further, they will find they have lost most of the value of their crops in the cost of transportation. This is why good flax is burnt in the West, and corn is used there for fuel.

With these facts and circumstances before them, it might be well for capitalists to direct their attention to the subject, in order that they may reap the manifest advantages which may be derived from the cultivation of flax and its manufacture into linens for a home and a foreign market.

THE LAW OF CYLINDER CONDENSATION IN STEAM ENGINES.

BY L. D'AURIA.

The weight of steam condensed at each stroke of piston in the cylinder of a steam engine is intimately connected with the loss of heat sustained by the cylinder and piston masses during the period of the exhaust, and this loss is dependent upon the rate with which the cooling takes place.

Newton was the first to propose a formula for determining the rate of cooling in bodies, but Dulong and Petit, by means of accurate experiments, proved the inapplicability of Newton's formula, and taking into consideration the mass and nature of the body subjected to cooling, the extension and form of its surface, its radiating power, the temperature of the ambient, the excess of the temperature of the body on the temperature of the ambient, the nature and the pressure of the latter, they proposed the following expression for the rate of cooling, which is found very well accordant with facts, viz.:

$$u = ha \left(\frac{e}{a - 1} \right) + k p^x e^y \quad (1)$$

in which t , and p , are respectively the temperature and pressure of the gas with which the cooling body is in contact; e is the excess of temperature of the body on the temperature of the gas; and the remaining quantities are numbers to be determined by experience.

The first term of equation (1) on the right hand side is due exclusively to radiation; and as with reference to steam engines, the radiation of the internal surface of the cylinder is not dispersive, we can drop such term altogether, and in our case write simply

$$u = k p^x e^y \quad (2)$$

Dulong and Petit found γ to remain constant for all gases and equal to 1.223; while x was found to vary from one gas to another.

For atmospheric air,	$x = 0.450$;
" carbonic acid,	$x = 0.517$;
" hydrogen,	$x = 0.380$.

The value of e which enters the expression (2) is given by the excess of the temperature T of initial steam on the temperature t of the exhaust, or $e = T - t$; for, the loss of heat which occurs during a single stroke is a very small fraction of the total heat contained in the mass of the cylinder, and the mean temperature of the latter at the end of stroke cannot therefore be much less than the temperature T . As to the value of p , we have to substitute for it the mean pressure of the exhaust steam.

Now the weight w of steam condensed at each stroke is proportional to the rate of cooling u (equation 2); to the mean surface Q exposed to cooling during the stroke; and to the duration of the latter $\frac{1}{N}$, N being the number of single strokes performed per minute. Hence, we can write

$$w = \frac{K Q}{N} p^x (T - t)^{1.223}.$$

Denote by A , area of pistons; by S , the stroke; by n , the grade of expansion, and by P , the pressure of initial steam above zero. Then the weight of steam indicated up to point of cut-off (clearance included) will be proportional to

$$P A S \left(\frac{1}{n} + c \right) = \frac{P A S}{n} (1 + nc);$$

c representing clearance in fraction of stroke.

If we indicate by θ the amount of cylinder condensation expressed in fraction of the weight of steam indicated up to point of cut-off, we can put

$$\theta = \frac{K Q n}{P A S N (1 + nc)} p^x (T - t)^{1.223}.$$

Represent by f the surface of steam passages at each end of the cylinder in fraction of it; and by D , the diameter of the cylinder will be

$$Q = \left(2 + f + \frac{2 S}{D} \right);$$

and consequently

$$\theta = \frac{n k}{P S N(1 + n e)} \left(2 + f + \frac{2 S}{D} \right) p^x (T - t)^{1.223}. \quad (3)$$

This formula applies equally to simple and compound ordinary engines; but when a duplex direct-acting pumping engine is concerned we have to take into consideration the pause which takes place at the end of each stroke, which pause is nearly equal to the duration of the stroke itself. In such case equation (3) is transformed in

$$\theta_1 = \frac{n k}{P S N(1 + n e)} \left(2 + f + \frac{S}{D} \right) p^x (T - t)^{1.223}. \quad (4)$$

Expressing temperatures in degrees Fahrenheit, and linear measures in feet, the writer has determined the values of k and x from few cases in his possession as following:

$$k = 0.64 \quad ; \quad x = 0.296.$$

[These values must not be considered as definitive ones, and it is to be hoped that engineers who are in possession of reliable data will not hesitate in applying them for a better determination of k and x , and make known their results.]

The above formulas can be made more handy by expressing T and t in friction of P and p . In such case we have for ordinary rotative engines

$$\theta = \frac{417.15 n}{P N S(1 + n e)} \left(2 + f + \frac{2 S}{D} \right) p^{0.296} \left(\sqrt[6]{P} - \sqrt[6]{p} \right)^{1.223}; \quad (5)$$

and for duplex direct-acting pumping engines

$$\theta_1 = \frac{417.15 n}{P N S(1 + n e)} \left(2 + f + \frac{S}{D} \right) p^{0.296} \left(\sqrt[6]{P} - \sqrt[6]{p} \right)^{1.223}. \quad (6)$$

In compound direct-acting pumping engines without cut-off valves,

$$p = P \left\{ \frac{r(1 + e) + R}{r(r - 1)(1 + e)} \text{hyp log} \frac{r(1 + e) + R}{1 + e + R} \right\} = P\phi;$$

R being the receiver space in fraction of the volume displaced by the high pressure piston at each stroke, and r the ratio of the cylinders. Hence for the latter case we have

$$\theta_2 = \frac{P N S(1 + e)}{417.15} \left(2 + f + \frac{S}{D} \right) P^{0.296} \times P^{\frac{1.296}{6}} \phi^{0.296} \left(1 - \sqrt[6]{\phi} \right)^{1.223};$$

or

$$\theta_2 = \frac{417.15}{PNS(1+c)} \left(2 + f + \frac{S}{D}\right) \phi^{0.296} \times P^{0.500} \left(1 - \sqrt[6]{\phi}\right)^{1.223};$$

or

$$\theta_2 = \frac{417.15}{NS(1+c)} \frac{1}{P} \left(2 + f + \frac{S}{D}\right) \phi^{0.296} \left(1 - \sqrt[6]{\phi}\right)^{1.223}; \quad (7)$$

in which

$$\phi = \frac{r(1+c) + R}{r(r-1)(1+c)} \text{hyp log} \frac{r(1+c) + R}{1+c+R}.$$

Examining formulas (5) and (6) it can be seen that, other things remaining the same, cylinder condensation would increase almost directly with the grade of expansion. But observing that whenever the grade of expansion n in a steam engine is increased a greater initial pressure P , is also required in order to obtain the same horse-power; it follows that the value of θ , in practice does not appear to be so much influenced by the point of cut-off as it has been stated above.

The most effective way to reduce cylinder condensation is by increasing the piston speed, which is clearly shown by the foregoing formulas.

A NEW INDUCTION IN SPECTROSCOPY.—There are reasons to suspect that the spectroscope has not told us the entire truth of gaseous nebulae, and that solid bodies, varying greatly as to number and size, are frequently important constituents of them. Probably nebulae vary indefinitely in the relative proportions of the solid and gaseous matter in their composition, from those which are nearly purely gaseous to those which contain scarcely anything but solid bodies. If these were exceedingly numerous, so as to overpower the gaseous spectrum of the nebula by the continuous spectrum they gave, and yet none were sufficiently large to appear as a distinct star, we should have presented to us the very features we recognize in the Andromeda nebula, and Sir John Herschel's provision, made more than half a century ago, would be realized, that "the great nebula in Andromeda may be, and not improbably is, optically nebulous owing to the *smallness* of its constituent stars. The cause of the appearance of these temporary stars still remains to be found. If we accept Denning's observations as proving that meteor-streams moving with a velocity of 200 miles a second and upwards are features of interstellar space, the passage of such a stream through a nebula might produce all the phenomena of a temporary star.—*Observatory, October, 1885.*