**SAGMILLING.COM backup calculation** 20-Sep-01

Alex Doll

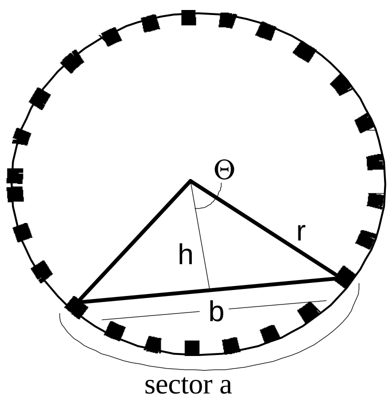
Mill Filling Calculation

**Purpose:** determine the volume percent loading of a grinding mill by counting the number of exposed shell lifters when the mill is stopped.

**Disclaimer:**

This calculation is included on the web site for reference and the author accepts no responsibility for its accuracy. People using it do so at their own risk!

**Procedure:**




**Nt** = number of lifters, total
**Ns** = number of lifters showing
**Nh** = number of lifters hidden (in chg)

**D** = inside diameter of mill
[measured inside the shell liners]

**r** = radius of mill (½ of diameter)
[measured inside the shell liners]

**Nt = Ns + Nh**

Angle subtended by Sector a (in radians) is determined as:

**Ð A = 2 p * Nh / Nt**

Angle Θ is ½ size of angle of Sector a      Q = p *** Nh / Nt**

Distance h is distance from top of charge to mill centre and is determined by:

**h = r *cos* Q**

Distance b is the length of the exposed surface of the charge (from shell to shell)

**b =** 2Ö **$r^2$ - $h^2$**

or **b = 2 (r * *sin* Q )**

Area of sector a is defined as half the angle in radians multiplied by the radius squared

http://www.gomath.com/geometry/seccircle.asp

**Area (a) = ½ $r^2$** * 2 Q

Area of Triangle is defined as half the height times the base

**Area (Triangle) = ½ b h**

Area of charge is the area of the Sector a less the area of Triangle

**Area (charge) = $r^2$ *** Q - **½ b h**

Expanding on the equation for area of charge,

**Area (charge) = $r^2$ *** Q - **½ b h**
**Area (charge) = $r^2$ *** Q - **½ (2r sin Q) * ( r cos Q)**
**Area (charge) = $r^2$ *** Q - **$r^2$ * ( sin Q) * (cos Q)**
**Area (charge) = $r^2$ * [** Q - **(sin Q ) * (cos Q ) ]**

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from Trig identities, ½sin(2x) = sin x cos x http://www.sisweb.com/math/trig/identities.htm

**Area (charge) = $r^2$ * [ Q - ½ ( sin 2 Q ) ]**

**Area (charge) = $r^2$ * [ p * Nh/Nt - ½sin (2p * Nh / Nt) ]**

The % volume of the charge is roughly equal to the % area of the charge in a cross section, assuming circular symmetry and negligible cone volumes at feed and discharge ends.

To get the mill percentage filling, divide the area of the charge by the total area of the mill

**%Filling = Area (charge) / Area (mill)**

Total area of the mill is simply: p $r^2$

Charge fraction **% Filling = $r^2$ * [ p * Nh/Nt - ½sin (2p * Nh / Nt) ]** / **p $r^2$**

Cancelling denominator

**% Filling = Nh / Nt - ½ (1 / p) * sin ( 2p * Nh / Nt)**

**Conclusion:**

The volume percentage filling of a grinding mill charge can be found by applying the following formula:

**% Filling = Nh / Nt - ½ (1 / p) * sin ( 2p * Nh / Nt)**

where: Nh- is the number of shell lifters hidden under the charge
Nt- is the total number of shell lifters in the mill

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**Example #1:**

Suppose during a crash stop of a 30' SAG mill with 48 rows of shell lifters, that between 28 and 29 rows of lifters are exposed.

| | | |
|---|---|---|
| **Nt =** | 48 | rows |
| **Ns =** | 28.5 | rows |
| **Nh =** | 19.5 | rows |

Volume of the charge = **31.8%**

**Example #2:**

Suppose after a grind out of a 30' SAG mill with 48 rows of shell lifters, that between 32 and 33 rows of lifters are exposed. Examination of the charge indicated that approximately 30% of the volume is still occupied with rocks, and balls occupy the remaining 70% of the volume.

| | | |
|---|---|---|
| **Nt =** | 48 | rows |
| **Ns =** | 32.5 | rows |
| **Nh =** | 15.5 | rows |

Volume of the charge = **18.0%**

Proportion of balls in the charge = 70%

Volume of balls in mill = **12.6%**