

T H E S I S.

DETERMINATION OF THE AMOUNT OF STEAM REQUIRED FOR
SLASHERS AND STARCH COOKERS AT BROOKSIDE COTTON MILLS,
KNOXVILLE, TENNESSEE.

by

A. B. Cox.

1906

Determination of the Amount of Steam Required for Slashers and Starchcookers at Brookside Cotton Mills, Knoxville, Tenn.

The test lasted 9 hours beginning 7 A.M. and ending 5 P.M., one hour being taken at noon.

To make the test it was necessary to break into the steam mains leading to the slashers and cookers and insert pipes of larger size, supplied with suitable fixtures for an orifice, pressure gauge on each side, calorimeter and steam separator on the high pressure side. A larger pipe was used so that the pressure would not be affected by the velocity of the steam.

The fine slashers were supplied with steam through a $1\frac{1}{2}$ " auxiliary pipe coming from the main, which carried boiler pressure, but the pressure was reduced by a reducing valve in the pipe supplying the slashers so that the pressure on the slashers was about 70#. As no estimate could be made of the amount of steam passing to the slashers, it was impossible to know what size orifice to use without trying different sizes, until one was found which would ^{just} supply the proper amount of steam. A $\frac{1}{2}$ " orifice was tried first, but would not furnish sufficient steam to cause the slashers to move. Then a $11/16$ " orifice was tried which supplied enough steam for running all the slashers except No. 5. Finally a $13/16$ " orifice was tried which proved to be of proper size.

The test consisted in taking readings at 5 minute intervals of pressure on both sides of the orifice. Also the temperature in the calorimeter at intervals of 30 minutes. From this temperature and the corresponding pressure before the orifice, the percentage of dry steam was determined.

By knowing the size of orifice and the pressure on both sides, it is possible to calculate the flow of steam through the orifice but this method is inaccurate. So for the sake of arriving at true results, the same apparatus was rigged up under the same conditions in laboratory and the results verified. This was done by grouping pressures that were about the same, taking their average and making a run of say 10 minutes with this average pressure. The steam passing through the orifice was condensed in a large condenser and weighed. The number of pressures in each group, times 5 minutes gave the length of time for the run corresponding to that group. So knowing the number of lbs. of water condensed for the 10 minute run, it was easy to get the total amount of water.

On rigging the apparatus in the laboratory to verify the results it was necessary to make connections with 1" piping whereas 2" piping was used on the test. with a 13/16" orifice it was impossible to maintain the same pressures as were taken on the test, due to so great a drop of pressure on opening the valve to the condenser. So instead of the 13/16" orifice a $\frac{3}{8}$ " orifice was used which admitted of the proper pressures. Runs were made with both orifices with the same differences of pressure. Then the number of lbs. discharged through the $\frac{3}{8}$ " orifice times the ratio of amounts discharged through 13/16" and $\frac{3}{8}$ " orifices respectively gives the number of lbs. discharged through the 13/16" orifice.

About the same general plan was carried out with the cookers as has just been explained. The three cookers were supplied with steam through a 1" pipe carrying boiler pressure. The pipe was enlarged to 2" where the orifice and instruments were inserted. A $\frac{3}{8}$ " orifice was

used to supply the cookers with steam. On verifying the results in the laboratory it was impossible to reach the same pressure as that of the test because the laboratory boiler pops off at 100# whereas the pressure on the cookers was about 110#. To take care of this, runs were made with the same differences of pressures as those on the cookers and from steam tables the density at each pressure was gotten. Then the number of lbs. discharged at the low pressure times the ratio of the densities at the high and low pressures gives the number of lbs. discharged at the high pressure.

Slashers.

65	25	5.8	63.6	368.88	99.25	895.8	281.1	889.1	1170.2	26.1	1144.1
66	39	5.9	58.3	343.97	99.22	895.2	282.0	888.2	1170.2	"	1144.1
68	30	6.3	58.3	367.29	99.10	893.9	283.9	885.9	1169.7	"	1143.6
68	59	4.2	15.9	66.78	99.10	893.9	283.8	885.9	1169.7	"	1143.6
69	38	6.1	58.3	355.63	99.07	893.3	284.7	885.0	1169.7	"	1143.6
71	41	6.1	21.2	129.32	99.03	892.1	286.4	883.5	1169.9	"	1143.8
71	45	5.8	42.4	245.92	99.03	892.1	286.4	883.5	1169.9	"	1143.8
71	54	5.0	15.9	79.50	99.03	892.1	286.4	883.5	1169.9	"	1143.8
73	66	5.4	68.9	372.06	99.00	890.3	289.0	882.0	1171.0	"	1144.9
74	60	5.1	47.7	243.27	98.98	890.3	289.0	881.2	1170.2	"	1144.1
76	71	3.5	26.5	92.75	98.95	889.2	290.6	879.9	1170.5	"	1144.4
78	38	6.5	42.4	275.60	98.87	888.0	292.2	878.0	1170.2	"	1144.1
81	75	3.8	21.2	80.56	98.80	886.3	294.6	875.7	1170.3	"	1144.2
				3021.53							

$$3021.53 \times 3.89 \times 5$$

----- = 14692# Total water used in 5 slashers.

4.

3.89 is the ratio of amount of water discharged through 13/16" orifice to that discharged through 5/8" orifice = 14694# 3021.53 x 3.89 is the amount of water discharged for 4 slashers, then to get the amount for 5 multiply by 5/4.

1144 = number of B.T.U. in 1 lb. of steam and there are 14692#

so 1144 = 14692 = 16807648 B. T. U.

Average pressure on high pressure side of orifice 72#

Average temperature, in calorimeter 261° F

	(Total slasher hours during 9 hr. run	29.9
	(Total lbs. water used in 5 slashers	14692
For 9 hrs. (	(Total B.T.U. consumed " " "	16807648
	(Total H.P. " " " "	56.04

Water per slasher per hour 326.5#

B.T.U. " " " " 373503.3

H.P. " " " " 11.21

The above were reckoned for 9 hr. run. H.P. for actual time slashers were in use 16.9

Cookers.

107	69	38	32	191.5	.2730	1.33	973.1	38.1	1186.2	26.1	1160.1
108	72	34	40	230.5	.2751	1.34	872.6	313.6	1186.4	"	1160.3
111	72	39	28	184.8	.2814	1.40	871.3	316.7	1187.0	"	1160.9
113	72	41	28	216.0	.2856	1.35	870.4	317.5	1187.9	"	1161.8

Experiment in Laboratory.

Pressure before orifice	Pressure behind orifice	lbs. water discharged per minute.	lbs. water for actual run	density.
75	37	4.5	144	.2052
75	41	4.3	172	"
75	36	4.7	132	"
75	34	5.7	160	"

1160 . No. B.T.U. in one lb. of steam and there are 882.8#

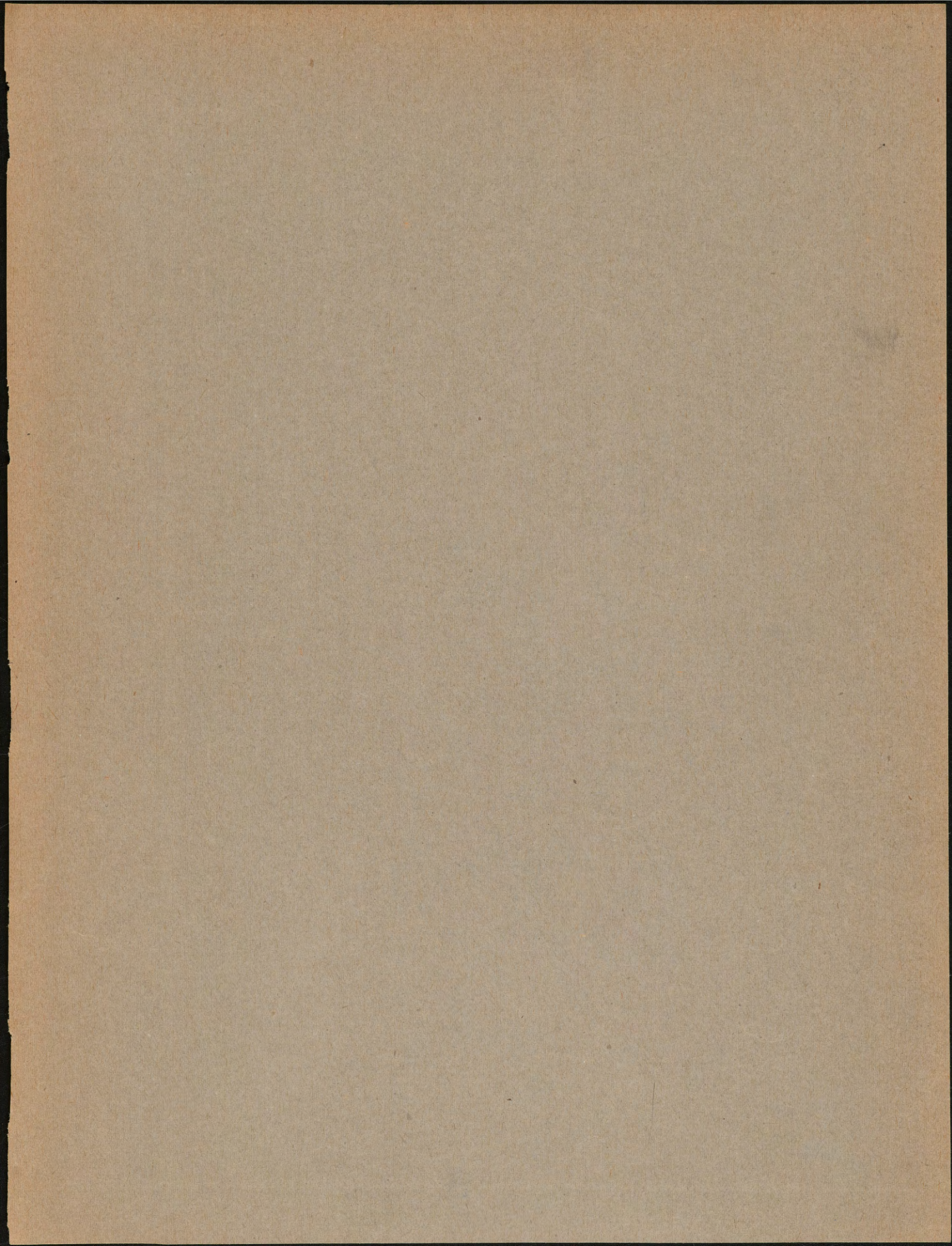
1160 x 882.8 = 1024048 B.T.U.

Only one cooker was run at any time.

	(Total cooker hours for 9 hr. run	2.13
	(	
	(Total water used in cookers	822.8#
For 9 hrs. (	(Total B.T.U. consumed in cookers	1024048
	(	
	(Total H.P. (reckoned for a period of 9 hrs.)	
	Water per cooker per hour	91.42#
	B.T.U. " " " "	113783#
	H.P. " "	3.37

The above are reckoned on 9 hr. run.

H.P. reckoned for actual time cooker was in use 2.13 hours = 14.4



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Slashers.

Pressure before orifice	Pressure behind orifice	lbs. water discharged per Min. by $\frac{3}{8}$ " Orifice	~~At Dry Steam~~ No. MIN FOR RUN.	lbs. water FOR RUN with $\frac{3}{8}$ " ORIFICE	% Dry steam.	For high pressure side of orifice				at Temp. Feed water	
						r	q	xy	xy+q	258°F	$(xy+q)-q_{58^{\circ}}$
65	25	5.8	63.6	368.88	99.25	895.8	281.1	889.1	1170.2	26.1	1144.1
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	Water per slasher per hour	326.5#
	B.T.U. " " " "	373503.3
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Cookers.

PRESSURE BEFORE ORIFICE	PRESSURE BEHIND ORIFICE	DIFFERENCE	NO. MIN. FOR RUN	ACTUAL WATER DISCHARGED	DENSITY ON HIGH PRESSURE SIDE	RELATIVE DENSITIES	FOR HIGH PRESSURE SIDE OF ORIFICE			AT TEMP. OF FEEDWATER	
							r	q	r+q	q	(r+q)-q _{58°}
107	69	38	32	191.5	.2730	1.33	873.1	38.1	1186.2	26.1	1160.1
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