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John Banks
Excerpt
More information

ON THE

POWER AND PROPERTIES

OF

DR. BARKER'S MILL.

THIS mill confifts of an upright tube, A B, Fig. 1, round or fquare, communicating with two arms A D, and A C, which have openings on oppofite fides, and which may be more or lefs clofed by flides as at S. That in the arm D is hid on the other fide. A ftream of water falls in at the top at B. The whole turns round on the pivot A, and is kept upright by the axle F B, which is fixed into the crofs pieces at F and B, and alfo may fupport a millftone, M.

On the caufe of motion.

When the water has filled the arms and trunk, the preffure of the water againft the fides of the horizontal arms will be directly as the altitude of the

the water A F, or A B. If the altitude A B is 12 feet, then the preſſure againſt the ſides of the arms will be 5.2 pounds on every ſquare inch.

Hence, if a hole one inch ſquare is cut in each arm, and on oppoſite ſides, and if the ſtream of water is ſufficient to keep the mill filled up to B, then the preſſure againſt thoſe ſides which are not cut, will be 5.2 pounds more than againſt the perforated ſides; hence we ſhall have 10.4 pounds acting on the arms to carry the mill round.

Additional power.

When motion is communicated to the mill by the power above deſcribed, another power begins to act in conjunction therewith, that is, the centrifugal force of the water in the horizontal arms, which is acquired by the whirling motion, and, like an additional head, cauſes the water to preſs with more force againſt the ſides of the arms. This power increaſes as the ſquare of the velocity, and, when that is known, may eaſily be compared with the firſt power, as ſhall be ſhewn hereafter. But, as the velocity increaſes, the reſiſtance increaſes, till theſe powers combined can no longer accelerate the motion, hence it becomes uniform; but at what degree of velocity is not to be aſcertained, but by experiment; becauſe the friction and different ſorts of reſiſtance cannot be accurately computed.

To

To compute the centrifugal force.

Let a = A C, or A D = 3 feet,
T = time of revolving = $\frac{1}{2}$ ſecond.

$a\sqrt{\frac{1}{3}}$ = 1.732 the centre of gyration of the arm, that is its diſtance from A, which, doubled, will be the diameter of a circle, in which the whole weight of both arms may be conſidered as acting; therefore if D = 3.464 and q = 3.1416, the centrifugal force will be expreſſed by $\frac{\text{D}q^2}{\text{ST}^2}$; (where S = 16 feet) and $\frac{33.9472}{4}$ = 8.4868 the centrifugal force compared with the weight, or quantity, or length of the arm; and, as the diameter of the arm will make no difference in the preſſure againſt a given ſpace, the quantity may be repreſented by a, the length of the arm, and $a \times 8.4868 = 25.46$ feet; ſo that the preſſure is equal to the original head added to this, viz. to 12+25.46, or to 37.46 feet, or with this additional force, the velocity of the water from the arms is as great, with a head of 12 feet, as it would be with a head of 37 feet, if the mill was at reſt.

This is perhaps a greater difference than might take place in practice; but the following experiments, made on a ſmaller ſcale, will ſhew that the power when the mill is moving, is much greater than when it is at reſt.

Experiments.

Altitude of the trunk - - - 1 foot $= b$.
Length of one arm - - - - .56 foot $= a$.
Diameter of circle of gyration $2 \times .323 = d =$ 646,
Time of a revolution - - - $\frac{3}{8}''$ $= T$,

When the mill is at reſt, it diſcharges 6.1 pounds per minute. When revolving 160 times per minute, 9.87 pounds per minute.

Then $\frac{Dq^2}{ST^2}$ or $\frac{1.154q^2}{16T^2} = 2.835$, which multiplied by the length of the arm .56 gives 1.585 for the additional force, which added to the other, is equal to a head of 2.585 feet; otherwiſe, the quantity of water diſcharged through given openings, being always as the ſquare root of the depth, we may ſay as 6.1 is to the ſquare root of 1 foot, ſo is 9.87 to the ſquare root of the depth, which would produce that velocity, viz.

$$6.1 : 1 :: 9.87 : 1.618;$$

the ſquare of which is 2.617 feet, for the head: differing only .032 foot from that computed by the laws of circular motion, and which ſmall difference may ariſe from the inaccuracy of the dimenſions, or of obſerving the time, or both.

Experiments

With a mill in which the water was kept at the height of 22 inches, and weights raiſed 6 feet 10 inches, by one gallon of water per minute.

Length

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No.	Weight raiſed.	Time in ſeconds.	Velocity of the wt. in inches.	Effect.	Velo. of the holes in feet.	Head in feet.	Velo. of the water.
	Length of the arms 5½ inches.						
1	1½	8½	9.64	14.46	5.759	2.43	8.37
2	2	11	7.45	14.9	4.466	2.19	7.99
3	2½	15	5.46	13.65	3.263	2.01	7.61
4	600 turns without weight in 2′ 12″.						
5	600 turns with a fly 1 pound weight and 15 inches diameter in 3′ 8″.						
	Length of the arms 7½ inches.						
6	2	10.2	8.03	16.06	6.54	2.606	8.694
7	2½	12½	6.56	16.4	5.34	2.351	8.262
8	3	14¾	5.46	16.38	4.52	2.202	7.992
9	600 turns in 2′ 50″						
10	600 turns with the fly, in 3′ 22″						
	The following with arms 19.6 inches. The weights raiſed 6 feet.						
11	3	18½	3.89	11.67	8.208	3.046	9.396
12	4	20	3.4	13.6	7.592	2.873	9.126
13	6	22	3.27	19.62	6.891	2.688	8.826
14	8	26	2.77	22.16	5.831	2.444	8.424
15	10	28	2.57	25.7	5.42	2.362	8.262
16	12	52½	1.37	16.44	2.89	1.983	7.603
17	8	27	with the fly.				
18	600 turns in 8′ 20″						
19	600 turns with the fly in 9′						

N. B. 17 Turns of the mill raiſes the weight 6 feet 10 inches.

It

It is not certain that in any of theſe experiments the greateſt effect has been produced, for in the firſt claſs it ought evidently to be ſomething leſs than 2 ounces; with the ſecond arms, it appears to be in raiſing between 2 ounces and 2½ ounces, and with the long arms, 10 ounces ſeem to be too much. But admit the 2d, 7th, and 15th experiments to be maximums, then we may infer that the force increaſes with the ſquare root of the length of the arms, and that the velocity of that part of the arms, where the water is diſcharged, is ⅔ of the velocity with which the water is diſcharged, for in this, different from the under-ſhot, the mill cannot leave the preſſure; and in the under-ſhot, at maximum, the floats are ſtruck with ⅔ the velocity of the ſtream, and the wheel moves with ⅓ thereof. Hence they who have ſuppoſed that the arms in this, as in the under-ſhot, ſhould move with ⅓ the velocity of the water diſcharged by them, ſeem, by theſe experiments to have reaſoned falſly.

In the 4th experiment the centrifugal force added to the height of the mill, gives a head equal to 58 inches.

In the 9th experiment the original head and centrifugal force equal to 63.6 inches.

In the 18th experiment the two combined are equal to 54.5 inches.

Whatever

Whatever length of arms be ufed, when the mill is at a maximum, the head by thefe experiments is raifed about $\frac{2}{7}$ of the height of the trunk, for inftance in the above, from 22 to 28.2 inches, as in the 2d, 7th, and 15th experiments, a head of 28.2 inches will produce a velocity of 8.1 feet per fecond, which multiplied by 60 gives 486 feet per minute, the length of a ftream, the folidity of which in this cafe is equal to 282 cubic inches, the area of its fection is .048353 inch, this fection multiplyed by 28.2 inches, and reduced into ounces is the force acting at the ends of the arms to turn the mill, and is equal to .788 ounce.

In the firft five experiments the diameter of the circle of gyration is .529 foot.

In the next five it is .7216 foot.

From the 10th to the 19th it is 1.885 feet.

To find the centrifugal force of the water in the arms.

Let D = the diemeter of the circle of gyration.
q = 3.1416.
S = 16.
T = time of a revolution.

Then $\frac{Dq_2}{ST^2}$ × the length of one arm, gives the altitude of a column, the preffure of which is equal to the centrifugal force.

EXAM-

EXAMPLE.

D = .529	Log.	1.7234557
q^2 =		.9943018
Dq^2 =		.7177575
S = 16		1.2041200
T^2 = .25 =		$\bar{1}$.3979400
ST^2 =		.6020600
$Dq^2 - ST^2$ =		.1156975
The length of one arm is .45833 foot —		$\bar{1}$.6611783
		1.7768758 = .59834,

which added to the height of the mill gives 2.43167 feet for the head.

ON

ON THE

VELOCITY OF AIR

FROM BELLOWS, &c.

A Tube filled with any kind of fluid, as AIR, WATER, QUICKSILVER, &c. and placed in a vacuum, every kind of fluid would flow out with the ſame velocity; for if quickſilver be heavier than water, and of conſequence produce a greater preſſure, yet the particles to be impelled are heavier alſo, and require force in proportion to their weight to project them with the ſame velocity as water. And if air is lighter than water, the particles to be projected are alſo lighter, hence the velocity by a given head will be the ſame in all.

A tube 16 feet long filled with air, would, like water, flow out with a velocity of 32 feet per ſecond, making no corrections for reſiſtance.

And if we take the gravity of air and water as 840 to 1, or if water is 840 times heavier than air

air, then one foot of water compreſſing air, would produce as great a velocity as 840 feet of air, or as a column of air 840 feet high could do by its gravity.

If we take the whole preſſure of the atmoſphere equal to 33 feet of water, or its height (ſuppoſing it to be equally denſe, which will make no difference in this caſe) equal to 33×840, equal to 27720 feet. Then as the ſquare root of 16 is to 32 feet velocity, ſo is the ſquare root of 27720 to 1332 feet, the velocity with which the air would enter into an indefinite vacuum.

To prove whether air compreſſed by 32 feet of water would be impelled into the atmoſphere with the above velocity, I made, amongſt many more, the following experiments.

Fig. 2.

A, is a caſk of a known capacity, into the top of which is ſcrewed an aperture *a*, of a known area.

The tube T *d*, recurve at *d*, is ſoldered or ſcrewed into the top of the ſaid caſk.

The hole *a* is ſtopped, and water poured into the tube at T, till it is full, at which time a quantity of water will have paſſed out of the tube at *d*, and