

air should pass through the grooves at a velocity not exceeding 100 ft. per second. The piston should, of course, work as close as possible to the cover, so as to make the clearance-space as small as possible. Only the best kind of piston-rings obtainable should be used in the air-cylinders. The piston of an air-compressor is more difficult to keep tight than a steam-piston; the moisture from the steam helps to keep the piston-ring tight, but the reverse happens with dry air.

The losses from friction of mechanism depend chiefly upon the accuracy of workmanship, the arrangement of the compressor, the efficiency of lubrication; all of which should be well attended to in the design and future working of the compressor. Equally so, good and reliable workmanship will often result in diminishing the losses from leakage in the air-mains. In bad arrangements great loss will result from leakages at the joints of the air-pipes; and more care is necessary with these than with steam-pipes, because a leakage of steam can be easily seen, whereas small leakages of air cannot be seen. Good joints should be made at first, providing properly for contraction and expansion; and they would give little trouble afterwards. The air-main should be sufficiently large. The loss due to friction in air-mains increases not directly as the velocity, but as the square of the velocity. Should the air-mains be too small it is quite evident the air will be wire-drawn, the pressure diminished, and the greatly increased velocity will produce a greatly increased friction. The delivery in the pipes should be more than equal to the quantity that the engines worked are capable of taking out.

In spite of these losses, compressed air is largely used for underground motive power; it has many advantages over steam under certain conditions, as the latter is not a convenient motive power to convey far into a mine. Compressed air as a motive power can be conveyed to any point in the workings, and the power can be readily split up by means of branch pipes, and carried in small quantities to numerous points. The exhaust air improves the ventilation, although this is hardly appreciable in well-ventilated mines, the cold air cools the mine, and quantities of gas can be cleared away by directing the air on to it.

As may be readily seen, the installation of a compressed-air plant requires a large capital expenditure; but once established it is not expensive to maintain. It requires extensive plant on the surface, a steam-engine being necessary in the first place to produce the compressed air; and to maintain a uniform pressure of air it is necessary that the generating plant should have a good margin of power and capacity. There are circumstances in which no other motive power can be so well applied, but on economical grounds, wherever practicable, steam, or some other force, should be employed direct.

If steam is not found advisable, and compressed air is preferred, then a good and large plant should be put down; the first cost of this should not be considered too much, while, on the other hand, the work to be done should be well considered, and a plant put down to do more than that work. The plant should be perfect in every possible item, and, in order to minimise the losses, only reliable and good workmanship employed, and sound material used.

A knowledge of the laws which govern the changes in the temperature, pressure, and volume of air should be of immense service to would-be users of compressed air:—

Let $P, V,$ and T = the initial pressure, volume, and absolute temperature respectively of a given weight of air,

and $p, v,$ and t = the final pressure, volume, and absolute temperature respectively of a given weight of air;

Then—(1.) At constant temperature $PV = pv$.

$$(2.) \text{ At constant pressure } \frac{V}{v} = \frac{T}{t}$$

$$(3.) \text{ At constant volume } \frac{P}{p} = \frac{T}{t}$$

If air be compressed or expanded adiabatically the following formulæ hold good:—

$$(4.) \frac{p}{P} = \left(\frac{V}{v} \right)^{1.408}$$

$$(5.) \frac{t}{T} = \left(\frac{V}{v} \right)^{0.408} = \left(\frac{p}{P} \right)^{0.29}$$

The units of work U required to compress a volume of air V to a volume of air v , or to compress a volume of air V from P to p , are:—

First, adiabatically—i.e., without loss of the heat due to compression,

$$(6.) U = \frac{PV^{1.408}}{0.408} \left(\frac{1}{v^{0.408}} - \frac{1}{V^{0.408}} \right)$$

Second, isothermally—i.e., at constant temperature,

$$(7.) U = PV \text{ hyp. log. } \frac{V}{v}$$

When air is compressed adiabatically the rise in its temperature is an exact measure of the work done upon it, and so the units of work required to compress it can be calculated from the increase of temperature. This rise in temperature $t - T$ is given by (5); and the units of work = this quantity $\times$ weight of the air in pounds $\times$ specific heat of air at constant volume expressed in foot-pounds—viz., 130.2. Thus, if W = weight of the air in pounds,—

$$(8.) U = (t - T) W 130.2.$$

In the following appendix will be found the annual reports of Inspectors of Mines, Wardens, and other officers; the questions used at the recent examinations of candidates for certificates of competency as mine-managers and battery-superintendents, together with a list of persons holding such certificates; and the usual schedules.

I have, &c.,

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Inspecting Engineer.

The Hon. the Minister of Mines.