WINDOW PSI	DP C-F PSI	RE ENDS	RE CENTER	FRICTION-F
2A	3.150	4.787	2.546	3.474	1.895	2.893	26095.8	48586.9	1.580619
4A	5.810	8.830	3.537	4.827	3.657	5.172	36560.1	68070.0	1.465657
5A	8.850	13.450	4.366	5.957	5.572	7.878	45207.7	84170.8	1.466517
6A	1.540	2.340	1.800	2.456	.948	1.393	18251.8	33982.5	1.520611

OTHER ACTIVITIES

Many special projects were performed for Wolverine Tube during the past year. One of these projects was the processing, with the IBM 709 computer at The University of Michigan, of the Wilson plot data taken on Wolverine Tube's concentric pipe heat exchanger. Project personnel also served in an advisory capacity for the Wolverine Tube Research and Development Division's concentric pipe heat exchanger program. Project personnel further assisted Wolverine Tube in the areas of plate fin heat transfer, base board heaters, and similar projects.

During the year project personnel reviewed heat transfer literature and the heat transfer papers presented at technical meetings. Information pertinent to the project's present or anticipated future needs were placed in the project's files. Similar information of importance to Wolverine Tube's Research and Development work was forwarded to Wolverine Tube.

A close liaison was maintained by Professor E. H. Young between the research project and the Bureau of Ships, Navy Department, Washington, D. C. and the U. S. Naval Engineering Experiment Station, Annapolis, Maryland. Professor Young participated in conferences at the Boiler and Heat Exchanger Branch of the Bureau of Ships with Mr. D. F. Grimm of Wolverine Tube on May 21, 1962, and with Mr. E. F. Hill of Wolverine Tube on September 26, 1962. Professor Young and Mr. Hill also participated in conferences with representatives of the U. S. Naval Engineering Experiment Station at Annapolis, Maryland.

Professor E. H. Young and other members of the research group participated in a total of 30 meetings with representatives of Wolverine Tube for the purpose of reporting results and planning future project activities. Additional conferences were held with representatives of several other companies concerning project activities, Wolverine Tube activities or project experience in certain areas. Professor Young participated in conferences at the Patterson-Kelly Company, East Stroudsburg, Pennsylvania, on February 13, 1962, and at the York Division of Borg-Warner Corporation, York, Pennsylvania on February 14, 1962, with Mr. D. F. Grimm of Wolverine Tube and Mr. R. Egan of Unifin Tube. On June 18, 1962, Professor Young attended a meeting on refrigerant condensing at the American-Standard Industrial Division in Detroit, Michigan, with several representatives of Wolverine Tube. On June 19, 1962, Professor Young met with Mr. R. L. Eichhorn of Whirlpool Corporation at St. Joseph, Michigan, to discuss their current work in thermoelectric refrigeration. Professor Young and Mr. D. M. Mellen of Wolverine Tube attended meetings on refrigerant condensing at the York Division of Borg-Warner Corporation on June 28, 1962. On July 10, 1962, Professor Young, Mr. D. F. Grimm and Mr. D. M. Mellen participated in conferences at the Trane Company, LaCrosse, Wisconsin. Professor Young and Mr. D. F. Grimm and Mr. A. L. Kaspark of Wolverine Tube held a conference on boiling refrigerants with Mr. Abdelmessih and Mr. M. W. Timby of the United States Air Conditioning Corp. in Delaware, Ohio, on July 17, 1962. On October 5, 1962, Professor Young and Mr. J. G. Lavin participated in boiling heat transfer conferences with Professor W. E. Fontaine, Professor J. B. Chaddock, and Mr. R. C. Johnston, Jr., of the Ray W. Herrick Laboratories at Purdue University, Lafayette, Indiana.

Professor E. H. Young and Mr. D. E. Briggs participated in heat transfer conferences at The University of Michigan with Mr. A. H. Abdelmessih and Mr. Wayne Timby of the United States Air Conditioning Corp. of Delaware, Ohio, and Mr. J. Roehm of Wolverine Tube, Columbus, Ohio, on November 26, 1962.

Mr. D. E. Briggs attended a conference at Wolverine Tube on December 7, 1962, with Messrs E. F. Hill, R. C. Cash, R. E. Seaton, and H. F. Powell of Wolverine Tube and Mr. J. J. Taborek of Phillips Petroleum. On December 8, 1962, Professor E. H. Young and Mr. D. E. Briggs held a conference at The University of Michigan with Mr. R. C. Cash and Mr. H. F. Powell of Wolverine Tube and Mr. J. J. Taborek of Phillips Petroleum.

Project personnel attended important heat transfer conferences. Professor Young attended the Symposium on Evaporation at the A.I.Ch.E. National Meeting in Baltimore, Maryland, on May 21, 1962. Professor E. H. Young and Mr. D. E. Briggs attended the Fifth National Heat Transfer Conference sponsored by the American Institute of Chemical Engineers and the American Society of Mechanical Engineers at Houston, Texas, August 5-8, 1962. Professor Young and Mr. Briggs presented a paper entitled "Convection Heat Transfer and Pressure Drop of Air Flowing Across Banks of Finned Tubes" at the meeting. Professor Young attended heat transfer symposia at the Annual Meeting of the American Institute of Chemical Engineers, Chicago, Illinois, December 2-6, 1962. While at the meeting, Professor Young participated in a meeting of the Executive Committee of the Heat Transfer Division of the American Institute of Chemical Engineers. Professor Young has been elected to a three-year term as a member of the Executive Committee starting January 1, 1963. Effective January 1, 1963, the name of the Heat Transfer Division will become the "Energy Conversion and Transport Division" of the American Institute of Chemical Engineers.

During the year Professor Young continued to remain active on the ASME Atmospheric Cooling Equipment Code Committee.

The research project received many requests for copies of the reports and technical papers which have been published as a result of the research program. The requests were fulfilled whenever possible.

CURRENT STATUS

The current priority list established by Wolverine Tube divided the project activities into two categories. One consisted of projects requiring laboratory facilities and the other consisted of non-laboratory investigations. At the end of 1962, the current priority list of projects was:

Equipment (laboratory) projects in order of priority

1. Investigation of the steam condensing characteristics of titanium tubes.

Non-laboratory projects in order of priority

1. Revision of the Williams-Katz report on the performance of Type S/T tubes in shell and tube heat exchangers.

2. Completion of a final report on the bond resistance of Type L/C finned tubes at elevated temperatures.