Using the Teledyne Hanson Flodex™ to Determine Intrinsic Flowability of a Powdered Raw Material

TELEDYNE HANSON
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Application Note: H-AN-005

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Introduction

The Teledyne Hanson Flodex (Part Number 21-101-050) offers a simple technique to resolve uncertainty in raw powder flow. Raw materials in powder form will vary in a number of ways when coming from different suppliers. This variability affects the powder's overall ability to freely flow when loaded into manufacturing equipment, disrupting the speed and accuracy of the manufacturing process.

The Flodex's ability for determination of intrinsic flowability is based upon the ability of powder to fall freely through a hole in a disk. The Flodex includes a complete set of disks with incremented hole diameters, which are used to determine the powder flow index. By progressing through the set of disks, flowability of a powder can be indexed on an arbitrary scale of 4 to 40, so that the powder behavior can be anticipated. This simple process is fully compliant with USP <1174> and accounts for numerous parameters that affect powder flowability such as particle size and shape, unit surface, poured bulk density, tapped bulk density, porosity, settling, electrostatic charge and others.

The Flodex can also determine the angle of repose of granular material (an extrinsic property of powder) which can also can be used to correlate the material's flowability with the index provided in USP General Chapter - <1174> POWDER FLOW.[1]

Background

Dr. Albert Gioia of Dow Pharmaceutical Research Labs in Milan, Italy defines intrinsic flowability as "the powder's ability to flow evenly, by means of gravity and other forces, from the top to the bottom of the hopper and then on to the dosage, compaction and crushing chambers." His techniques used the Teledyne Hanson Flodex apparatus to determine a repeatable powder flowability classification, indexing the powder within an arbitrary scale of 4 to 34.

The flowability of the powdered materials used in a tablet formulation is an important consideration in the production of dosage forms. Powder with a high degree of flowability offers several advantages:

1. Minimizes air-pocket formation due to the smooth downward flow of the powder material.
2. Decreases variation in average-weight coefficient (and increases average weight) because the dosage chamber is accurately filled. This also results in even pressure during compression, thereby lessening wear on machine parts.

Image 1: Flodex apparatus with loading funnel, cylinder and disk set.

3. Increases the reproducibility of feed parameters, which results in consistent tablet hardness, friability, dissolution rates and blood levels.
4. Expels air well during compression, due to the powder's high degree of permeability, assisting in elimination of tablet flaws such as capping and splitting.
5. High production speeds are maintained due to the consistency and predictability of the manufacturing process.

Additionally, classification of a powder's flowability allows careful selection of the raw powder for the manufacturing process and results in two advantages:

1. Lubrication is simplified due to the limited surface area of the powder particles.
2. Yields are increased due to the reduced waste from electrostatic/pneumatic dust sprays of fine powders, which in turn keeps manufacturing facilities and machinery clean.

For additional information, refer to the Teledyne Hanson Flodex Operational Manual (21-101-000), which contains Technical Bulletin 99-380-001 - a reprint of the original article by Dr. Albert Gioia in Pharmaceutical Technology, Feb 1980.[2]

General Test Method for Powder Flow

The Teledyne Hanson Flodex can be used to perform two test methods described in USP General Chapter - <1174> POWDER FLOW:

1. Flow of a powder through a hole.
2. Angle of repose of a powder.

Test Method 1: Flow of a Powder Through a Hole

Experimental Setup

1. Assemble the Flodex according to the Flodex Operational Manual (21-101-000).
2. Use the funnel to load the cylinder to within ~1 cm of its top edge. For most powders, 50 g of sample will suffice, although powder density will affect the required weight. Wait 30 seconds after loading to allow the sample to settle and flocculate.
3. Begin the test with the 16 mm disk, which has a center hole diameter greater than six times the diameter of the powder particles. The diameter of the cylinder is greater than two times the diameter of the disk's opening. The powder should fall freely, leaving a cavity shaped like an upside-down, truncated cone as shown in Figure 2. Repeat the test three times with same disk to confirm that results are consistent.

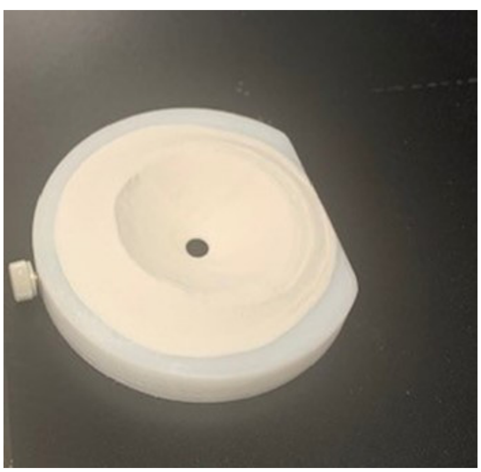

Image 2: Appearance of a successful powder flow test (part of cylinder removed for clarity).

Figure 2 shows a successful powder flow test. If the powder flocculates or the flow ends abruptly and fails to form a cylindrical cavity, the test is considered negative and should be repeated with a disk that has a hole one size greater than the disk which produced the negative result.

Image 3: Image of negative test.

The most common method for determining the rate through a hole is affected by three important experimental variables:

1. Type of container used to hold the powder.
2. The size and shape of the hole used.
3. The method of measuring the powder rate.

Because the measurement of the flow rate is critically dependent upon the method used, no general use scale for powder flow existed prior to the Flodex apparatus. Using the Flodex, the disk hole size (mm) is used as the arbitrary index for the powder material tested. The rate of flow is generally measured as the mass per time from any type of container (such as cylinders, funnels, hoppers, etc.). Measurement of the rate of flow can be made in discrete increments or a continuous amount.

For example, it can be measured as the time in seconds that it takes for 100 g of powder to pass through the disk hole (to the nearest tenth of a second) or the amount of powder passing through the hole in 10 seconds (to the nearest tenth of a gram).

The Flodex is based on the direct relationship between the radius of the hole and the internal friction coefficient of the powder (i.e., viscosity). This relationship can be demonstrated using the friction coefficient formula:

$$K \leq 490 \cdot rd$$

Where:

- K = dynes per square centimeter (or poise) and 490 is equal to half the acceleration of gravity or ½ g
- "r" is the radius in centimeters of the smallest hole in the disk that allows the powder to flow freely
- "d" is the tapped bulk density of the powder in g/mL

It can also be said that a powder having viscosity (or shearing strength) "K", and poured bulk density "d", is sure to fall freely if:

$$R \geq \frac{K}{490 \cdot d}$$

Where:

- "R" = radius of the hole in the disk
- "K" = dynes per square centimeter (or poise) and 490 is equal to ½ the acceleration of gravity or ½ g
- "d" = poured bulk density

For example, a powder having a poured bulk density of 0.5 g/mL, passing through a hole with a diameter not smaller than 24 mm (i.e., r = 1.2 cm), has a viscosity (or shearing strength) of K ≤294 poise or 29,400 cp. For a detailed explanation, refer to the Flodex Operation Manual (21-101-000), REV 3 or greater.[3]

Method 2: Angle of Repose

The Flodex apparatus can also be used to determine a powder's angle of repose. The typical method for determining the static angle of repose involves the choice of one of the following important experimental variables:

- The height of the funnel through which the powder passes may be fixed relative to the base, or the height may be increased as the pile forms.
- The base upon which the pile forms may be of a fixed diameter, or the diameter of the powder cone may be allowed to increase as the pile forms

Experimental Setup

1. Assemble the Flodex with only the funnel and base (no disk installed).
2. Perform a trial to find out the funnel height using 100 g of powder. The funnel height should be 2 to 4 cm above the cone formed from the powder flow.
3. Fix the funnel height, and then clean the funnel, base and surrounding area.
4. Allow ~100 g of powder sample to pass through the funnel and create a cone shaped pile of material on a flat surface. Measure the height and base of the material collected beneath the funnel. Use the measured values to calculate the angle of repose using the following equation:

$$\theta = \mathrm{Tan}^{-1}\frac{h}{r}$$

Where:

- "θ" = angle of repose
- "h" = height of pile
- "r" = radius of pile

Assessing the Flow Properties Using the Angle of Repose

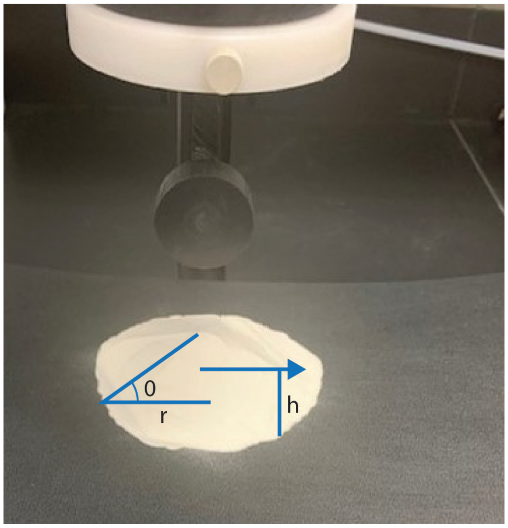

Image 4: Flodex apparatus being used to determine angle of repose. Measurement of the pile should be performed as indicated.

Once the angle of repose in degrees has been determined, it can then be correlated to a generally agreed upon USP <1174> "Flow Property" rating from "Excellent" to "Very Poor".

There may be some variation in the qualitative description of powder using the angle of repose, however a majority of pharmaceutical research literature tends to make consistent use of the USP <1174> classifications shown in Table 1. It should be noted that there are examples in the literature of formulations with an angle of repose in the range of 40° to 50° that were manufactured satisfactorily. When the angle of repose exceeds 50°, it is rarely acceptable for manufacturing purposes. Further information on this procedure is found in USP General Chapter - <1174> POWDER FLOW.

Flow Property	Angle of Repose (Degrees)
Excellent	25-30
Good	31-35
Fair - aid not needed	36-40
Passable - may hang up	41-45
Poor - must agitate, vibrate	46-55
Very poor	56-65

Table 1: UPS <1174> Properties and Corresponding Angles of Repose

References

1. United States Pharmacopeia (2022). General Chapter - *<1174> Powder Flow*. USP-NF. Rockville, MD: United States Pharmacopeia . (Available for download: https://doi.usp.org/USPNF/USPNF_M99885_01_01.html).
2. Gioia, Albert Dr. Technical Bulletin 99-380-001 - Intrinsic flowability: a new technology for powder-flowability classification. Reprinted from *Pharmaceutical Technology*, Feb. 1980. Hanson Research Corporation (Teledyne Hanson). (Included in the Flodex Operation Manual, Rev E, June 18, 2019).
3. Flodex Operation Manual (21-101-000), Rev E, June 18, 2019. Teledyne Hanson, Chatsworth, CA. (Available for download: https://www.teledynehanson.com/support/).

About Teledyne Hanson

Teledyne Hanson is a global technology company specializing in analytical test instruments for the pharmaceutical industry. Founded by the innovator of modern dissolution test technology, Teledyne Hanson helps ensure that the world's pharmaceuticals are pure, safe, and effective by manufacturing equipment that sets the global standard for quality, innovation, and long-term value. Teledyne Hanson instruments are used by scientists in over 75 countries worldwide and are supported by the industry's top customer service team. For more information, please visit teledynehanson.com.

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