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A COMPARATIVE TEST OF THE AIR CONSUMPTION OF ROCK DRILLS

by

John Elmer Schultz

and

Christian R. Miller.

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A

THESIS

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

DEGREE OF

BACHELOR OF SCIENCE IN MINE ENGINEERING

Rolla, Mo.

1911

Approved by C.R. Forbes

Assistant Professor of Mining.

11876

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THESIS SUBJECT

A COMPARATIVE TEST OF THE AIR CONSUMPTION OF ROCK DRILLS

The aim of this thesis is an attempt to determine the relative efficiency, of four standard types of rock drills, as to air consumption. The air consumption was based upon the cubic inch of rock drilled by each machine. The orifice method of measurement being utilized, in connection with the exhaust to determine the desired consumption. Previous tests of a similar character have, in every instance, provided for a measurement of the compressed air used, through the medium of considerable tank storage capacity. The pressure being maintained constant or permitted to range between certain fixed limits. The limited capacity of the compressed air storage tanks at the Missouri School of Mines would have rendered anything but a very short rock drill run impossible, for this reason the usual methods of air tank measurement, of above mentioned, gave way to the orifice measurement of the exhaust air.

As a means of comparison only short runs were made, in which, the tank measurement method was adopted with a pressure range of 60 to 100 pounds. In this connection it might be stated that considerable difficulty was experienced in accurately determining the volume of the total exhaust of the Leyner Drill,due to the character of construction,which permits a portion of the exhaust to escape about the drill steel,at the base of the front head,while additional air escapes through the core of the hollow drill steel,being utilized in connection with the water feed. A packing was devised for the front head and the core in the drill steel was plugged up thus forcing all the exhaust air through the exhaust port,but this was manifestly unjust to the drill,as running conditions were therefore not normal to the drill construction,but runs were made simply as a matter of experiment. The tank measurement was therefore the only method which could be satisfactorily used in connection with the Leyner Drill and such method was resorted to in this connection.

The rock drillsselected for the tests were manufactured respectively by the: Ingersoll-Rand Drill Co., Sullivan Machinery Co.,Wood Drill Works,and the J.George Leyner Engineering Works Co..

The machines are those carried regularly instock by the respective manufacturers and were purchased shortly before the tests were carried out. The first three named are the piston type,the last is of the hammer type.

The following is a descriptive summary of the drills tried out.

Company	Type	Diam.Cylind.	Lgth.Stroke.	Lgth.Feed	Wgt.
Sullivan	U5	2 1/4"	5"	15"	145
Ing-Rand	A 86	2 1/4"	5"	15"	140
Wood	No.2 1/4	2 1/4"	4 1/2"	20"	125
Leyner	No.7	2 1/2"	2 3/4"	30"	125

Before being placed in service for the tests the machines were given preliminary runs, to enable the working parts to wear smooth.

The drills were rigidly mounted on a bar, which in turn was wedged between 12 by 12 timbers, 6 feet apart, the bases being imbedded in concrete and further stiffened by side braces and a tie rod.

All holes were drilled at angles varying from 15 degrees up to 25 degrees down, into a block of granite 3'x4'x4'. The granite was procured from the Pre-Cambrian area, near Graniteville, in South East Missouri, and was freshly quarried.

Compression was secured by one single stage Rand Imperial Type Air Compressor of 77 cubic feet per minute free air capacity and pressure up to 100 pounds per square inch gage and one Two-Stage compressor of 100 cubic feet and 100 pounds gage pressure. The compressed air was conveyed to two receivers of a combined capacity of 1695.7 cubic feet, and from thence conveyed by one inch pipe to the place of drilling. The connection with the drill being made with one inch hose. The exhaust from the drill was conveyed by one and one-half inch hose, 50 feet long, to an iron drum 8 feet long by 2 feet in diameter, supplied with an orifice, cut in No. 14 copper plate.

The pressure gage used was a standard Crosby Gage, and the necessary correction was determined by a stanard gage tester. The ordinary cross-bit made by the Leyner Sharpener on one inch octagonal steel was used, the starter had a gage of 1 7/8 inches, each successive gage being 1/4 inch less than the preceeding.

METHOD OF TAKING DATA.

Compression was maintained at nearly constant gage, by varying the speed of the pressure. Since the compressors were located immediately adjacent to the drilling location, this adjuctment was easily made.

Preliminary experiments were made to determine the necessary size of the orifice, for the drum, which would bring the pressure from the exhaust air within the drum to less than one foot of water head. A 1 1/2 inch orifice was finally accepted as satisfactory. All holes were first dollared before the actual run, on which data was collected, was started. With everything in readiness and the air pressure constant, the machine was started and drilling continued until a change of drill steel was required. The time of stopping and starting was recorded by means of a stop watch,the time taken up by the stoppages being deducted to give the net running period.The temperature,of the free air in the drum,was noted by means of a thermometer,inserted in an aperature in the drum,and likewise the water differential gage recording the pressure. In the latter data,readings were taken for every fluctation of the water gage,some times every five or ten seconds. The outside temperature of the atmosphere was also noted. At the finish of the drilling the depth of the hole was measured and the degree of pitch of the same were all made a part of the record.

Having noted the temperature of the free air in thr drum,the diameter of the orifice,differential gage reading,compressed air gage,the data was inserted in the formula for finding the weight of air passing per second, as given in Compressed Air Cumputations by Harris:

$O = \frac{\pi d^2}{4 \times 144}\sqrt{2g\frac{1}{12} \times 62.5 \frac{W_a^2}{W_a}}$. In which O represents the weight of air passing per second,d is the diameter of the orifice in inches,W_a is the weight of a cubic foot of air in pounds and g is 32.2. The formula in turn reduces to $0.1632\, d^2\sqrt{\frac{1}{t} p_a}$ in whick p is the air pressure in pounds per square inch inside the drum,and t is the absolute temperature,Fahr.scale. The above represents the theoretic formuls to which must be applied an experimental coefficient whose value is dependant on the size of the orifice and the differential water gage reading. In the case of a 1 1/2 inch orifice the coefficient varies from 0.601 to 0.603. Having the weight of air in pounds per second,the free air volume per minute is secured by multiplying by 60 and deviding by the weight of a cubic foot of free air at the elevation of Rolla and at the recorded temperature. The cubic feet of free air per minute consumed was multiplied by the time run and in turn, was devided by the cubic inches of hole drilled. The latter result forms the essential basis of comparison.

The following summarizes the data obtained from the runs made at the varying pressures,the short time allotted made it impossible to carry out the desired number of runs and in some instances,due to the lack of time in conjunction with other factors,only one satisfactory run was secured.

Ingersoll-Rand Drill:

80# Gage

Water gage reading.	Cu.ft.free air per min.	Duration of run.	Cu.ft.free air per cu.in.drilled.
5.7 in.	71.00	5.00 min.	22.30
5.58	69.00	6.50	15.50
6.20	75.06	5.53	18.05
5.42	70.40	7.42	16.06

4.20	61.08	19.75	35.80
		85# Gage	
5.30	68.80	6.35	15.82
3.90	58.96	4.50	13.10
4.67	64.58	5.50	12.44
		90# Gage	
5.80	72.30	8.33	28.60
		95# Gage	
5.20	68.10	8.00	18.00
6.01	73.18	9.00	30.40
3.18	55.30	8.00	11.23
		100#Gage	
5.90	73.20	3.25	16.40
4.30	62.10	3.75	9.55

Wood Drill:

		80# Gage	
2.60	48.33	12.50	16.83
1.62	38.07	9.33	12.06
		85# Gage	
3.62	57.00	6.00	13.39
		90# Gage	
4.62	63.30	9.00	17.05
		95# Gage	
2.96	51.44	12.00	16.87

3.38	55.61	7.00	17.06
4.05	64.30	6.50	14.56
		100#Gage	
3.38	55.61	6.50	17.06

Sullivan Drill:

		80# Gage	
3.66	59.72	8.75	13.52
3.54	56.30	7.50	10.73
		85#Gage	
2.96	52.17	8.00	15.19
		90# Gage	
4.11	65.72	6.50	12.00
4.21	64.52	7.00	15.85
4.17	61.65	7.00	16.03
3.20	54.16	7.00	17.16
4.20	61.05	9.25	15.98
3.40	54.92	10.67	14.38
		95# Gage	
3.42	55.81	8.00	13.76
4.72	65.47	5.00	15.20
4.25	61.67	13.00	31.90
		100# Gage	
3.53	57.00	9.00	19.05
4.45	65.15	2.00	10.50
3.55	56.70	7.75	14.43

Leyner Drill:

		95# Gage	
2.54	43.57	2.25	8.96
2.57	48.13	5.25	37.83
2.20	47.78	1.00	6.02
		100# Gage	
3.12	52.97	4.00	25.25
2.63	51.53	2.00	4.24

Tank Measurement

Leyner Drill:

Duration of run.	Gage	Volume of hole.	Cu.ft.free air for run.	Cu.ft.free air per min.
3.5 min.	100#-80#	17.39	238.1	68.03
1.0	100#-80#	15.28	238.1	238.1
2.0	80#-60#	11.92	173.2	86.6
Sullivan Drill:				
7.0	100#-60#	17.73	274.3	69.5

Arranging the results gives the following records for comparison.

Orifice Measurement.

Drill	Gage in.	Cu.ft. free air per min.	Length of run	Cu.ft.free air per cu. in.drilled	Depth of hole dia. 1 3/4"
			80# Gage		
Wood	2.11	45.20	10.41	14.44	15.0"
Ing.Rand	5.58	69.31	8.50	21.54	11.2
Sullivan	3.60	58.01.	8.12	12.12	16.1
			85#Gage		
Wood	3.62	57.00	6.00	13.39	10.9
Ing.Rand	4.62	64.11	5.43	13.12	11.1
Sullivan	2.96	52.17	8.00	15.19	11.7
			90# Gage		
Wood	4.62	65.50	9.00	17.05	13.7
Ing.Rand	3.80	58.20	8.25	12.64	12.9
Sullivan	4.05	62.20	8.25	15.44	13.8
			95# Gage.		
Wood	5.46	57.12	8.50	16.16	12.5
Ing.Rand	4.42	62.24	8.21	18.31	9.5
Sullivan	4.13	60.98	8.67	20.28	10.8
Leyner	2.43	46.49	2.83	17.61	2.8
			100# Gage		
Wood	3.38	55.61	6.50	17.08	8.8
Ing.Rand	3.50	67.65	8.00	12.97	17.4

Sullivan	3.50	67.65	8.00	12.97	17.4
Leyner	2.87	52.25	3.00	14.74	4.4
Tank Measurement					
Gage 100#- 60#					
Leyner		108.23	3.00	15.10	8.9
Sullivan		69.5	7.00	17.73	11.4
Gage 100#- 80#					
Leyner		68.03	3.50	13.70	7.2

The variations in the above tests were due to several factors. First the form bit, which is not adapted to dry holes, of wet holes in which the water is fed by hand; as this method of feeding the water does not give a uniform feed. Another factor was the lack of uniformity in shape of drill bits, which was due to the want of a competent drill sharpener.

The results obtained by testing machine drills, on the surface, are apt to be misleading unless carried on for a great length of time. This was exemplified in the first South African Drill Contest which was won by the Gordon Drill; this machine was afterwards tried out underground and proved to be far less efficient than was indicated by the results of the test.

The tests as herein made are useful however for determining the actual drilling speed and air consumption of different machines under ideal conditions, but do not necessarily show the true worth of the machine when applied to the conditions met with in underground work.

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