

# The Brazil Nut Effect

<https://www.youtube.com/watch?v=ktA9CjbvDRo>

Granular convection is a phenomenon where granular material subjected to shaking or vibration will exhibit circulation patterns similar to types of fluid convection.

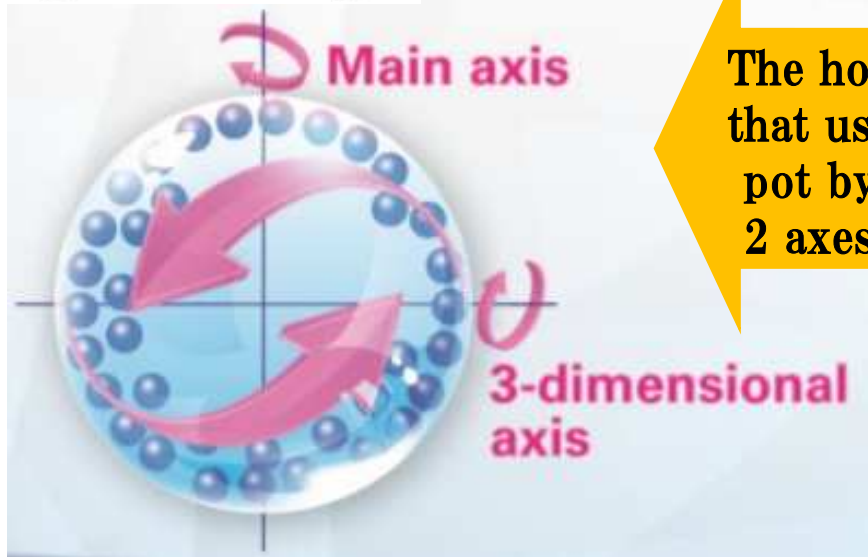
It is sometimes described as the Brazil nut effect when the largest particles end up on the surface of a granular material containing a mixture of variously sized objects.



# 3D Ball Mill



It coordinate the turn of two axes.  
The ball realizes the 3D campaign for cube in the pots inside.



The homogenize crush that used the whole pot by the turn of 2 axes.

(Reference) Conventional t

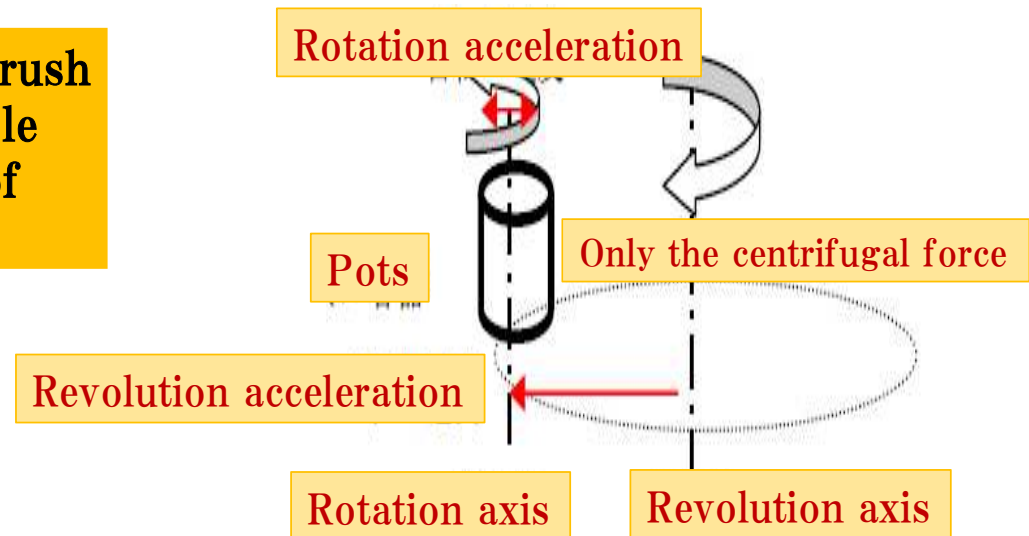


NAGAO SYSTEM

# Planetary Ball Mill

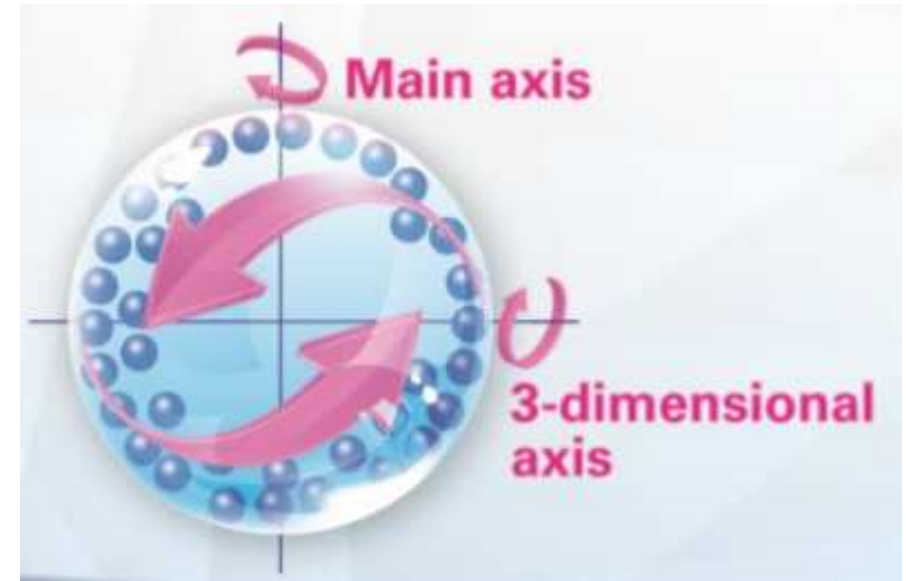
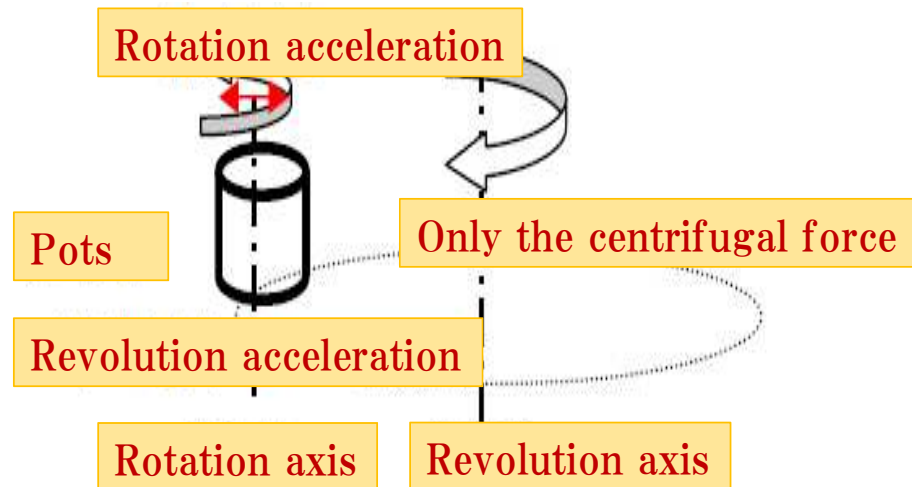
The crush that the whole homogenize is weak

The rotation direction and the revolution direction are the same planes.  
There is the advantage of the destructive power.  
However, there is the fault that the part which power does not act on in the pots produces.



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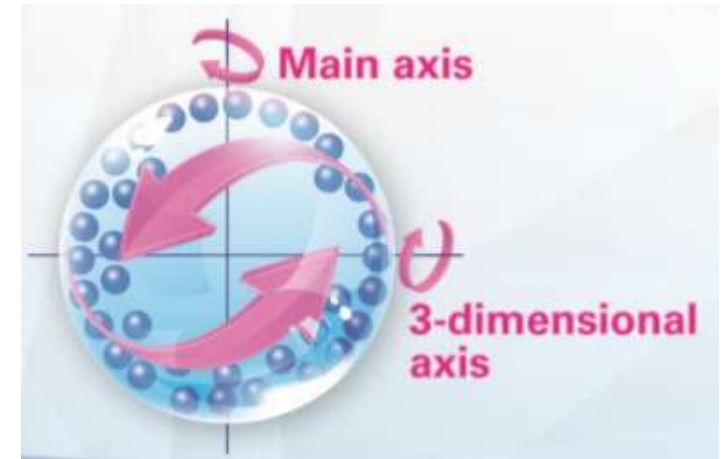
The fine powder of the 2D rotation goes to the bottom.

The 3D ball mill did not have the Brazil nut effect.

After All, The fine powder condensed.

Because, It is not affected by the gravity.

# *The Brazil nut effect did not occur to the 3D Ball Mill.*

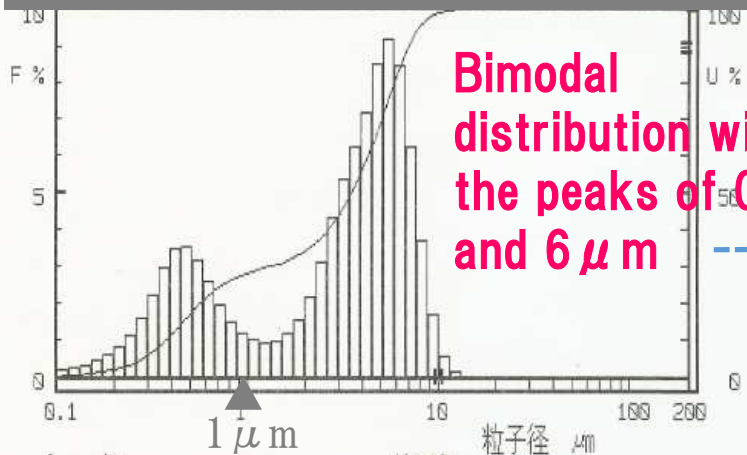


The sample pulverized by the Brazil nut effect goes to the bottom.

When the pulverized samples collect at the bottom, it is pushed on the ball for crushes and coheres.

The 3D ball mill did not have the Brazil nut effect. Because It is not affected by the gravity.

## Original particle size distribution



**Bimodal distribution with the peaks of 0.45 and 6 μm**

Comparison of particle size distribution after 3D ball milling with that after planetary ball-milling.

**Dry condition**

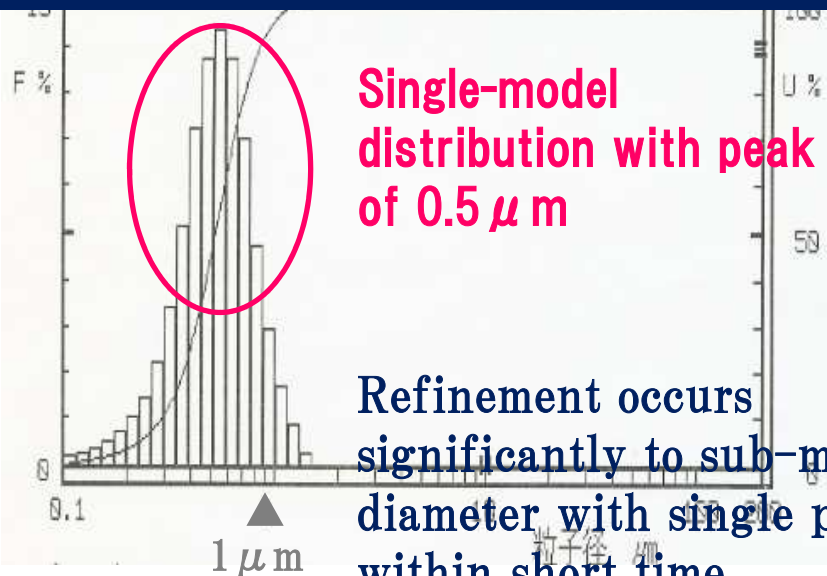
**Sample ⇒ Nickel oxide (NiO)**

Ordinate : Volume %

Abscissas : Particle diameter

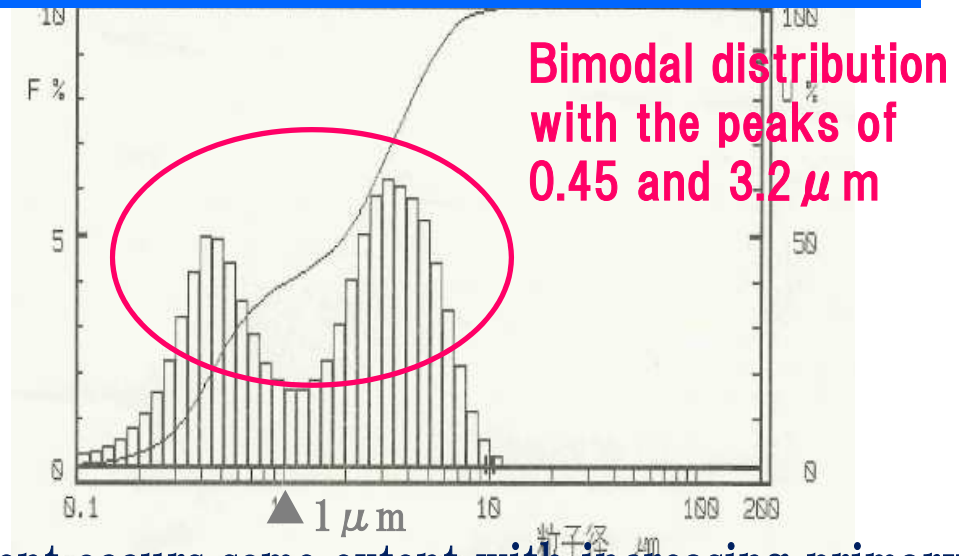
**30min Planetary Ball-Milling**

## 30min 3D Ball-Milling



**Single-modal distribution with peak of 0.5 μm**

**Refinement occurs significantly to sub-micron diameter with single peak within short time**



**Bimodal distribution with the peaks of 0.45 and 3.2 μm**

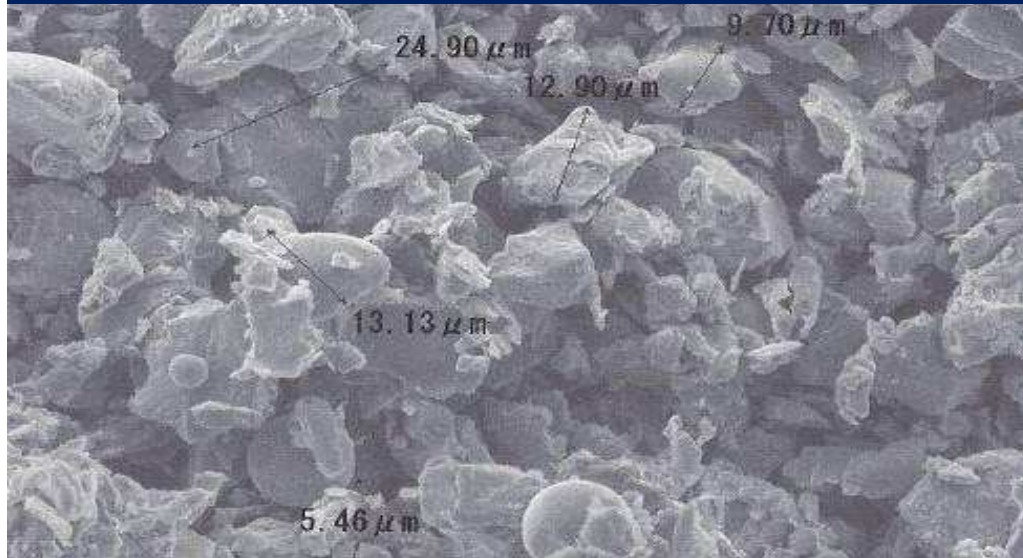
**Refinement occurs some extent with increasing primary peak height and decreasing secondary peak height accompanying peak shift to small diameter (6 ⇒ 3.2 μm)**

# Comparison of SEM image for material crushed by 3D ball-mill with that by planetary ball-mill

Wet process

Material  $\Rightarrow$  Fe-V-Al-Si Alloy

## 90min 3D Ball-Milling



Round and bulky shape of the particle by **strong frictional force.**

## 48h Planetary Ball-Milling



Sharp edge and bulky shape of the particle by **strong impact force.**

# Super points of 3D ball mill (compared to conventional one)



NAGAO SYSTEM

- ① Pots (sample container) of 3D ball mill is set at center of revolution (weight balancing of the pots are not required)
- ② Higher milling energy (potential) with small electric power (higher efficiency)
- ③ Lower opportunity to re-bind powder materials during dry operation.
- ④ Lower heat generation during operation.
- ⑤ We are equivalent to the material varying in the specific gravity. Homogenize mixture, blend kneading on fire, the dispersion are possible, too.