

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.



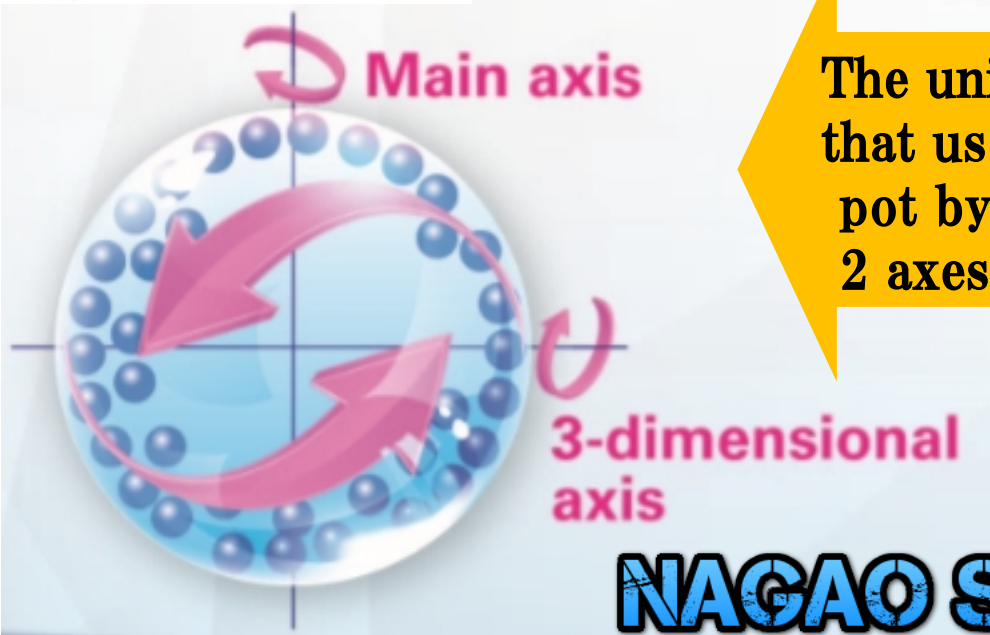
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3D Ball Mill(3D Reactor)



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

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

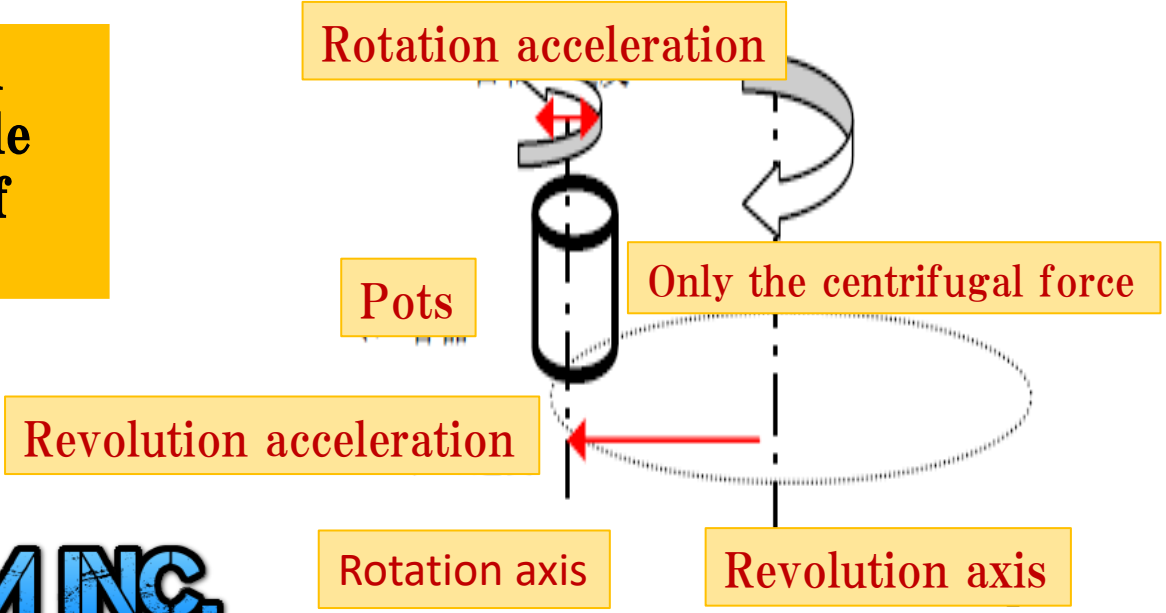


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(Reference) Conventional technique

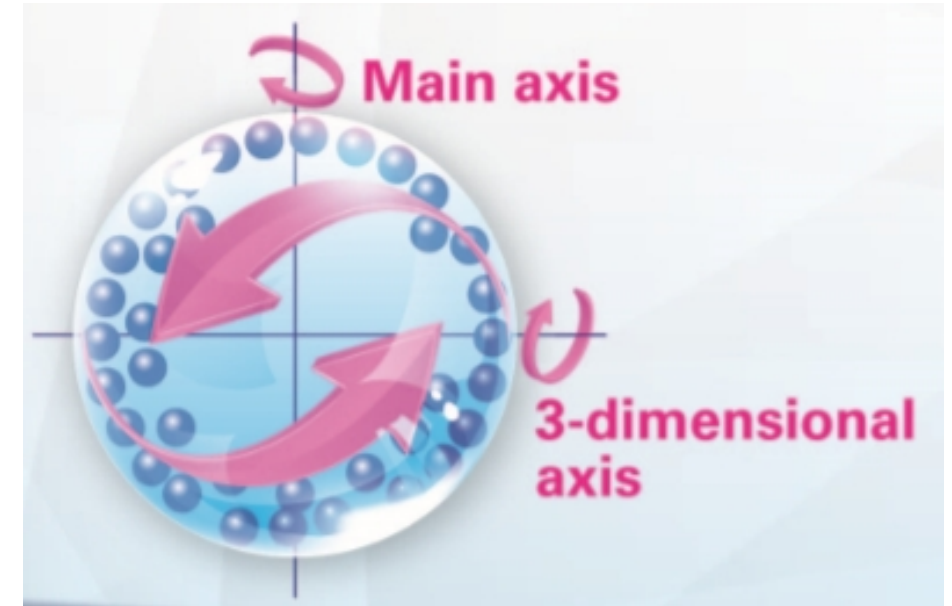
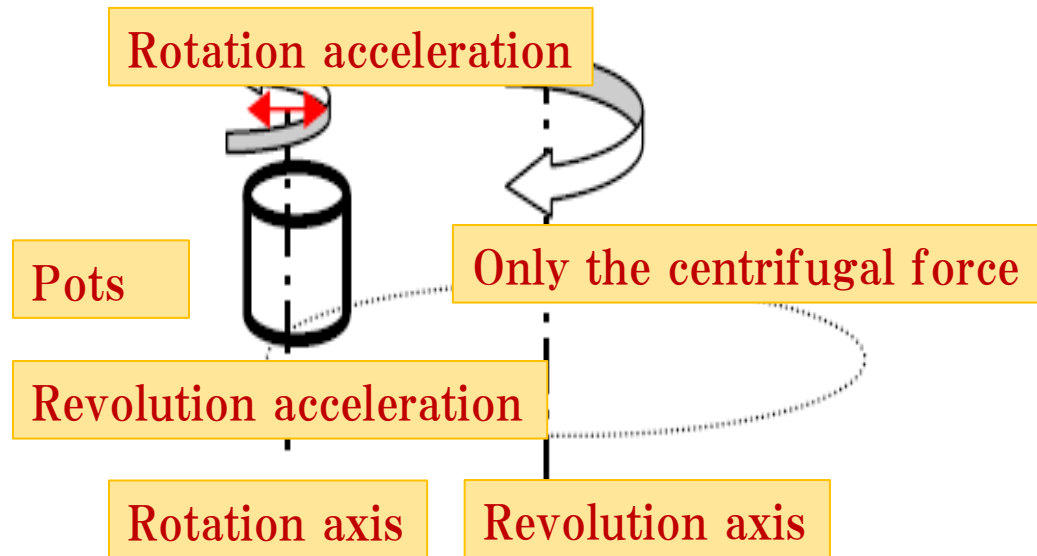
Planetary Ball Mill

The crush that the whole is uniform 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 motion goes to the bottom.

After All, The fine powder condensed.

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

Because, It is not affected by the gravity.

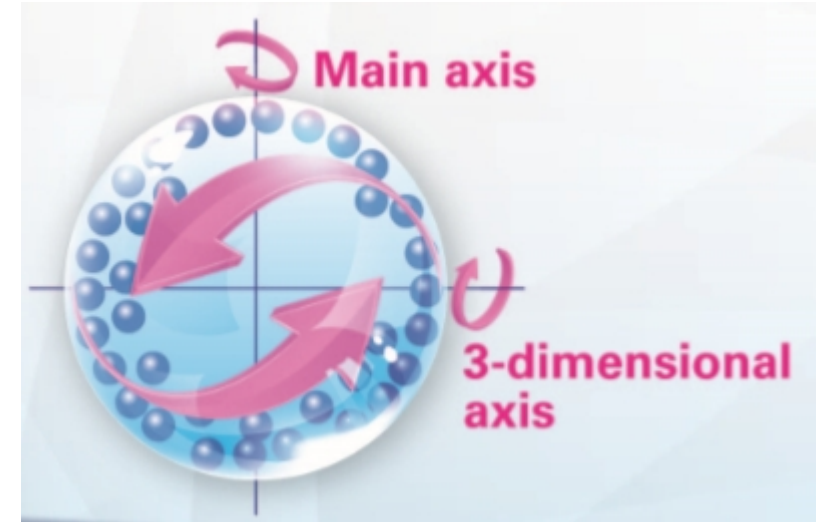
The Brazil nut effect did not occur to the 3D Ball Mill.



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.



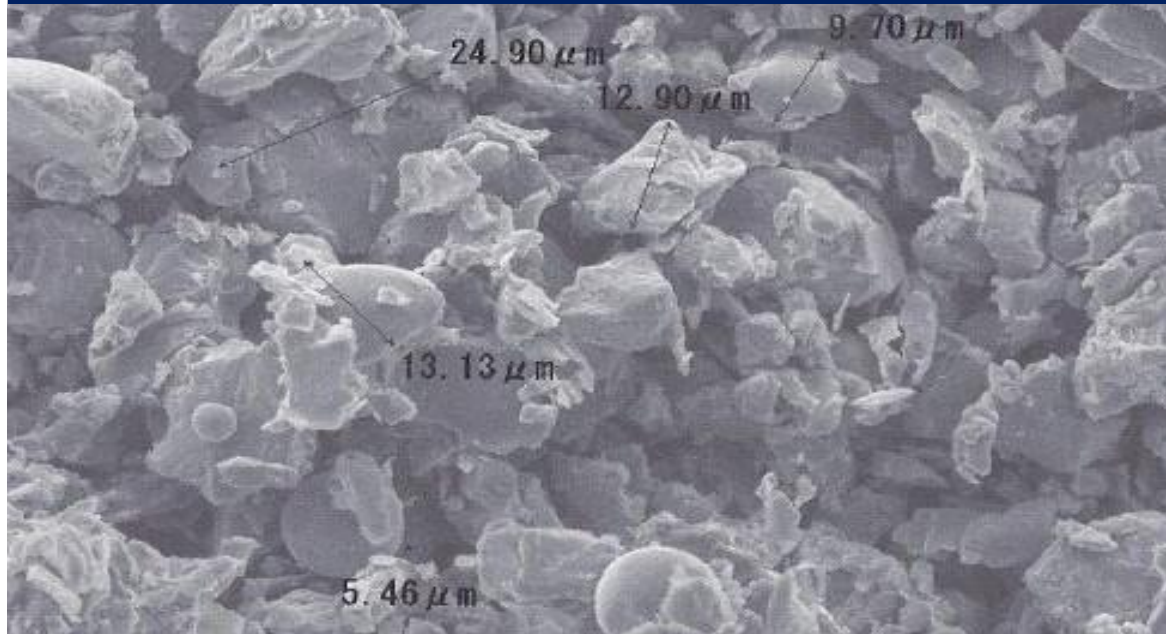
The 3D ball mill did not have the Brazil nut effect. Because It is not affected by the gravity.

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

Wet process

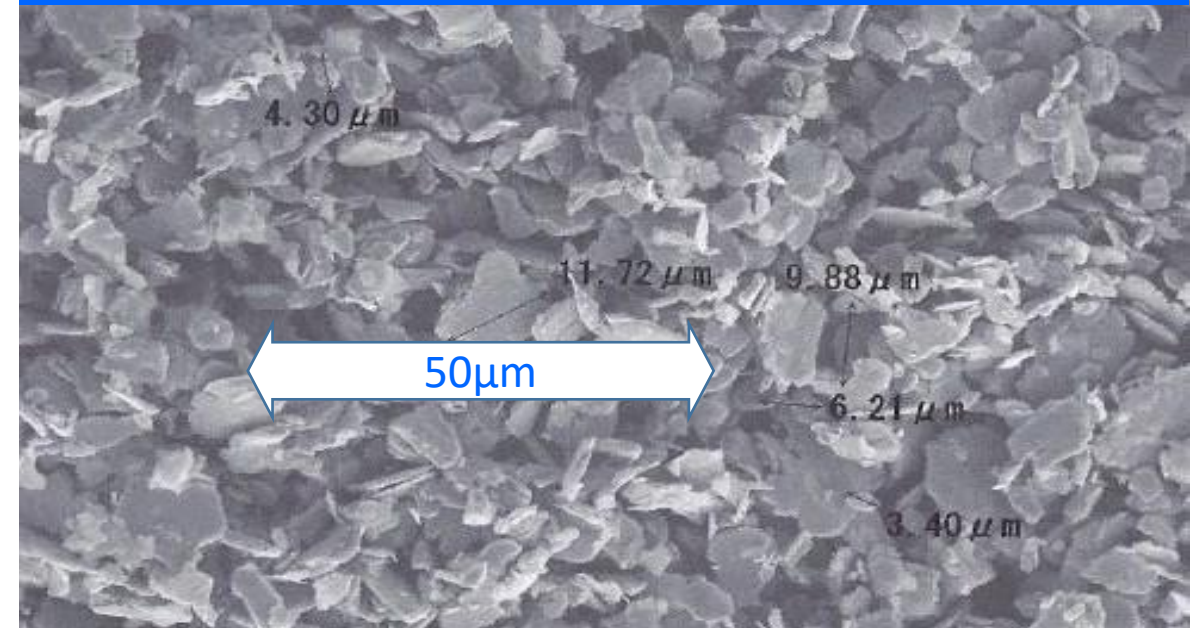
Material \Rightarrow Fe-V-Al-Si Alloy

90min 3D Ball-Milling



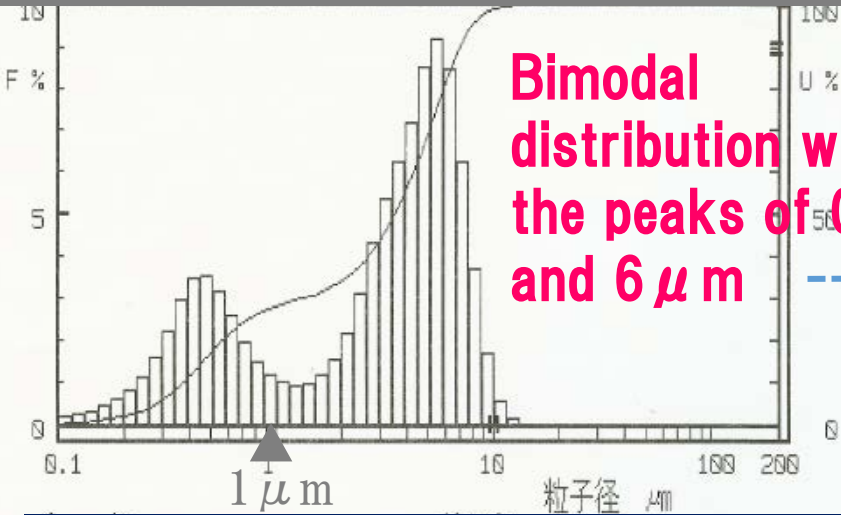
Round and bulky shape of the particle by **strong frictional force.**

48h Planetary Ball-Milling



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

Original particle size distribution



Bimodal distribution with the peaks of 0.45 and 6 μm

Dry condition

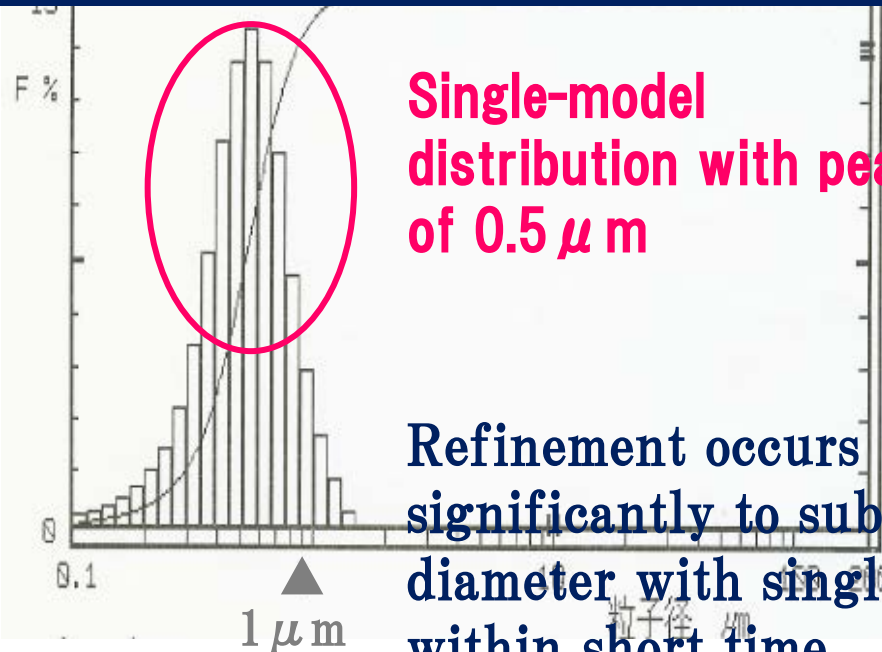
Sample ⇒ Nickel oxide (NiO)

Ordinate : Volume %

Abscissas : Particle diameter

30min Planetary Ball-Milling

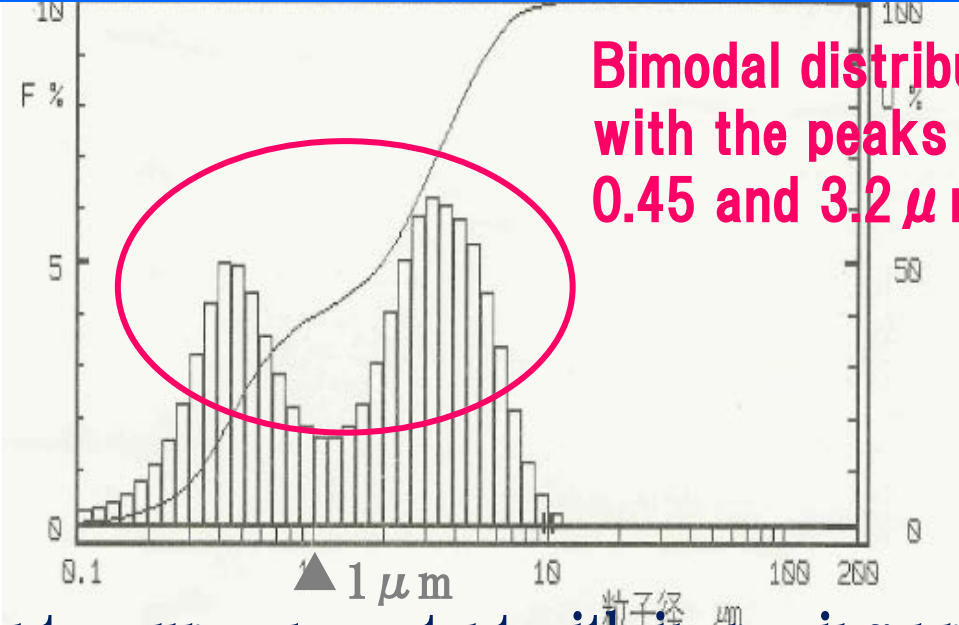
30min 3D Ball-Milling



Single-modal distribution with peak of 0.5 μm

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

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



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)

Superior points of 3D ball mill(3D Reactor) (compared to conventional one) **NAGAO SYSTEM INC.**

- ① Dry process pulverization without solidification
- ② Low thermogenesis with spherical motion
- ③ Uniform pulverization, mixing and dispersion
- ④ Non-criticality based on high-speed motion
- ⑤ Uniform mixing without propeller/blade
- ⑥ Utilizing friction force and achieved pulverization with maintaining particle form