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DESIGN AND CONSTRUCTION OF AN EQUIPMENT FOR PERMEABILITY TEST OF MOLDING SANDS

Mohammad Imrul Kayes Saurav[1], **Aktaruzzaman Al-Hossain**[2] **and Md. Sazzad Hosen**[3]

[1-3]Department of Mechanical Engineering
Khulna University of Engineering and Technology, Khulna 9203, Bangladesh

[1]saurav_kuet@yahoo.com, [2]zicome33@gmail.com, [3]sazzad31@gmail.com

Abstract*-As the title stated, an equipment was designed and constructed for the permeability test of sands. The equipment and its parts were constructed according to the design and using local components considering the construction cost. A cylindrical drum was inserted to another drum of the same kindwith a larger diameter. Then the airwas forced by the created pressure during insertion of drums as there was no leakage. The airwas then passed through the pipes and the sand sampleunder controlled conditions and the time consumed was measured. After that using the required equation permeability number of specific sand was calculated.*

Keywords: Permeability, Sand test, Core sand, Green sand, Permeability number

1. INTRODUCTION

Permeability is defined as the property of molding sand with respect to how well the sand can vent, *i.e.* how well gases pass through the sand. And in other words, permeability is the property by which we can know the ability of a material to transmit fluid/gases. One of the essential qualities of molding sand is sufficient porosity to permit the escape of gases generated by the hot metal. This depends on several factors including the shape of sand grains, fineness degree of packing, moisture content and amount of binder pressure. Permeability is the measurer of the openings between grains which gives passage for air, gas or steam to escape when molten metal is poured in the mold[1].

Permeability of sand can be classified into several categories[2]-

1. Base Permeability: It is the permeability of sand without any clay or additive.
2. Green Permeability: It is the permeability of sand at room temperature.
3. Dry Permeability: It is the permeability of the sample when it is dried at 105-110°C to remove any moisture.
4. Baked Permeability and Core Permeability: It is the permeability of the sand mixture or core at the baked (above 110°C) or cured state.

2. PERMEABILITY EQUATION

There are different types of permeability measuring devices. Most of the devices consist of a permeability meter which uses a standard specimen. In this project, we will use the following equation to determine the permeability number of molding sand at room temperature:[1]

$$P = \frac{v.h}{p.a.t}$$

Here,
P = permeability number to be determined
v= volume of air passing through the specimen in cm^3
h= height of the specimen in cm
p = pressure of air in gm/cm^2
a= cross-sectional area of specimen in cm^2
t= time for air to pass in minutes

3. DESIGN AND CONSTRUCTION

3.1 Design Procedure

Depending upon the formula $P = \frac{v.h}{p.a.t}$, we may design equipment shown in the following image-

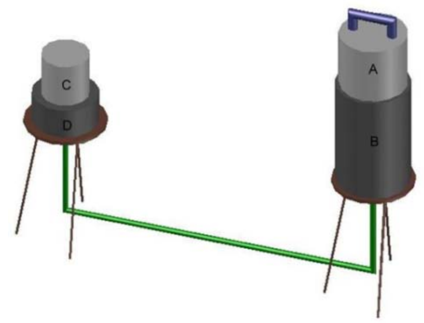

Fig 1: Schematic view of the equipment

Let, R_A = Radius of drum A = 10 cm
We know, V=Volume of air = $\pi R^2 H$…………….(1)
Here, V = 2000 cc
So, Height = H = $\frac{V}{\pi r^2}$
From equation (1), H_A=Height of drum A= $\frac{2000}{\pi \times 10^2}$ cm = 6.366 cm
So, our minimum height of drum A should be 6.366 cm
Again, if we design R_A = 7.25 cm, then from the equation (1),
H_A= $\frac{2000}{\pi \times 7.25^2}$ cm = 12.11 cm
This minimum height is more suitable than the height found by previous solution.
So, we can design the diameter of drum A= D_A=14.5 cm
And H_A = 23.2 cm
Hence, it is important that diameterof drum B (D_B) must be larger than the diameterof drum A.
So, the boundary condition is $D_B > D_A$.
Again, the clearance between $D_B$and D_A should be such that drum A can fall downward with minimum resistance to contact with the wall.
So, we can design that-
D_A = 16 cm
D_B = 14.5 cm
Diameter of drum D (D_D) must be greater than 5.08 cm, because we have to insert a specimen holder in it whose diameter is 5.08 cm.
So, we can design, D_D = 6.08 cm
This drum D should be connected with ½ inch diameterG.I pipe.
So, we can design height of drum D = H_D = 7.5 cm
Specimen holder must be 5.08 cm in diameter and the height should be greater than 5.08 cm. So, our specimen size is 5.08 cm in diameter and 5.08 cm in height.
We can design the height of specimen holder = 14.2 cm

3.2 Components of unit

1. G.I pipe of diameter ½ inch (17ft).
2. Compressor liner.
3. G.I pipe for drum a (14.5 cm diameter), drum D (6.08 cm diameter) and specimen holder (5.08 cm).
4. Rod and plate for stand.
5. Brass rod for gas welding.
6. Net, bend, T and gate valve.
7. Seal, grease to prevent air leakage.

Fig 2: Photographic view of equipment.

4. RESULT AND DISCUSSION

From the above calculation, after constructing the equipment following result has been found for different types of sand specimens under test.

Table 1: Comparison result of Permeability numbers of Core sand specimen

No. of observations	Permeability Number		Difference	Error percentage
	Experimental result	Conventional result		
1		0.318	0.0412	12.95%
2		0.321	0.0442	13.76%
3		0.324	0.0472	14.57%
4		0.3185	0.0417	13.09%
5		0.308	0.0312	10.12%
6		0.312	0.0352	11.28%
7		0.310	0.0332	10.70%
8		0.305	0.0282	9.24%
9		0.305	0.0282	9.24%
10	0.2768	0.306	0.0292	9.54%
11		0.303	0.0262	8.64%
12		0.296	0.0192	6.48%
13		0.298	0.0212	7.11%
14		0.298	0.0212	7.11%
15		0.295	0.0182	6.17%
16		0.295	0.0182	6.17%
17		0.299	0.0222	7.42%
18		0.300	.0232	7.73%
19		0.298	0.0212	7.11%
20		0.299	0.0222	7.42%

Table 2: Comparison result of Permeability numbers of Green sand specimen

No. of observations	Permeability Number		Difference	Error percentage
	Experimental result	Conventional result		
1		0.316	0.0614	19.43%
2		0.318	0.0634	19.93%
3		0.311	0.0564	18.13%
4		0.312	0.0574	18.39%
5		0.310	0.0554	17.87%
6		0.308	0.0534	17.33%
7		0.305	0.0504	16.52%
8		0.308	0.0534	17.33%
9		0.309	0.0535	17.31%
10	0.2546	0.305	0.0504	16.52%
11		0.302	0.0474	15.69%
12		0.300	0.0454	15.13%
13		0.296	0.0414	13.98%
14		0.298	0.0434	14.56%
15		0.289	0.0344	11.90%
16		0.290	0.0354	12.2%
17		0.289	0.0344	11.90%
18		0.291	0.0364	12.5%
19		0.290	0.0354	12.2%
20		0.289	0.0344	11.90%

The aim of this project was to design and construct an equipment to measure the permeability number of different molding sand samples. The sand samples were bound by using molasses, clay and water. These binding materials were mixed in appropriate proportions at room temperature. Proper sealing was made to ensure that there was no leakage of air inside the cylinders. It was observed that the permeability number varies with the change in sand specimen. The moisture contents for each of the specimens were also measured by the difference in their dry and wet masses. Conventional measurement of permeability numbers was obtained by using a permeameter and applying the 'Falling Head Permeability Test'.

For Core sand we have got the lowest 7.11% error in result in our constructed equipment. The correction factor in permeability number for this sand is +0.0292 in average. So we have to add this amount with our measured permeability number every time we measure from our constructed equipment to get the best possible result.

In caseof Green sand the correction factor is +0.0454 and the lowest error is 11.90% in measured results. Due to friction in cylinder walls and imperfect binding materials this error in result occurred.

5. CONCLUSIONS

The objective of this project was to construct an equipment to measure the permeability number of different sand samples. It was made sure that the components used in this arrangement can be easily obtained and the overall equipment was simple in operation. More modern equipments are available in many of the laboratories over the world. But the arrangements used here require less complexity and can be provided with a cheaper cost to the laboratories where permeability numbers for different molding sands are needed to be measured.

From our measurement we have achieved the followingresults and correction factors of sandsamples:

Table 3: Permeability number and correction factors for different types of sands

Types of sands	Permeability number	Correction factor
Core sand	0.2768	+0.0292
Green sand	0.2546	+0.0454

6. REFERENCES

[1] Jain, R.K, *Production Technology*, 16th Edition, 2009, Khanna Publishers, New Delhi-110002.

[2] Mukherjee, P.C, *Fundamental of Metal Casting Technology.*vol. 7, no. 1, pp. 1101-1119, 2002.

[3] Rajput, R.K, *A Textbook of Manufacturing Technology*, 1st Edition, 2007, Laxmi Publications (P) LTD, New Delhi-110002, pp. 347-380.

[4] Granlund, Matt (1999-03-01), "Understanding the basics of green sand testing", Modern Casting, vol. 5, no. 2, pp. 523-562, 2003.

[5] http://en.wikipedia.org/wiki/Permeability_%28foundry_sand%29 (22/8/12)

7. NOMENCLATURE

Symbol	Meaning	Unit
D_A, D_b, D_c, D_d	Diameter of drum A, drum B, specimen holder C, drum D respectively	(cm)
R_A, R_b, R_c, R_d	Radius of drum A, drum B,specimen holder C, drum D respectively	(cm)
V	Volume of air	(cc)
H_A	Height of drum A	(cm)