Thesis

By

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A TEST OF THE POWER PLANT OF THE KNOXVILLE CITY MILLS.

1905

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The plant consists of a 1000-H. P. cross compound Corliss engine, manufactured by Filer and Stowell, a battery of two 350-H. P. Heine boilers, an open feed-water heater (not used in test), an ejector condenser, and auxilaries as follows: One pump used to lift water from creek to top of condenser, one pump to put water into the heater from the hot well, two pumps to put water into the boiler from the heater (only one used during the test), one small engine to run the dynamo (not used during the test). All steam pipes are well covered with a compound of magnesia and asbestos.

When we started the test we put a blind flange in the exhaust line into the heater, then turned the exhaust through a surface condenser and weighed the condensed water, thus determining the amount of steam used by the auxiliaries. We took water from the hot well and delivered it to our weighing barrels. The boiler feed pump took it from a tank under these and put it in the boiler. A Carpenter calorimeter was placed on the steam line just above the throttle of the main engine. All other observations were taken in the usual manner.

The men taking these observations were as follows:

J. B. Hicks	Indicator and Calorimeter
A. B. Cox	Temperatures, etc.
E. S. Maclin.	Coal and ashes.
W. L. Newton)	
)	Feed Water.
H. P. Gant)	
G. A. Worthington	Condensed steam from auxiliaries.

The boilers and engine were both in good condition through-out the run, and all things were exactly as in ordinary use, except the feed-water heater. All instruments used were carefully calibrated and corrections have been made where necessary.

The results of the test show the plant to be in fine condition. Both engines and boilers are working far below their normal rating, so it is probable that under a heavier load they would show a still better economy.

Data and Results of Evaporative Test.

Made by H. P. Rodgers and students from the University of Tenn., on the Heine boilers at the Knoxville City Mills, to determine economy under actual working conditions.

Kind of fuel--3" steam from Wooldridge Coal Co. Falls Branch Mine, Oswego, Tenn. Method of starting and stopping the test "alternate." (See Articles X. and XI. of code.)

Grate surface 84 sq. ft.

Water heating surface 2826 sq. ft.

Total Quantities.

Date of trial	May 2nd, 3rd, 1905.
Duration of trial	24 hours.
Weight of coal as fired	34,560 lbs.
Percentage of moisture in coal.	3.74 per cent.
Total weight of dry coal consumed	33,267 lbs.
Total ash and refuse	3219 lbs.
Percentage of ash and refuse in dry coal.	9.3 per cent.
Total weight of water fed to boiler.	259,997 lbs.
Water actually evaporated corrected for moisture.	256,617 lbs.
Equivalent water evaporated into dry steam from and at 212°...	299,236 lbs.

Hourly Quantities.

Dry coal consumed per hour . . . . . 1386 lbs.

Dry coal per sq. ft. of grate surface per hour . . . . 16.5 lbs.

Water evaporated per hour corrected for quality of steam... . . . . 10,692 lbs.

Equivalent evaporation per hour from and at 212° . . . 12,468 lbs.

Equivalent evaporation per hour from and at 212°, per sq. ft. of water heating surface . . . . . 4.41 lbs.

Average Pressures, Temperatures, etc.

Steam pressure by gauge . . . . . 132 lbs. per sq. inch.

Temperature of feed-water entering the boiler . . . . . 94°

Temperature of escaping gases from boiler, ... 531°

Force of draft between damper and boiler. . . . . $\frac{5}{8}$" of water.

Percentage of moisture in steam . . . . . 1.3 per cent.

Horse-Power.

Horse-power developed . . . . . 36 1.4 H. P.

Builders rated horse-power. . . . . 700 H. P.

Percentage of builders rated H. P. developed. . . . . 51.6 per cent.

Economic Results.

Water apparently evaporated under actual conditions per pound of coal as fired . . . . . 7.52 lbs.

Equivalent evaporation from and at 212° per pound of coal as fired.... . . . . 8.66 lbs.

Equivalent evaporation from and at 212° per pound of dry coal..... . . . . 8.99 lbs.

Equivalent evaporation from and at 212° per pound of combustible..... . . . . 9.46 lbs.

Effiziency.

Calorific value of the dry coal per pound, ... 12,644 B. T. U.

Calorific value of the combustible per pound . . . . 13,819 B. T. U.

Efficiency of the boiler (based on combustible). . . 66.11 per cent.

Efficiency of boiler, including grate (based on dry coal)... . . . 68.67 per cent.

Cost of Evaporation.

Cost of coal per ton of 2000 pounds, delivered in boiler-room....$1.40.

Cost of coal required for evaporating 1000 pounds of water from and at 212° . . . . . $0.08.

Data and Results of Feed-Water Test of Steam Engine,

Made by H. P. Rodgers and students from the University of Tenn., on engine located at Knoxville City Mills, to determine economy under actual working conditions.

Date of trial . . . . . May 2nd and 3rd'05.

Type of engine. . . . . cross-compound, condensing.

Class of engine . . . . . mill.

Rated power of engine . . . . . 1000 H. P.

Name of builders. . . . . Filer and Stowell.

Dimensions of engine:	High Pressure Cylinder.	Low Pressure Cylinder.
(a) Double acting		
(b) Cylinder dimensions		
Bore in inches	24	50
Stroke in feet	4	4
Diam. of piston rod, ins.	4-5/8	5-9/16
Tail-rod	none	none

(c) Clearance in per cent of volume displaced by piston per stroke:

	H. P.	L. P.
Head end	2.5	2.5
Crank end	2.5	2.5
Average	2.5	2.5

(d) Ratio of volume of low pressure cylinder to volume of high pressure cylinder 4.34

(e) Horse-power constant for one pound mean effective pressure and one revolution per minute:

H. P.	L. P.
0.1096	0.476

Total Quantities, Time, etc.

Duration of test . . . . . 24 hours.

Total water fed to boiler. . . . . 259.997 lbs.

Moisture in steam near throttle. . . . . 1.3 per cent.

Factor of correction for quality of steam. 987

Total dry steam consumed for all purposes. . . . . 256,617 lbs.

Hourly Quantities.

Total water fed to boiler per hour . . . . . 10,833 lbs.

Total dry steam consumed per hour. . . . . 10,6 92 lbs.

Dry steam consumed per hour,

(a) By engine . . ; . . . . . 8727 lbs.

(b) By auxiliaries. . . . . 1965 lbs.

Pressures and Temperatures (corrected).

Steam pressure near throttle by gauge . . . . . 132 lbs per sq. in.

Barometer reading in inches of mercury. 28.90

Pressure in receiver by gauge . . . . . 9.5 lbs per sq.in.

Vacuum in condenser, in inches of mercury 23½

Indicated Diagrams.

	H. P. Cyl.	L. P. Cyl.
Commercial cut-off in per cent of stroke	17.3	17.2
Initial pressure in lbs. per sq.in. above atmosphere	130	9
Back-pressure at mid-stroke (above) (below) atmosphere	10	8
Ratio of expansion	24.7	

Speed.

Revolutions per minute	76 rev.
Piston speed per minute	608 ft.

Power.

Indicated H. P. developed by high-pressure cylinder	314 H. P.
" " " " low-pressure "	288 H. P.
Total	602 H. P.

Efficiency Results.

Dry steam consumed per I. H. P. per hour by engine	14.49 lbs.
Dry steam consumed per engine I. H. P. per hour by engine and auxiliaries	17.76 lbs.

Proximate Analysis of Coal.

Moisture	3.74 per cent.
Volatile matter	22.68 " "
Fixed carbon	65.15 " "
Ash	8.43 " "
Total	100.00 " "