The Problem: What is the cost of steam lost through leaks?

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With rising costs for labor and materials involved in generating steam, attention to preventing steam leaks becomes increasingly important. The purpose of this article is, therefore, to indicate the order of what these losses may be from such items as valves, fittings, and traps.

In this connection, the following approximate formula, which applies to dry, saturated steam and was deduced by Napier, is useful in estimating the weight of steam lost through holes of different sizes:

$$ W = \frac{P \cdot a}{70} $$

in which \( W \) is the weight, in pounds, of steam lost per second; \( P \) is steam pressure, in pounds per square inch absolute; and \( a \) is the area of the hole, in square inches.

This formula is applicable when the back pressure is not more than 58 percent of the initial pressure. Thus, if the initial absolute pressure is, say, 75 pounds per square inch, the formula may be applied so long as the back pressure does not exceed 75 \times 0.58 = 43.5 pounds per square inch absolute. With dry-kiln heating equipment, steam leaks escape into the atmosphere, which has a normal maximum pressure of 14.7 pounds per square inch absolute. Consequently, under these conditions the formula is applicable.

An example of the use of the formula, let us suppose that the gage pressure is 60 pounds per square inch and that the opening is a hole 1/8 inch in diameter. Then the absolute pressure is 60.0 + 14.7, or 74.7 pounds per square inch. The area of a hole that is 1/8 inch in diameter is 0.012 square inch. Then,
\[ W = \frac{74.7 \times 0.012}{70} = 0.013 \text{ pound of steam per second, approximately} \]

\[ 0.013 \times 60 \times 60 = 46.8 \text{ pounds of steam per hour} \]

\[ \frac{46.8}{34.5} = 1.36 \text{ boiler horsepower. (1 boiler horsepower is equivalent to the evaporation of 34.5 pounds of steam from water at 212° F. to steam at 212° F. per hour.)} \]

\[ 46.8 \times 24 = 1,123 \text{ pounds of steam per day} \]

\[ 1,123 \times 30 = 33,690 \text{ pounds of steam per month} \]

To estimate the cost of this quantity of steam, let us assume that coal with 12,500 British thermal units per pound costs $10 a ton, or 0.5 cent per pound, and that the overall efficiency of the boiler and furnace is 70 percent. Then 12,500 \times 0.7 = 8,750 \text{ British thermal units per pound available for steam generation. If the boiler feed-water temperature is 70° F., about 1,144 \text{ British thermal units are required to generate a pound of steam at 75 pounds of pressure per square inch absolute. Hence,} \]

\[ \frac{8,750}{1,144} = 7.65 \text{ pounds of steam generated per pound of coal costing 0.5 cent;} \]

\[ \frac{33,690}{7.65} \times 0.5 = $22 \text{ (approximately), the cost of a steam leak 1/8 inch in diameter per month. The cost per year would then be $22 \times 12 = $264. The cost is proportional to the area of the hole, and therefore varies as the square of the diameter. Hence, the cost of a steam leak 1/16 inch in diameter would be $264 \times \frac{1}{4} = $66 per year. The corresponding cost of steam lost through a hole 1/4-inch in diameter would be $264 \times 4 = $1,056 per year. It is evident, therefore, that a number of even small steam leaks in the heating system of a dry kiln can be a source of heavy monetary loss and justify thorough maintenance. It should be noted that these estimates do not include any allowance for such items as labor, amortization, maintenance, taxes, and insurance.} \]

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