THE PRINCIPLES AND PRACTICE OF COLLIERY VENTILATION

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649334988

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Edited by Trieste Publishing Pty Ltd.
Cover @ 2017

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OF

COLLIERY VENTILATION.

BEING A TREATISE ON THE
LAWS GOVERNING THE MOTION OF AIR IN MINES,
AND AN EXPLANATION OF
THE FURNACE AND VACUUM FAN SYSTEMS
OF VENTILATION.

BY

ALAN BAGOT,

Mining Engineer, Graduate Inst. Mech. Engineers.

(Author of "Accidents in Mines.")

BIRMINGHAM:
E. C. OSBORNE, 84, NEW STREET.
1879.

PREFACE.

The ventilation of a colliery is so important a matter, and so severely insisted upon by legislation that it is a matter of great necessity that engineers, and more especially their subordinates, should thoroughly understand the laws of nature which govern the motion of air through pipes, and the majority of works on Ventilation in Collieries are written on the assumption that the reader is well acquainted with Physics, and the Mathematical knowledge required to understand them is of such a high standard, that the overmen and firemen of a colliery are compelled to work by rule of thumb. My object in compiling this work has been, therefore, to try and render intelligible to young mining engineers and the sub-officials of a colliery the laws which govern the motion of the air in Mines. Technical knowledge is of no use whatever, if it is not based on some sort of scientific truth to start with, and I wish to call the attention of workmen to the chapter on the expansion of gases in volume under change of temperature, and to caution them that, as shewn by the chart of observation, the gas may be brought down on the roadway by a change in temperature. Some measurements and formulæ are given in the French Metric System for simplicity's sake, and are not of actual necessity to English Miners. I have not entered into the use of fire-damp indicators in Mines, as I am thoroughly opposed to their use. Either we must depend on good ventilation, or on the indicator; it is obvious therefore that the former is to be preferred, since if the latter indicates the presence of gas, we require the former agent to disperse it; then, why have the latter?

CHAPTER I.

General Principles of Ventilation in Collieries.

CORRECTIONS & ERRATA.

Page 7, lines 25 and 26, read—"*To understand the general features of the construction of a furnace is a very simple matter.*"

Line 28—"practise" read "practice."

Page 12, line 16—"a general rule."

Page 15, line 15—for "abvise" read "advise."

Page 24, line 14—for "produces" read "produce."

Page 27, line 3—for "principal" read "principle."

Page 35, line 40—for "especially" read "especial."

motion and the velocity of the whole of the air in the tube will also continue constant, and in one and the same direction.

We propose treating of the Furnace system first—This system is only an artificial development of the natural laws of ventilation.

If air is heated under a constant pressure it expands $\frac{1}{450}$ of its volume at the temperature of Zero of Fahrenheit's Thermometer, and it can easily be understood that if the mean temperature of the Upcast Shaft is artificially increased, the heated air becomes lighter, bulk for bulk, than that in the Downcast Shaft; the consequence being that the heavier air column in the Downcast Shaft overcomes the lighter air column in the Upcast, forcing the latter up the shaft before it, and if we were to prolong the Upcast Shaft to an indefinite length, the heated column of air would stand, possibly 60 feet higher than the level of the top of the cold air column. This difference is called the "Head of Air." The cool air, taking the place of the heated air, passes over the furnace in its turn, and so a perpetual current is kept up by the cool air going down one shaft and forcing the heated air up the other before it. It will be observed that the deeper the Upcast Shaft the more rapid will the draught be, and that the secret of a brisk circulation of air in the Upcast Shaft lies in the whole of the heat from the furnace being applied directly to increase by its action the temperature of the air column in the Upcast Shaft, and so set it in motion. The dumb drift should therefore be as short as possible, as far as is consistent with safety. The best method of laying out the furnace is as follows:—

Near the bottom of the Upcast Shaft the main return air-way, is split into two ways; the furnace is placed in a recess, cut out in the face of the smaller split of the main return air-way, the main return itself enters the Upcast Shaft a little below the smaller drift; by means of a damper placed in front of the furnace, the amount of air necessary to support the combustion of the furnace is regulated. The result is that no more air than is actually necessary is consumed, and the remainder has access to the Upcast, by way of the main drift below the smaller one; by arranging the depth of the furnace below the entrance of the main return air-way and furnace drift, the supply of air and the temperature of the Shaft may be so kept uniform, that men may travel in the Shaft. It must be borne in mind, however, that this system is fraught with danger. In the first place if the cage becomes fast in the Shaft, the men would be suffocated, and the ventilation of the mine very seriously impaired, and any blower of gas that may be present in the pit would cease to become diluted, and would ultimately charge the partially choked Upcast Shaft like a gun-barrel, until it became ignited at the furnace. If, however, it is absolutely necessary to use the Upcast Shaft as a drawing shaft, then air doors should be fitted to the shaft to close at the furnace drift, and in the event of an accident they should be promptly closed and the fires damped out. Care must be taken in erecting these doors, to allow for the expansion of the iron guide blocks, or when the furnace is burning they will not close just at the critical moment. On the whole, travelling in the Upcast Shaft is an economical practice that should be avoided. It will naturally occur to the reader to ask, why the two air columns, if of the same temperature, but of different diameters, or rather sectional areas, balance each other. It must be evident, that the weight of a column of air, like that of a column of water, is directly as its height, and that whatever extra pressure exists on the area of the smaller column of air, by reason of the greater dimensions of the larger column, is really exerted, not on the sectional area of the smaller column, but on that part of the mine where the area of the larger column becomes diminished to the area of the smaller one, such as the sides of the air-ways. In this way equilibrium is preserved. The elements of success, therefore. in furnace ventilation, are as follows :—

The Upcast Shaft should be free from obstruction, the deeper of the two, and every pound of coal consumed in the furnace should do its share of work in setting the hot air column in motion ; no more air should be admitted to the furnace than is absolutely necessary to support combustion, and the temperatures in the two shafts should differ considerably, yet uniformly. Checks on the temperature, or careless firing will check the air current, and this is to be avoided. We must consider, therefore, some of the laws, which govern the mechanical properties and effect of heat, in order to proportion our furnace to our requirements.

Coal is composed of Carbon and Hydrogen, and some other substances that are not necessary for our consideration. $2\frac{1}{4}$lbs. of coal require 29 cubic feet of air to insure complete combustion ; this is on the supposition that the whole of the Oxygen contained in the air is converted by combination with the Carbon into Carbonic Acid Gas ; but in practice it will be found that the best furnaces only burn half the Oxygen of the air passing through them, so double the amount of air must be provided. The process of burning is this : the greater part of the Carbon is transformed into Carbonic Acid Gas, the remainder into Carbonic Oxide : the Hydrogen combines with the remaining Oxygen to form steam. A remarkable feature of the case is that at equal temperatures the volume of the gases resulting from combustion is nearly equal to that of the air passing through the furnace. It is therefore of no importance in calculating the effective force of a furnace, to ascertain whether all the air has been consumed in passing over the furnace or not. The same volume of air will be obtained whether the air has passed the furnace or not; that is to say, the quantity of air admitted to the furnace will not be appreciably diminished in bulk by passing through the furnace. From these facts the following formula has been obtained.

A volume of air V arriving at a temperature t at the furnace.

In the Upcast Shaft when the temperature is represented by t^1

then $V = \frac{v^1 + a\,t^1}{1 + a\,t}$

This shows that it increases in volume, in a proportion due to its temperature, and to no other agency.

The next question is, what is the difference of weight due to the difference of temperature in the two columns. In Mining Engineering the difference is called the *head of air*, or *motive column*, since it is the exact Mathematical representation of the force exerted to produce the motion of the two air currents. This case is found as follows :—

Let H = Head in feet.
D = Depth of Downcast Shaft in feet.
t = Temperature of Downcast Shaft.
T = Temperature of Upcast Shaft.

$$H = D\,\frac{T - t}{T + 459}$$

Or representing the difference of the two temperatures by x.

$$H = \frac{-Dx}{T + 459}$$

Or a simpler method of obtaining the same result, is found as follows :—

Let D Represent the length of the downcast column of air.
U = Length of Upcast ditto
T = Number of degrees in excess of 32° F in D.
t = Ditto in Upcast.

$$U = D\left(\frac{480 + t}{480 + T}\right)$$

To give the length of the Upcast; then $U - D$ will equal the *head* H, and $8\sqrt{H}$ will give the velocity of the air current in feet per second, in the Upcast Shaft.

This result H will represent the power we have from our furnace to impart motion to the air column, and can be converted to inches of water gauge, as follows :—

A column of water in millimetres of water weighs per square metre 1 kilogram, and a column of air of a temperature of t in metres weighs p per metre in height. H expressed in metres of air at a temperature t^1 can be represented in kilos per square metre, by the product of H multiplied by the weight of 1 cubic metre of air, at a temperature of t^1, or by $p \frac{1 + a t}{1 + a t^1}$

Let $H =$ the height in water gauge readings in millimetres, then,

$$h = H \frac{a (t^1 - t)}{1 + a t} \times p \frac{1 + a t}{1 + a t^1} \quad (I.)$$

$$= p \, . \, H a \; \frac{t^1 - t}{1 + a t^1}.$$

from this equation t^1 may be extracted

$$t_1 = \frac{h + p \, . \, H \, . \, a \, . \, t}{a (p H - h)} \qquad (II.)$$

A millimetre being 0·039370 of an inch, this may easily be converted to the English reading.

Equation I., gives the mean temperature at which the air should ascend to produce a reading h in millimetres of water.

Equation II, demonstrates that as the temperature increases, the value of the depression becomes less as the temperature increases.

The calorific capacity of air was determined by M. Regnault, and is represented by 0·237. So that to raise 1 kilogramme of air 1° centigrade, 0·237 kilos. of heat will be required.

The calorific power of coal varies with its composition, but to no very great extent; as a general rule it may be estimated that 1lb. of coal will circulate 13,000 cubic feet of air. M. Devillez states that 1 kilogramme of small or slack coal will produce 7500 units of heat; a kilogramme being 2lbs. 3¼oz.

It is now necessary to know what velocity is acquired for a given known difference in temperature between two shafts, or for a given head. M. Peclet has worked out these calculations, and they are applicable to the requirements of the viewer, as they are based on sound scientific principles.

He admits that the temperature will be 300° in the Upcast; that 18 cubic metres at 0° cent. will be required to burn 1 kilo. of coal, and he applies this hypothesis that the chimney will be