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МАЗМҰНЫ

МАТЕМАТИКА

ФИЗИКА

ИНФОРМАТИКА

БАҒЫТТАР БОЙЫНША ҒЫЛЫМИ-МЕТОДОЛОГИЯЛЫҚ ЗЕРТТЕУЛЕР

СОДЕРЖАНИЕ

МАТЕМАТИКА

ФИЗИКА

ИНФОРМАТИКА

НАУЧНО-МЕТОДОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ ПО ОТРАСЛЯМ

CONTENT

MATHEMATICS

PHYSICS

INFORMATICS

SCIENTIFIC AND METHODOLOGICAL BRANCH RESEARCHES

Во всех случаях задача многокритериальной оптимизации каким-то способом сводится к задаче с одним критерием. Существует много способов построения такого окончательного критерия, однако ни одному из них нельзя заранее отдать наибольшее предпочтение. Для каждой задачи этот выбор должен делаться лицом, принимающим решение.

СПИСОК ИСПОЛЬЗОВАННЫХ ИСТОЧНИКОВ

1 **Зайченко, Ю. П.** Исследование операций. Изд. дом «Слово». – Киев, 2003. – 688 с.

2 **Макаров, И. М.** Теория выбора и принятия решений: Учебное пособие / И. М. Макаров, Т. М. Виноградская, А. А. Рубчинский, В. Б. Соколов. –М. : Наука, 1982.– 210 с.

3 **Волков, И. К.** Исследование операций / И. К. Волков, Е. А. Загоруйко: под ред. Зарубин В. С., Крищенко А. П. – М. : Изд-во МГТУ им. Н. Э. Баумана, 2000. – 435 с.

4 **Де Гроот, М.** Оптимальные статистические решения. – М. : Мир, 1974. – 492 с.

5 **Майзер, Х.** Исследование операций: учебник в 2-х томах. / Майзер Х., Эйджин Н., Тролл Р. и др. – М. : Изд-во Мир, 1981.

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В. М. Жеребцов

Көпкритерийлі оптималдау есептерді мінсіз нүкте әдісімен шешу

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Жезқазған университеті, Жезқазған қ.
2015 ж. 25.05. баспаға түсті

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Solving the problems of multi-criterion optimization with ideal point method

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Мақалада көпкритерийлі оптималдау есептерді мінсіз нүкте әдісімен шешу методологиясы қарастырылған. Мінсіз нүкте әдісін іске асыру ерекшелігі нақты шарттарды ескере отырып, практикалық мысалдармен Парето шекарасының тұрақтануы, утопия нүктелерінің координаталарын, мінсіз нүкте координаталарын анықтау көрсетілген.

In the article the methodology of solving multi-criterion optimization problems with ideal point method is discussed. The features of the realization of ideal point method are considered through examples, where depend on particular conditions the establishment of the Pareto frontier, the coordinates of the utopia, and identification an ideal point coordinates are shown.

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*ANOMALOUS INCREASE OF APPARENT MASS IN A SILO DUE TO PERCOLATION**

The apparent mass measurement at the bottom of a granular pile confined in a vertical tube decreases for denser granular packing. In this letter, we report that the denser granular packing comprising of two different diameters of granules augment the apparent mass instead. This anomalous behavior occurs when small granules are stacked on the large ones. In the case of anomalous increase, a percolation effect is found and correlated with the augment of apparent mass at the bottom of granular column. Finally, the results are qualitatively explained by Janssen model.

Keywords: a granular pile, denser granular packing, Janssen model.

INTRODUCTION

Granular materials are ubiquitous and play an important role in many industries such as pharmaceutical, chemical, food etc, [1–3]. These materials exhibit complex and exceptional properties, which resemble sometimes that of the liquid and sometimes that of solid. When a silo is filled with a certain mass of granular materials for instance glass beads the mean pressure at the bottom is a linear function of height, this behavior is similar to fluid confined in a container. After a critical height λ, the top weight is screened by the side walls. The force felt at the base of container, known as apparent mass, is only a fraction of total filled mass. This behavior of granular material was described and modeled by Janssen [4]. Since then, many experiments have been carried out under various conditions to investigate the pressure profile at the base of silo [5– 11]. It is worthy of note that Clement group by using a robust experimental approach have checked Janssen law against the theory of incipient failure and the oriented stress linearity (OSL) model [7]. The conclusion was in favor of OSL model.

Previous efforts have mainly concentrated on monodisperse granular materials. However, few attempts involved with granular layers with different diameters in a silo were performed, although the kind of research has many applications in engineering and geophysics [12]. In this letter, we report the influence of layered structure on the apparent mass from a new perspective to investigate the silo problem. An anomalous increase of apparent mass is observed, and its mechanism is found to be the percolation effect. We use Janssen model to qualitatively explain the phenomenon.

Experimental set-up. The experimental set-up is depicted in figure 1. Granules with mass M are poured into a vertical cylinder with internal diameter D = 46.3 mm and the bottom of the cylinder is formed by the horizontal top surface of a piston. The design avoids the leakage of grains and the piston does not touch the cylinder wall during its motion. Consequently, the average pressure is entirely transmitted to the pressure sensor. In this experiment we use non-cohesive, dry and mono disperse glass beads with density 2.5 g/cm^3 and diameters d = 2 mm, 4mm and d =10.5 mm.

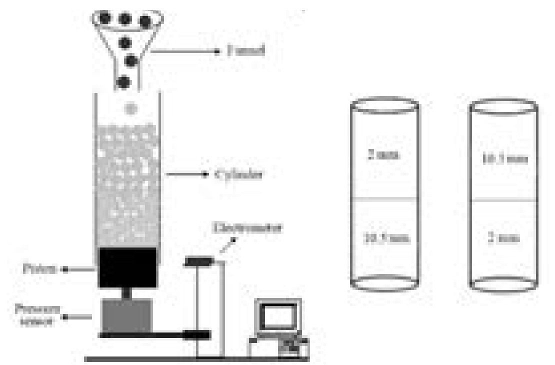

Figure 1 – Left sketch shows the experimental set up. Right sketch depicts the top and bottom positions of beads in a cylinder.

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Measurement procedure. These granules are filled in the container by a funnel placed on the top. Then the piston is allowed to descend a total distance of 20 mm at a slow velocity (0.02 mm/s). So friction force between the granules and the confining wall is fully mobilized, and a maximum percolation is achieved. Here we take 500 data points to measure the apparent mass M_a .To assure the reproducibility and also reduce the error the experiment is repeated 5 times.

In order to construct layered structure, the cylinder is filled with 2 mm beads up to 450g at intervals of every 50g. Then 10.5 mm beads are stacked on by the same way. This configuration is represented by 2 – 10.5 mm. The reverse arrangement is represented by 10.5 – 2 mm. The first and last digit shows the bottom and top position of beads respectively. Both configurations are illustrated by the right sketch of figure. 1. In the case of dual layers 2 – 10.5 mm the packing fraction was found to be 0.576 ɣ 0.002 while it is 0.605 ɣ 0.009 for 10.5 – 2 mm configuration. The difference in packing fraction is attributed to percolation in which small beads can penetrate into the gaps of larger ones.

MAIN PART

In previous experiments the pouring in a silo was made once. However, in our experiment the construction of layers requires that pouring must be done in intervals. Therefore, we need to investigate whether the apparent mass is affected by filling in intervals. The apparent mass plotted as a function of filling mass for d = 2 mm and d = 4 mm glass beads is shown in the inset of figure 2. It indicates that these saturation curves are similar; either the silo is filled with or without intervals. Since the apparent mass is independent of interval filling method, dual-layer packing are prepared and the variations in apparent mass for different configurations are investigated.

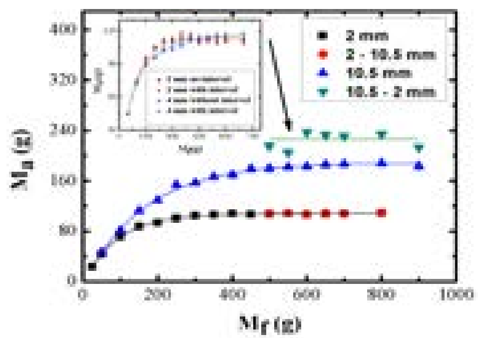

Figure 2 – Apparent mass as a function of filling mass in different cases

Each curve in figure 2 corresponds to exponential fit. (■,●) Indicate data measured for d = 2 mm and dual layers 2–10.5 mm (bottom and top position of beads) respectively, both curves overlap. (▲,▼) Show 10.5 mm and dual layers 10.5 – 2 mm respectively. Note a discontinuity shown in 10.5 – 2 mm curve is indicated by an arrow, also here M_a is higher than the others.

Figure 2 displays the curves of apparent mass as a function of filling mass for 2 mm, 10.5 mm, and dual-layer structures. It is shown that for 2mm, and 2 – 10.5 mm cases the curves overlap with each other but for 10.5 mm and 10.5 – 2 mm arrangements the curves branch off and a discontinuity indicated by an arrow is observed. The main finding is that the apparent mass for the case of 10.5 – 2 mm is not only higher than the 2 – 10.5 mm but also than the 10.5 mm. It is worthy of note that in 10.5 - 2 mm configuration the packing fraction is 0.605 ɣ 0.009 whereas for 2 – 10.5 mm the packing fraction is found to be 0.576 ɣ 0.002. Why the largest value of apparent mass is measured in the case of stacking 2 mm of beads on the top of larger beads? Although it is well known that a denser packing of grains makes the apparent mass decrease [1, 13]. In order to interpret this seemingly contradiction we use Janssen model [4]. The model describes that the weight measured at the bottom of granular column does not increase indefinitely with the filling mass, but saturates exponentially, thus implying a redirecting of vertical stresses, that is, to horizontal direction. The mass measured at the bottom of cylinder, known as apparent mass M_a , is only a part of filled mass and the rest is screened out by the side wall. The relationship between the filling mass M_f and the apparent mass M_a is shown as follows

$$M_a = M_s\left(1 - e^{-M_f/M_s}\right) \quad (1)$$

where

$$M_s = \rho\pi (D/2)^3/(2\mu K) \quad (2)$$

M_s is saturation mass, ρ is the density of the material, μ is the coefficient of friction between grains and wall, K is a redirection parameter. From Janssen law the difference of apparent mass depicted in figure 2 for 2 mm and 10.5 mm can be ascertained given same filling mass. It is attributed to the explanation that with the increase in granular diameter the redirecting of vertical stresses is weakened and more stress reach at the bottom of cylinder, resulting in higher apparent mass. Hence the stress saturation curve of 10.5 mm is higher than the 2 mm. For the 2 – 10.5 mm configuration it can be noted that the presence of 2 mm beads with the filling mass of 450 g in the lower region of the silo has already attained a saturation state. Therefore, any increase of weight, even 10.5 mm granules on its top does not vary the apparent mass because the top weight is

screened by the walls of the container in accordance with Janssen model, causing overlap of data curves in cases of 2 mm and 2 – 10.5 mm. However, the presence of larger beads 10.5 mm at the lower region of container, and pouring of 2 mm granules on them results in percolation. Because the size of small beads is less than the gaps formed by the large beads, they can sieve through the gaps and most of small beads accumulate at the bottom of the container. It appears that due to the percolation the apparent mass increases.

In order to further demonstrate that the percolation effect is correlated with the augment of the apparent mass, we investigate the effect of percolation on apparent mass separately. In the investigation, each layer of granules has same mass. For instance, the filling mass of 50 g means that firstly 25 g of 10.5 mm beads are poured in a silo, and then 2 mm beads with equal mass are poured on it. Similarly for the filling mass of 100 g, grains of 10.5 and 2 mm each 50 g are poured. In next trial a piece of paper with negligible mass is inserted at the interface of two layers to prevent the percolation in every case, while the construction process is same as mentioned above. In figure 3 the circles represent the occurrence of percolation and the squares indicate the absence of percolation. It is clearly illustrated in figure. 3 that the apparent mass with percolation display higher value than that without percolation. According to Janssen model the lower region of the silo exhibits hydrostatic behavior, due to percolation of smaller beads into the gaps of larger ones more mass is accumulated in that region, so the apparent mass in the case of percolation is augmented. Thus it is clearly demonstrated that the percolation effect increases the apparent mass at the bottom of silo.

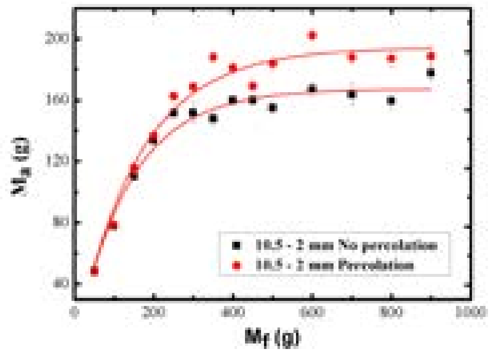

Figure 3 – The Effect of percolation on apparent mass

● indicates the percolation case, realized by stacking 10.5 mm beads at the bottom and 2mm on the top, each bead has same filling mass. ■ indicates the case without percolation prevented by inserting a piece of paper at the interface of two layers of 10.5 mm and 2 mm beads. Note that percolation effect causes higher apparent mass.

It may be attributed to the reason that the force chains among the grains transfer the weight to the confining wall rather than to the base, but force chains are greatly perturbed due to percolation. Hence part of weight is not deflected towards silo wall but directly to the base. Consequently the Ma exhibits higher values in the case of percolation compared to the case without percolation.

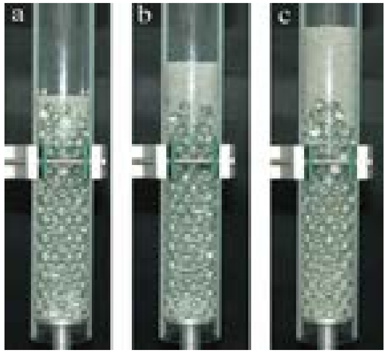

Figure 4 – Photographs showing percolation of small beads into the gaps of large ones

Furthermore, in order to clearly illustrate the effect we present the pictures of percolation. The photographs shown in figure 4 depict graphically the percolation for dual-layer configuration, they are taken after the steady state when the piston stopped moving. The pictures *a*, *b* and *c* in figure 4 illustrate that on the lower layer consisting of 10.5 mm beads with the filling mass of 450 g, then 50 g, 100 g, and 200 g of 2 mm beads are poured respectively. It can be observed that during a slow descent of the column the small beads percolates progressively into the gaps available among the large beads, and some of them accumulate at the lower region of cylinder.

CONCLUSION

In conclusion, we report the variation of apparent mass due to different granular configurations, which is realized by stacking beads in order. Present work indicates the relationship between the denser packing comprising of two different diameters of beads and the variations of the apparent mass. The continuous percolation of small beads to the gaps formed by the larger ones augments the apparent mass in a silo. In conclusion, the denser granular packing causes the increase of apparent mass rather than the decrease as expected before. This study reveals that the structure of dual layers (large-bottom, small-top) can result in more stresses toward the base than monodisperse materials and this may be helpful in comprehension of unexpected silo failure.

REFERENCES

1 **Vanel, L.** Pressure screening and fluctuations at the bottom of a granular column / L. Vanel and E. Clement // Eur. Phys. J. B 11. – 1999. – P. 525-533.

2 **De Gennes, P. G.** Granular matter: a tentative view // Rev. Mod. Phys. 71, S374. – 1999.

3 **Jaeger, H. M.** Granular solids, liquids and gases / H. M. Jaeger, S. R. Nagel, and R. P. Behringer // Rev. Mod. Phys., Vol. 68, No. 4. – 1996. – P. 1259-1273.

4 **Janssen, H. A.** Versuche ber getreidedruck in silozellen / H. A. Janssen and Z. Vereins // Dtsch. Eng. 39: 1045. – 1895.

5 **Vanel, L.** Experimental tests of construction history on stress distributions under sandpiles / L. Vanel, D. Howell, D. Clark, R. P. Behringer, and E. Clément // Phys. Rev. E. 60. R5040. – 1999.

6 **Vanel, L.** Stresses in silos : Comparison between theoretical models and new experiments / L. Vanel, P. Claudin, J.-P. Bouchaud, M. E. Cates, E. Clément, and J. P. Wittmer // Phys. Rev. Lett. 84,1439. – 2000.

7 **Wittmer, J. P.** An explanation for the central stress minimum in sand piles / J. P. Wittmer, P. Claudin, M. E. Cates, J. P. Bouchaud // Nature 382. – 1996. – P. 336-338.

8 **Liu, C. H.** Force fluctuations in bead packs / C. H. Liu, S. R. Nagel, D. A. Schecter, S. N. Coppersmith, S. Majmudar, O. Narayan, and T. A. Witten // Science 269. (5223): 513-5. – 1995.

9 **Bertho, Y.** Dynamical Janssen effect on granular packing with moving walls / Y. Bertho, F. Giorgiutti-Dauphiné, J. P. Hulin // Phys. Rev. Lett. 90(14): 144301. – 2003.

10 **Ovarlez, G.** Overshoot effect in the Janssen granular column: a crucial test for granular mechanics / G. Ovarlez, C. Fond, E. Clément // Phys. Rev. E.67 (6 Pt 1): 060302. – 2003.

11 **Claudin, P.** Models of stress fluctuations in granular media / P. Claudin, J.-P. Bouchaud, M. E. Cates, and J. P. Wittmer // Phys. Rev. E. 57, 4441. – 1998.

12 **Aste, T.** Stress transmission in granular matter / T. Aste, T. Di Matteo, and E. Galleani d'Agliano // Journal of Physics: Condensed Matter, 14. – 2002. – P. 2391-2402.

13 **Mehta, A.** Granular Physics / Anita Mehta. Cambridge University press. – Cambridge. – 2007. – 247 p.

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Цилиндрдегі іркілу нәтижесінде рұқсат етілген массаның аномальды артуы

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Аномальное увеличение допустимой массы в цилиндре из-за просачивания

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Едәуір тығызырақ түйіршіктелген қаптамада вертикаль орнатылған құбырда түйіршіктелген үйіндінің негізінде рұқсат етілген массалық өлшеу азаятындығы белгілі. Мақалада диаметрлері әр түрлі екі түйіршікті тығыздалған қаптама рұқсат етілген массаны арттыратындығын көрсетеміз. Бұл аномальды әрекет кішкентай түйіршіктер ірі түйіршіктерге біріккенде орын алады. Аномальды ұлғаю жағдайында іркілу эффектісі рұқсат етілген массаның өсімшесімен түйіршіктелген бағамның негізінде анықталады және түзетіледі. Нәтижелер Дженссен моделімен сапалы түсіндіріледі.

Известно, что допустимое массовое измерение у основания гранулированной груды, заключенной в вертикальной трубе, уменьшается для более плотной гранулированной упаковки. В статье показываем, что более плотное гранулированное упаковочное включение из двух различных диаметров гранул увеличивает допустимую массу. Это аномальное поведение происходит, когда маленькие гранулы сложены на большие. В случае аномального увеличения эффект просачивания находится и коррелируется с приращением допустимой массы у основания гранулированной колонки. Результаты качественно объяснены моделью Дженссена.

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STABLE LAWS AND THE NUMBER OF ORDINARY

Power total number of primes from the discharge of the decimal system is identified by the law of exponential growth with 14 fundamental physical constants. Model obtained on the parameters of the physical constants, proved less of the error and it gives more accurate predictions of the relative power of the set of prime numbers.

The maximum absolute error of power (the number of primes), the traditional number is three times higher than suggested by us complete a number of prime numbers. Therefore, the traditional number 2, 3, 5, 7, ... is only a special case.

The transformation it was a rough rounded, leading to false identification of physics-mathematical regularities of different series of prime numbers.

Model derived from physical constants, proved more accurate than the relative accuracy, and it gives more accurate predictions of the relative power of the set of prime numbers with increasing discharge the decimal number system.

Keywords: primes, total number, physical constants, the relationship.

INTRODUCTION

Prime number – is a natural number $N = \{0, 1, 2, 3, 4, 5, 6, \ldots\}$ that has two positive divisors: one and itself.

There are several variants of distribution or a series of prime numbers (SPN):

1) finite number of critical primes $P = \{0, 1, 2\}$;

2) non-critical prime numbers $P = \{3, 5, 7, 11, 13, 17, \ldots\}$;

3) the traditional [1] number of primes $a(n) = \{2, 3, 5, 7, 11, 13, 17, \ldots\}$ with

ОБРАЗЦЫ ОФОРМЛЕНИЯ БИБЛИОГРАФИЙ:

ОПИСАНИЕ КНИГ

К-во авторов	Примеры
1	1 **Эльсгольц, Л. Э.** Дифференциальные уравнения и вариа-цион-ные исчисление: [учебник]. – М. : Наука, 1965. – 424 с. 2 **Фихтенгольц, Г. М.** Курс дифференциального и интеграль-ного исчисления: [учебник]. В 3-х томах. Т. 1. – 7-е изд. стер. – М. : Наука, 1970. – 607 с.
2 и более	1 **Луговая, Г. Д.** Функциональный анализ. Специальные кур-сы:[учебное пособие] / Г. Д. Луговая, А. Н. Шерстнев. – М. : ЛКИ, 2008. – 255 с. 2 **Канторович, Л. В.** Функциональный анализ: [учебник] / Л. В. Канторович, Г. П. Акилов. – 2-е изд., перераб. – М. : Наука, 1977. – 741 с. 3 **Виленкин, Н. Я.** Дифференциальные уравнения: [учебное пособие] / Н. Я. Виленкин, М. А. Доброхотова, А. Н. Сафо-нов. – М. : Просвещение, 1984. – 176 с.

ОПИСАНИЕ СТАТЬИ ИЗ НАУЧНОГО ЖУРНАЛА

К-во авторов	Примеры
1	1 **Рахимжанова, А. К.** О политике безопасности компьютер-ных сетей в корпоративных инфраструктурах // Вестник ПГУ. Серия физико-математическая. – 2013. – №2. – С. 98-103.
2 и более	1 **Зацепин, П. М.** Комплексная безопасность потребителей экс-плуатационных характеристик строений / П. М. Зацепин, Н. Н. Теодорович, А. И. Мохов // Промышленное и граждан-ское строительство. – 2009. – № 3. – С. 42.

ОПИСАНИЕ СТАТЬИ ИЗ СБОРНИКА НАУЧНЫХ ТРУДОВ КОНФЕРЕНЦИЙ

К-во авторов	Примеры
1	1 **Тургумбаев, М. Ж.** О коэффициентах двойных рядов Фурье по мультипликативным системам // Материалы III Республиканской научной конференции по теории приближения и вложения функциональных пространств. – Караганда, 1998. – С. 140-144.
2 и более	1 **Данилова, Н. Е.** Моделирование процессов в следящем приво-де с исполнительным двигателем постоянного тока при независи-мом возбуждении / Н. Е. Данилова, С. Н. Ниссенбаум // Инновации в образовательном процессе: сб. тр. науч.-практич. конф. – Чебоксары: ЧПИ (ф) МГОУ, 2013. – Вып. 11. – С. 158-160.

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