METHOD OF CALCULATING HORSE-POWER.*

The engineer often finds it necessary to utilize an available waterfall or stream for power purposes. But before the wheels, turbines, or whatever method of developing the power, are installed, he must know the horse-power of the stream or fall.

The problem of calculating the horse-power of a waterfall or running stream is reduced to a simple formula, which any miner of ordinary intelligence can work out. It is based on the assumption that a horse-power is equal to 33,000 pounds lifted one foot per minute. This is the basis used in computing horse-power in any type of power developing machine. It is really more than the average horse is capable of, rather than less, as is generally supposed, the horse being able to lift only 22,000 pounds one foot per minute.

On this basis, however, that of 33,000 pounds lifted one foot per minute, the horse-power of a waterfall or stream is found by multiplying together the number of cubic feet of water which fall per minute, the vertical height or "head" in feet through which it falls, and the number, 62.3, this being the weight of a cubic foot of water in pounds; then divide the product of the whole by 33,000 Reduced to a formula, the problem appears as follows:—

$$\text{Horse-power} = \frac{\text{Cu. ft. per Min. x Vertical ht. ft. x 62.3 pounds.}}{\text{33,000-ft. pounds.}}$$

To better explain this formula, let an average case be supposed: Over a fall 20 feet high 1,000 cubic feet of water is discharged per minute. This problem would take the following simple form:—

$$\frac{\text{1,000 cu. ft. x 20 ft. x 62.3}}{\text{33,000-ft. pounds.}} = \frac{124,600}{33,000} = 40.71$$

horse-power.

It will be observed that to use this formula the miner must know the amount of discharges of the waterfall in cubic feet per minute. This, however, is not difficult to ascertain. By careful observations the cross-section area of the fall is learned and computed; this is then multiplied by the rate or velocity of the fall in feet per minute. This will give the number of cubic feet of water discharged per minute. In this, as in all other problems of like nature, the results are only approximate; but the main idea is to be as accurate as possible in making observations and securing data. It should be remembered that the formula itself is right; if errors occur, it must either be in the observations or in the final calculations.

The power of the waterfall will be developed by a breast-wheel, overshot, turbine or other type. But whatever the type, there must necessarily be considerable loss. Even though the miner has been careful in his observations, and has correctly calculated the horse-power by the above rule, he must allow for loss in the selecting of the wheels. Thus, an undershot realizes only one-fourth or, at best, one-third the actual power of the fall; a breast-wheel realizes one-half; an overshot wheel from two-thirds to three-fourths; a turbine from 0.75 to 0.87, and even as high as 0.90 of the fall, depending upon the skill of workmanship in manufacture and the manner in which it is installed. While an undershot or breast-wheel costs less to place, unless the miner has "water to throw away," it is far cheaper in the long run to place a good overshot wheel or a turbine.

Sometimes the miner wishes to utilize the power of a running stream, and would like to know how much it is capable of developing. To make these calculations it is presumed that the stream is confined at its point of proposed use to a flume of known dimensions. As the stream must be so confined before the water-wheel is placed, the estimates or figures for such conclusions will not be difficult to secure. About the only type of wheel that can be used in developing the power of a running stream is that with simple float-boards, instead of buckets or flanges. Thus, the wheel is driven by the ordinary or natural current of the stream without any appreciable fall like that in the preceding case. To apply the formula already given in calculating the water power of a running stream, the miner should first learn the virtual head, or rate of flow of the current. This is done by using floats, and by taking a number of observations between given points, "time" the speed of the floats and learn the velocity of the stream in feet per minute. Having thus found the head, the miner must next find the quantity of water which passes any given area of the stream in a minute. Thus, to use an average case, let it be supposed that the velocity or rate of flow of the stream is 250 feet per minute, and that the immersed part of the water-wheel float is 6 feet long and 1 foot wide or deep; then the area of the part of the wheel which receives the force of the current is 6 by 1, or 6 square feet. Hence, the formula for finding the cubic feet per minute would be in this case:—

6 sq. ft. x 250 ft. per min. = 1,500 cu. ft. per min.

The vertical height, or head of a running stream would virtually be the "grade" of the stream for a 10-foot section, or merely that portion used where the wheel is installed. In average cases this would amount to 0.19 or 0.2. Thus with the cubic feet of discharge per minute ascertained, and the head known, the miner will then proceed to find the horse-power by the formula given above for waterfalls. To use the case just cited, the results would be as follows:—

$$\frac{\text{1,500 cu. ft. per min. x 0.19 vert. ht. in ft. x 62.3 pounds.}}{\text{33,000 ft. pounds.}}$$

= 0.54 horse-power.

In a running stream, as in a waterfall, there is considerable loss when the utilization of its power be attempted. As but one type of wheel can be used, it is estimated that this loss in running streams is 0.6; that is, the wheel actually realizes only 0.4 the actual power of the stream. Hence, in the case just given the power developed would only be 0.54 by 0.4, or 0.216 horse-power. Multiplying this by 33,000 foot-pounds, it will be found that the wheel would be capable of lifting 7,128 foot-pounds per minute. But a rough allowance would still have to be made for friction of the journals, cutting the actual power of the wheel down to 7,000 foot-pounds per minute, which would be very close to what such a wheel, driven by a current of this velocity, head and size would develop.

In measuring the velocity of a running stream, the miner should not make his calculations upon the surface speed of the current. The usual method, and that most likely to give average results, is to use a float which is submerged to a depth of one-half the width or depth of the wheel paddle; that is, if the paddle of the wheel dips into the water one foot, the float for estimating the velocity of the current should be submerged six inches.

*Abridged from an article by Dennis Stovall in The Mining World.