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EXPLORING ANGLE OF REPOSE: DESIGN, DEVELOPMENT AND COMPARATIVE ANALYSIS OFMEASUREMENT METHODS.

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ABSTRACT

Objective: The main objective of our study was to design, development and compare the present methodto measure angle of repose and novel developed apparatus for Angle of repose measurement of bulk solids such powders or granules.

Methods: Traditional method to measure angle of repose and apparatus-based angle of repose determination method.

Results: The novel apparatus is developed for measuring angle of repose of granules which showed easy, fast, accurate and precise results.

Conclusion: In field of pharmaceutical industry, the determination of angle of repose have limited set of techniques, do not have specific process and not shows accurate, precise results. To overcome the limitations of traditional method novel apparatus designed and developed which gives more promising option and for accurate, precise, reliable determination of Angle of repose.

INTRODUCTION:

In pharmaceutical manufacturing, granulation process is used to combine powdered particles to form relatively bigger ones called granules, which are used for commercial production of tablets and other dosage forms. Design, operation and quality assurance in many industrial processes involving granular material heavily rely on the ability to quantitatively determine the propensity of powders to flow, usually called flowability. Free flowing powders are usually sought because they are easier to handle and hence do not frequently cause difficulties on the plants.

There are many techniques to determine the flowability of powders like Angle of repose, Hausner's ratio, Carr's index. flow.

As defined by the US Pharmacopeia (USP), Angle of repose represents the consistent three-dimensional inclination, relative to the horizontal base, adopted by a cone-shaped accumulation of material formed using various methodologies. In other words it is the steepest angle or incline at which a pile of granular or bulk solid material remains stable without collapsing or flowing.Accurate measurement of this angle is fundamental for ensuring quality standards, optimizing product design, and refining industrial processes.

The development of methods for determination of AoR was intensively conducted from past whichis traditional method to measure AoR. Using this method at the time and the available assortment of excipients, relevant techniques for evaluation of this chrematistics was developed and extrudability optimums that are still used in development of semi solid dosage form. However, a significant expansion of excipient for pharmaceutical technology and improvement for analytical and technological methods makes it necessary to review and

validate the methods for determination of AoR for their use in modern dosage forms. The study aims to analyse the Comparision between existing method and novel developed apparatus for determining the parameter "Angle of repose", by using different granular preparations.

MATERIAL AND METHODS:

The samples of the different granules were selected as objects of the study.

Material for traditional method testing aluminium collapsible tube were taken from pharmaceutics lab whereas material like iron stand, fitting nob, holder plate, pressure applying tool from workshop of mechanical department and weighing balance DT600 from pharmaceutics department.

Material for traditional method involves a funnel, iron stand from pharmaceutical lab and lengthy calculation using existing formula.

The traditional method for determination of AoR have chances of human error while adjustment of height as well as measurement of radius of circle which is required for calculation and obtaining results. It should be considered that each two different persons will take the measurements and calculate AoR that means how much quantity of dosage form get extrudes whereas for newly developed instrument-based method should be considered to take results precisely and results were calculated and compared.

Traditional method: [7,8,9,10,11]

The most common method for determination of AoR is fixed funnel method. This method is usedin most of pharmaceutical labs to measure AoR and determine the flowability of bulk solids. This method is messy and time consuming. During the measurements using the fixed funnel method, the material is poured through a fixed funnel to form a cone. The tip of the funnel should be held close to the growing cone and slowly raised as the pile grows, to minimize the impact of falling particles. Material is stopped from pouring once the pile reaches a predetermined height or the base a predetermined. Rather than attempt to measure the angle of the resulting cone directly, divide the height by half the width of the base of the cone. The inverse tangent of this ratio is the angle of repose.

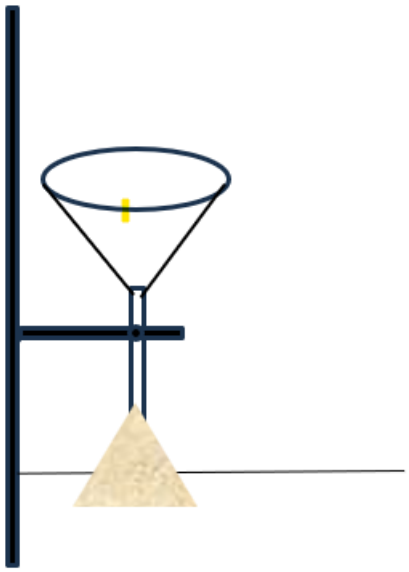

Fig No. 1: Traditional method for determination of Angle of repose

Limitations of previously used method: [11,12]

The previously used funnel method, has been a widely used method for determination of Angle of repose. However, it has certain limitations:

1.Subjectivity and human error.2.Time-consuming process.

3. Limited throughput.
4. Potential for sample contamination.5.Lack of automation.
6. Difficulty in detecting accurate AoR value.

Novel apparatus to measure extrudability:

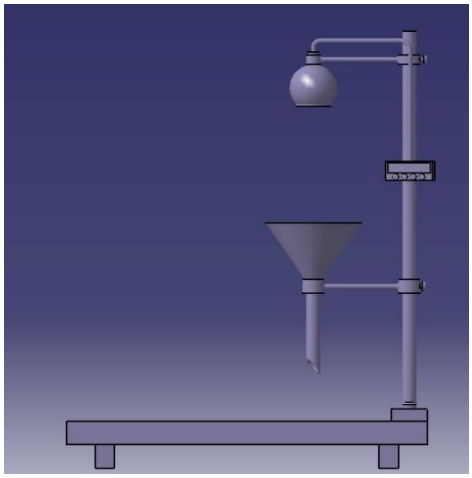

Fig No.2: Novel apparatus for determination of Angle of repose

Novel apparatus for determination of angle of repose:

The instrument made of materials like iron stand, fitting nob, base plate, funnel, web camera, digital display etc.

- **Iron stand:** this is provided to attach all tools on it and gives support to instrument. It is made of iron.
- **Base plate:** The material poured from top of funnel forms a pile on this base plate.
- **Funnel:** A funnel made up of glass is fixed to the iron stand which allows the material to flow from its top onto the base plate.
- **Display:** This is main part of instrument which has fixed position and it gives direct value of AoR.
- **Web camera:** Web camera fitted at the top of instrument helps to capture the radius of pile formed by material.

Method/ Process:

Step 1 : Take granular sample.
Step 2 : Pour it from glass funnel.
Step 3 : Stop pouring granular material once it touches the end of funnel

Step 4 : value of angle of repose with flowability for the sample will be displayed on display automatically.

Table 3: To rate flowability of bulk solids:

Description	Angle of Repose
Very Free flowing	25-30
Free flowing	31-35
Fair	36-40
Passable	41-45
Poor	46-55
Very Poor	56-65
Very very poor	>66

Sr. No.	Sample	Measurement of AOR by traditional method	Measurement of AOR by automatic apparatus	Accuracy (%)
1.	Acetyl salicylic ac id granules	26.4	26.6	99.24%
2.	Methyl cellulose	44	45	97.78%
3.	Hydroxy propyl m ethyl cellulose	39	39.2	99.49%
4.	Bentonite	44	44	100%
5.	Borax	39.2	39	100.5%
6.	Zinc oxide	45	45	100%
7.	Baking powder	36.2	36.4	99.45%

CONCLUSION:

In field of pharmaceutical industry, the determination of angle of repose for bulk solids has limited set of methods. Traditional method has been used from so long to measure AoR which varies the results for same dosage form and leads to non-precise results. So, for more promisingoption and for accurate, precise, reliable determination of AoR is by using “novel method for measurement of angle of repose.” It uses the various tools for suitable measuring of AoR and allows comprehensively evaluating flowability parameter.

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