WHAT IS THE MOST ECONOMICAL POINT OF CUT-OFF FOR STEAM ENGINES?

By WM. D. MARKS,

Whitney Professor of Dynamical Engineering, University of Pennsylvania, Phila.

Probably no question is more frequently asked, and has hitherto received more unsatisfactory replies from the experts in steam engineering, than What is the most economical point of cut-off for steam engines?

Some writers have recommended that the point of cut-off should be determined by dividing two by the square root of the steam pressure in pounds per square inch, although they have not stated their reasons when they stated their facts; others have passed this point over in silence, and still others have endeavored to determine the point of cut-off, giving the most economical results by many and costly experiments.

When we reflect upon the fact that nearly every man, woman and child in this country has laboring for it one horse-power in its steam engines, the immense saving derivable from a ready rule for the economical adjustment of the expansion of steam will appear in all its importance, and the writer therefore hopes that the following original investigation and enunciation of a simple rule will prove of much interest and profit to all using steam.

It will at once be perceived that the work done during one stroke of an engine is equal to the mean pressure multiplied by the volume of the cylinder swept through by the piston.

Let P = the mean pressure in pounds per square inch (absolute).

" P_b = the initial " " " "

" B = the back " " " "

" c = the fractional part of the stroke at which the steam is cut off by the valve motion.

" V = the volume of the steam cylinder.

" E = the economy.

Now it will further be acknowledged that the economy increases directly as the work done during one stroke and inversely as the steam used during one stroke. Therefore we have

$$E = \frac{PV}{eV} = \frac{P}{e} \quad (1)$$

We have further the well known formula for the mean effective pressure of steam used expansively, supposed to expand according to Mariotte's law—

$$P = e P_b \left[1 + l \frac{1}{e} \right] - B \quad (2)$$

While this does not accurately represent the law of expansion of steam, it does it with close approximation, for all practical purposes. Substituting the value of P from equation (2) in equation (1), we have

$$E = P_b \left[1 + l \frac{1}{e} \right] - \frac{B}{e} \quad (3)$$

Differentiating with respect to e , and seeking the maximum, we find it to be

$$e = \frac{B}{P_b} \quad (4)$$

That is, *the fractional part of the stroke giving the most economical point of cut-off for a steam engine equals the absolute back pressure per square inch divided by the absolute initial pressure of the steam per square inch.*

EXAMPLE.—In a condensing engine, let the gauge pressure = 45 pounds, and the absolute back pressure = 3 pounds.

$$e = \frac{3}{45+15} = \frac{1}{20} \text{ of the stroke.}$$

If the engine be supposed non-condensing, and the absolute back pressure = 15 pounds (1 atmosphere), we have

$$e = \frac{15}{60} = \frac{1}{4} \text{ of the stroke.}$$

If in equation (3) we substitute the value of $e = \frac{B}{P_b}$ we have

$$E = P_b \left[1 + l \frac{P_b}{B} \right] - P_b = P_b l \frac{P_b}{B} \quad (5)$$

which gives us a comparative estimate of the economy of the condensing and non-condensing engines having the same initial pressures.

Thus, for the non-condensing engine we have

$$E = 2.3026 P_n \log. \frac{P_b}{B}$$

or

$$E = 2.3026 \times 60 \times 0.60206 = 83.17$$

and for the condensing engine we have

$$E = 2.3026 \times 60 \times 1.30103 = 179.74$$

showing that, when both engines are worked to the best advantage, the condensing engine is more than twice as economical as the non-condensing engine. The writer proposes to add a more exact demonstration in the near future, but engineers will find the above method simple and exact enough for all ordinary practical purposes.

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THE DECIMAL GAUGE.

By ROBT. BRIGGS, C.E.

The Society of Telegraphic Engineers of London have had under consideration the subject of a gauge for wires to be used for telegraphic purposes. The conclusions of the committee (as reported in the *La Lumière Electrique* for Feb., 1880, which is the source from which the writer derived his knowledge of the action of the English society) correspond in some regards to the argument of the paper relating to a decimal gauge which appeared in the JOURNAL OF THE FRANKLIN INSTITUTE for December, 1877. Thus it is recognized at once that there exists a real necessity for a gauge for thickness of metal which shall not follow an arithmetical progression, but which shall give a constant proportionate ratio of decrement or increment, or, in other words, follow a geometric progression.

The ratios of progression proposed in the JOURNAL in 1877 as expressed as relating to the *thickness* of the several numbers of the gauge were

For decrement $a\ 0.9^N$ or $= \frac{1}{10}$ successive reductions.

For increment $a\ 1.11111^N$ or $= \frac{1}{9}$ successive increases.*

* It will be noted that the increases of thickness for each number of the scale of $\frac{1}{9}$ are made by dividing the value below by 9, extending the division one decimal point in each instance, and that increases of weight for each number of the scale are made by two similar divisions.