

充分な粉碎,混合効果を可能とした3次元ボールミル(3次元リアクター)のご提案  
To provide the 3D ball mill(3D Reactor) provided with the  
sufficient pulverization and mixture effect.

July, 7, 2017

NAGAO SYSTEM INC.

**【Company Profile】** NAGAO SYSTEM INC. is a professional group that solves mixing, dispersion and milling, which was previously considered impossible by utilizing high-speed 3D motion of a patented 3D Ball Mill (3D Reactor). We are good at mainly small rotating research equipment. mm or less (organic / inorganic) materials can be finely pulverized, mixed and dispersed to nano & microns (dry & wet type possible).

Company Name (社名)	NAGAO SYSTEM INC.
Established (設立)	Oct. 1994
Location (所在地)	<ul style="list-style-type: none"> <li>• Head Office: Kawasaki</li> <li>• Exhibition Room : Kawasaki</li> <li>• Bangkok Office: Asok Bangkok</li> <li>• Ho Chi Minh Office</li> </ul>
Business Domain (事業領域)	Manufactures/Wholesale/Retail
Employees (従業員数)	3
Annual Sales (年間売上)	500,000 (US Dollar)

Products

- **(Middle Size) Separate type 2-axis 3D Ball Mill (3D Reactor)**
  - 3DB-210(Separate)
  - Container diameter Φ210mm
  - Maximum amount of processing 100g(ml) ~ 1,200g(ml)



- **(Small Size) Separate type 3D Ball Mil(3D Reactor)**  
**(Glove box insertion model)**
  - 3DB-80 (Separate )
  - Container diameter Φ80mm
  - Maximum amount of processing 2g(ml) ~ 100g(ml)

Unique mixing / milling machine

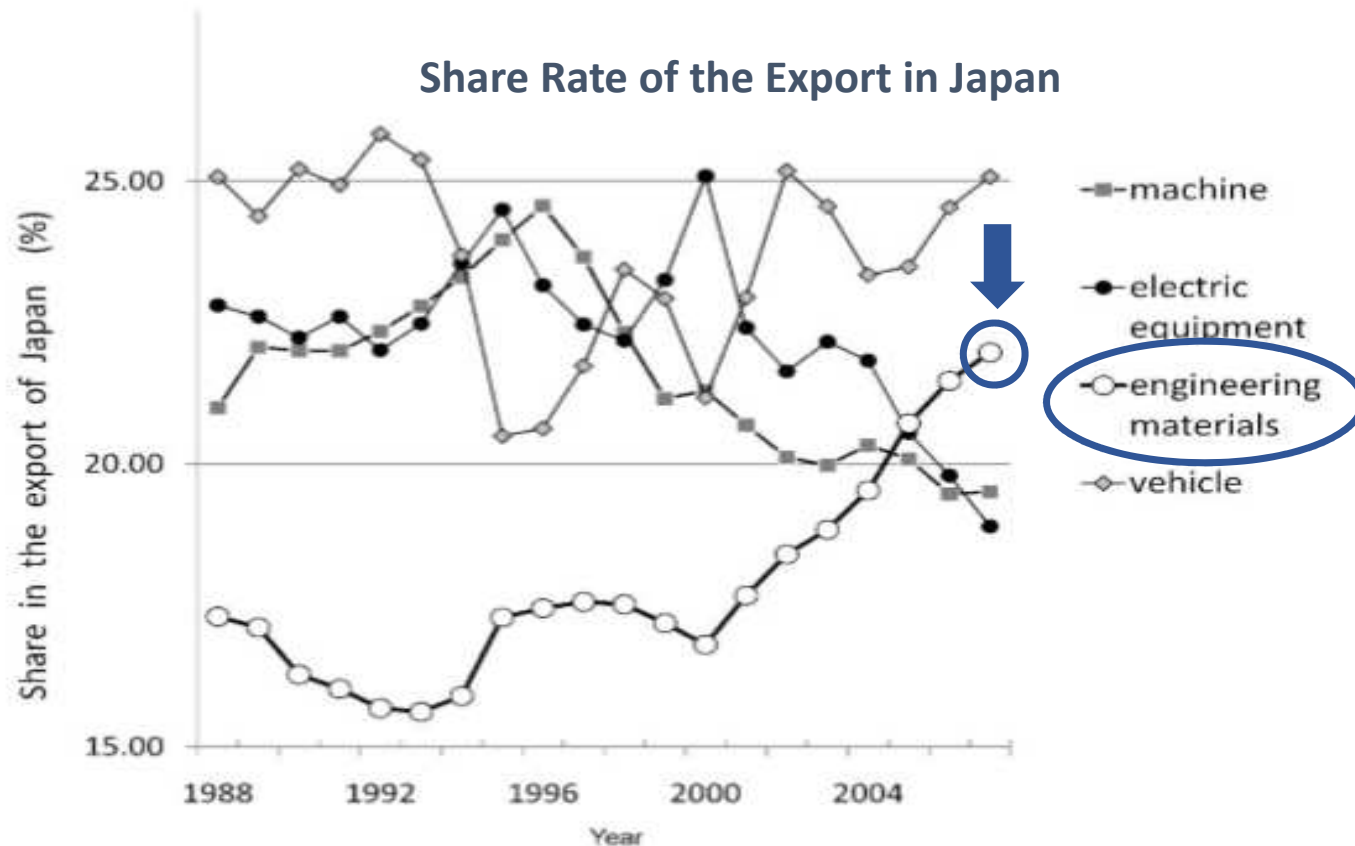
Contributing to development of research equipment such as 3D Ball Mill (3D Reactor)



## 【Business market】

Industrial material ratios increase of the export in JAPAN.

The overseas needs is very high now.



国立研究開発法人 物質・材料研究機構  
National Institute for Materials Science

3 Source:



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**【We've got a suggestion.】 We realize impossibility and done pulverization, mixture, dispersion by manufacturing development of the industrial materials conventionally and strengthen your products.**

### Products solution

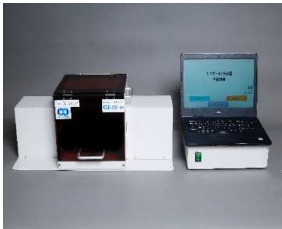
1



**3DB-210**

- (Middle Size) Separate type 2-axis 3D Ball Mill (3D Reactor)
- Container diameter  $\Phi 210\text{mm}$
- Maximum amount of processing 100g(ml) ~ 1,200g(ml)

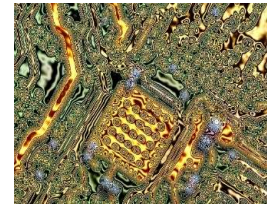
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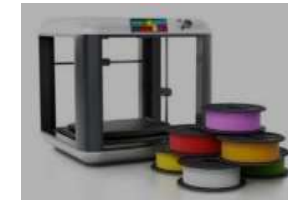
**3DB-80(PC)**

- (Small Size) Separate type 3D Ball Mil(3D Reactor) (Glove box insertion model)
- Container diameter  $\Phi 80\text{mm}$
- Maximum amount of processing 2g(ml) ~ 100g(ml)

### Application Scene



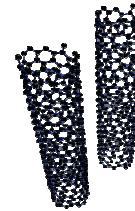
**Conductive pastes**



**3D printer modeling materials**



**Battery materials**



**CNT**



**Inks, Printer inks**



**Ag nanoparticles**



**Chemical materials**



**Pharmaceutical products**



**Cosmetics**

The best choice for research institutes, companies, and universities developing new materials using nano-sized and micron-sized fine particles.

## 【Background of increased demand for mixing】

Challenges in mixing and dispersing. Cohesion, fever, irregular, occur chronically. Impact on revenue.

Development of the industrial material/Development Issues 【Solution】

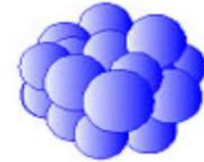
### Challenge

- After 2D motion pulverization and mixture generated fine particles cohere at the bottom.
- Highly focused impact force causes of thermogenesis.
- The problem is that particle sizes are not uniform after pulverization and mixture.
- With 2D motion mixing, unevenness is a problem.

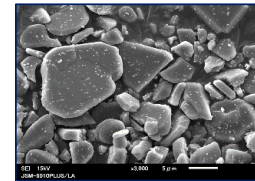


### We have a solution

- 3D Ball Mill(3D Reactor)
  - Realize non-cohesion
  - Single Peak Mixing, Milling achieved
  - Mix material of specific gravity and viscosity difference to highly homogeneous mixture



- After 2D motion pulverization and mixture generated fine particles cohere at the bottom.



- The problem is that particle sizes are not uniform after pulverization and mixture.



- Highly focused impact force causes of thermogenesis.



- With 2D motion mixing, unevenness is a problem.

sales

- Solidification, thermogenesis, and non-uniformity in pulverization; and unevenness in mixing often occur and affect sales profits.

cost

- The outbreak of irregular material cost and personnel expenses suppresses cost.

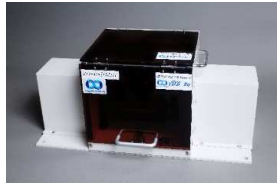
## 【Company solution】

It adopted 3D motion, and difficulty and done pulverization, mixture, dispersion were enabled conventionally.

### Products specifications

#### Characteristics

- Non criticality by high speed 3D motion
- High uniform mixing and dispersion without blades
- Unused blades are not affected by shear heat
- Reduced heat generation utilizing the entire container
- Mixing and dispersing without destroying the particle shape making use of frictional force



### Merit

- 1 **Solidification in 2D motion dry pulverization, mixture, and dispersion.**  
 ➤ **Solution:**  
 Achieving no solidification by high-speed 3D motion dry pulverization, mixture, and dispersion. .
- 2 **Thermogenesis problem in 2D motion pulverization, mixture, and dispersion.**  
 ➤ **Solution:**  
 Utilizing the entire inner area of the container promotes the dispersion of frictional heat and its generation. Effective with organic and inorganic substances.
- 3 **Uneven particle size in 2D motion pulverization, mixture, and dispersion.**  
 ➤ **Solution:**  
 High-speed 3D motion is a batch type mixture that makes use of frictional force. Because it always moves around inside the container, there is no time to solidify.
- 4 **Uneven 2D rotation mixing (because of only one axis)**  
 ➤ **Solution:**  
 Without blade. High-speed 3D motion makes it possible to use entire inner area of container efficiently. Low thermogenesis and uniform mixing can be achieved.

### End-users have the benefits

- There is almost no shear or impact heat.
- Highly homogeneous mixing, dispersion keeps the stability of the material.
- The specific gravity of metals, resins, etc., the mixing and dispersion with viscosity difference are possible.
- It can be used for organic matter and inorganic matter.





















### Sales agents have the benefits

- The smile curve product without the competition that our products acquired the patents.
- After sale, there are optional parts, repair.
- After sale, the relations with the customer last long.(stock business model)
- It may solve our products that the user of other brands was not able to come out.
- It can raise competition superiority than other companies.

# 【Merit : 2D Ball Mill VS 3D Ball Mill(3D Reactor)】

2D motion, there was a problem of the irregular by Dry pulverization, mixture, dispersion.

3D motion, there was no the irregular by Dry pulverization , mixture, dispersion

	Organic Matter Mixture - pulverization	Inorganic Matter Mixture pulverization	Influence of mixture and milling heat	Solution of the irregular	Mixing - Milling cohesion
2D Ball Mill (Competing products)	 	 	 	 	 
3D Ball Mill (3D Reactor) (Own Products)	 	 	 	 	 

## 【Comparison】

### 2D Ball Mill VS 3D Ball Mill (3D Reactor)

3D are better than 2D.

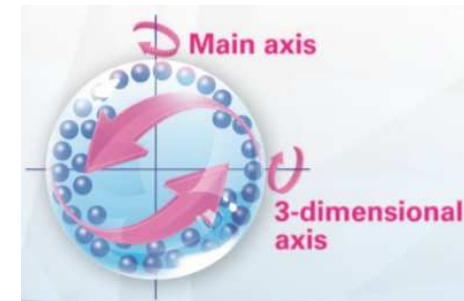
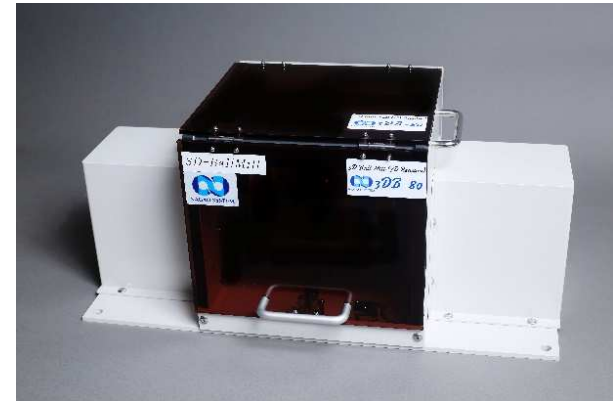
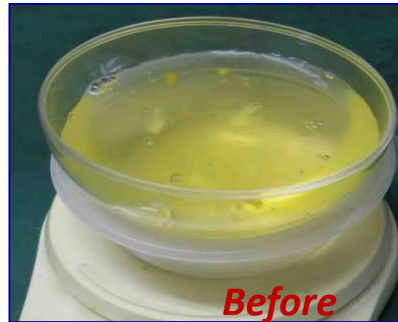
【Merit in details ①Organic Matter Mixture】

- High-speed 2D motion is one direction only.
- High-speed 3D motion realizes highly efficient motion by using the whole container.

Operating time (Mixture)=3min

2D Mixture ⇒ 3D Mixture

The white egg mixing



**2D Mixing**  
There are many irregular. Unevenness in mixing. Less volume.

**3D Mixing**  
There are not many irregular. No unevenness and uniform mixing. Having higher volume as a whole.



【Merit in details ①Organic Matter Mixture】

2D motion⇒ Sesame with low specific gravity moves outwardly Salt with high specific gravity moves inwardly.

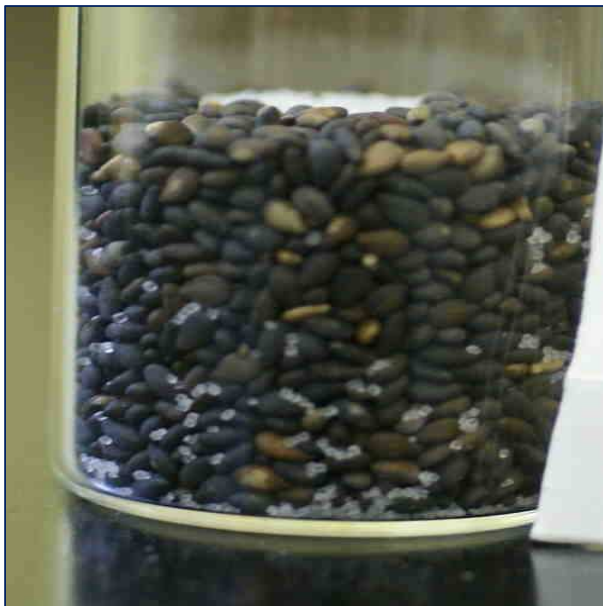
3D motion⇒Uniform mixing of whole content.

【Usually】

- Light sesame seeds go up.
- Heavy salt goes down.

Operating time  
(Dry Mixture「Sesame & Salt」)=2min

2D Ball Mill



- Light sesame outwards
- Heavy salt to the inside

3D Ball Mill (3D Reactor)



- Mix uniformly

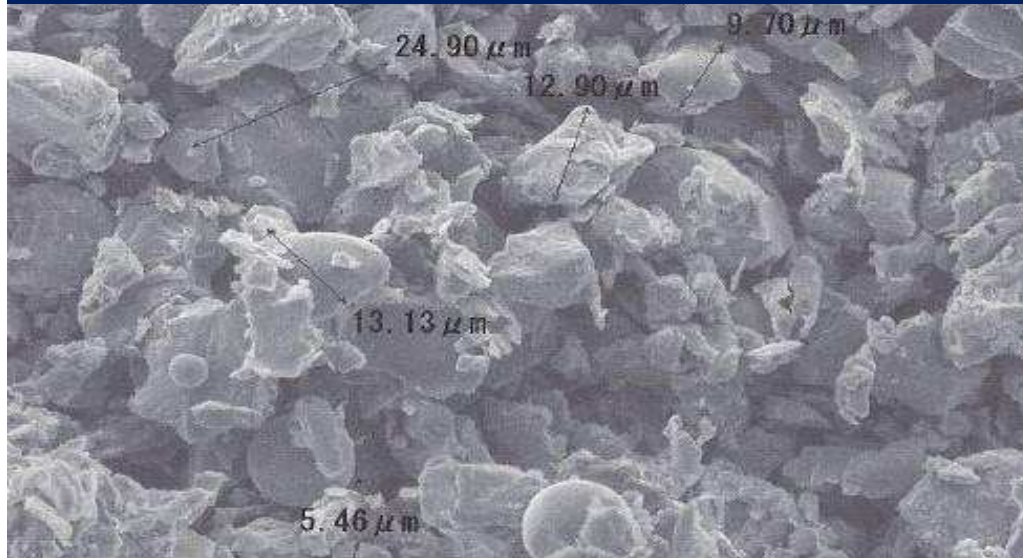
【Merit in details  
②Inorganic milling】

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.**

**【Merit in details ②Inorganic Matter Mixture】**

Confirmation of the ultra Fine bubble

To mix water with a machine.

- The 2D Ball Mill is no change.
- The 3D Ball Mill(3D Rector) is homogeneous, and it produces many quantity of Nano-bubbles in a liquid.

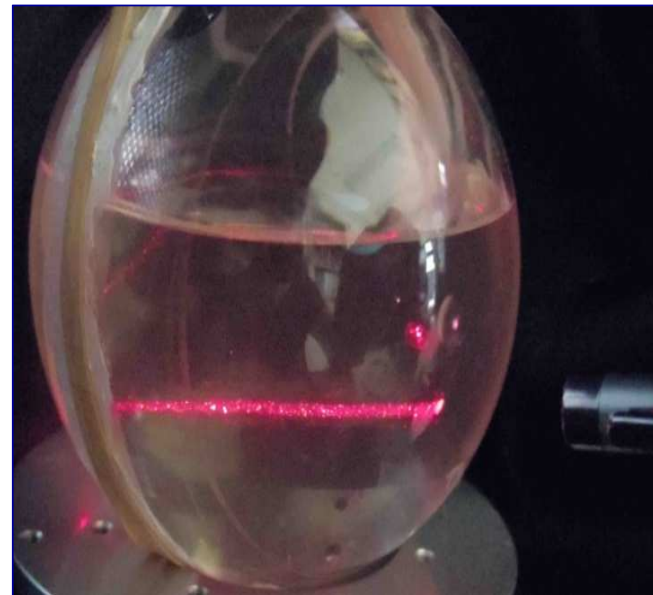
Operating time  
(Mixture)=15min

**2D Ball Mill**



• The laser trace is non-outbreak

**3D Ball Mill(3D Rector)**



- To confirm a laser trace.
- Air was occurred to many quantities in the liquid.

【Merit in details ①Organic Matter milling】  
 【Merit in details ③Influence of mixed and milling heat】  
 The 2D ball mill changes to paste by very high impact force heat.  
 The 3D ball mill (3D Reactor) has low impact force heat.

**Sesame Dry Milling**  
**(Room Temperature 23°C)**

Operating time  
 (Milling)=5min

2D Ball Mill



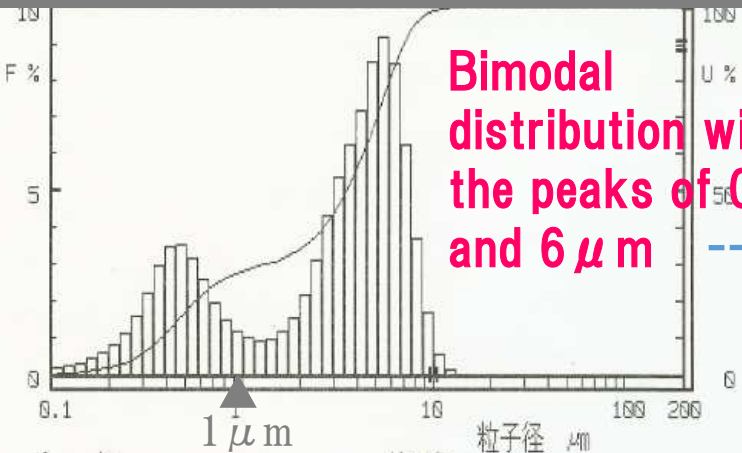
- Rotation axis: 600rpm
- Revolution axis: 1500rpm
- Total load electric current: **2.5A**
- **Fever: 42°C** (Room Temperature 23°C)
- **Change to paste with impact heat.**
- **Milling failure.**

3D Ball Mill (3D Reactor)



- Vertical revolutions : 400rpm
- Horizontal revolutions : 400+400=800rpm
- Total load electric current: **0.2A**
- **Fever: 26°C** (Room Temperature 23°C)
- **Low impact heat.**
- **Milling success.**

### Original particle size distribution



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

【Merit in details ④Solution to irregularity】  
 【Merit in details ⑤Non-solidified admixture of Dry pulverization】

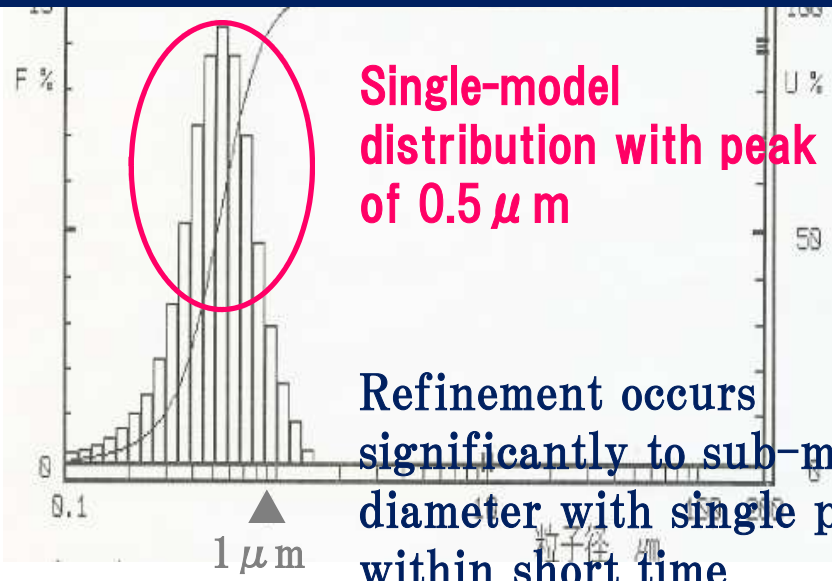
**Dry condition**

Sample ⇒ **Nickel oxide (NiO<sub>2</sub>)**

Ordinate : Volume %  
 Abscissas : Particle diameter

**30min Planetary Ball-Milling**

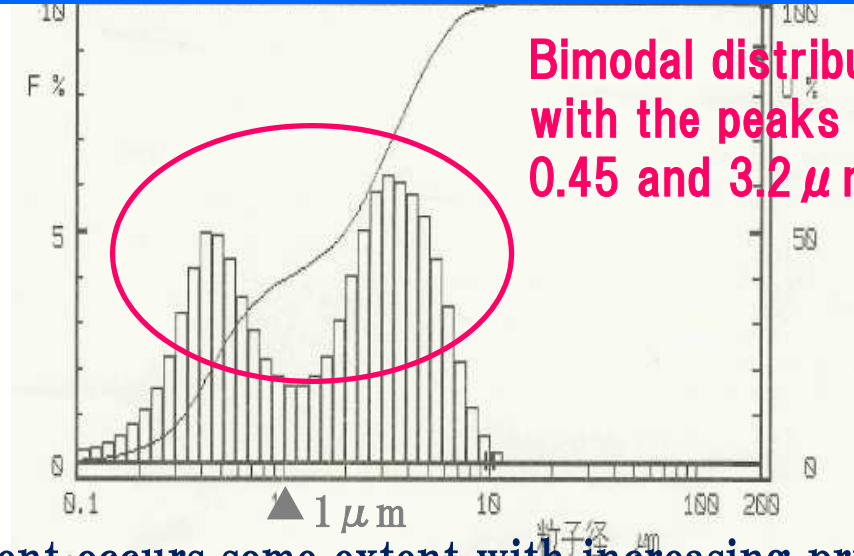
**30min 3D Ball-Milling**



**Single-model 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.

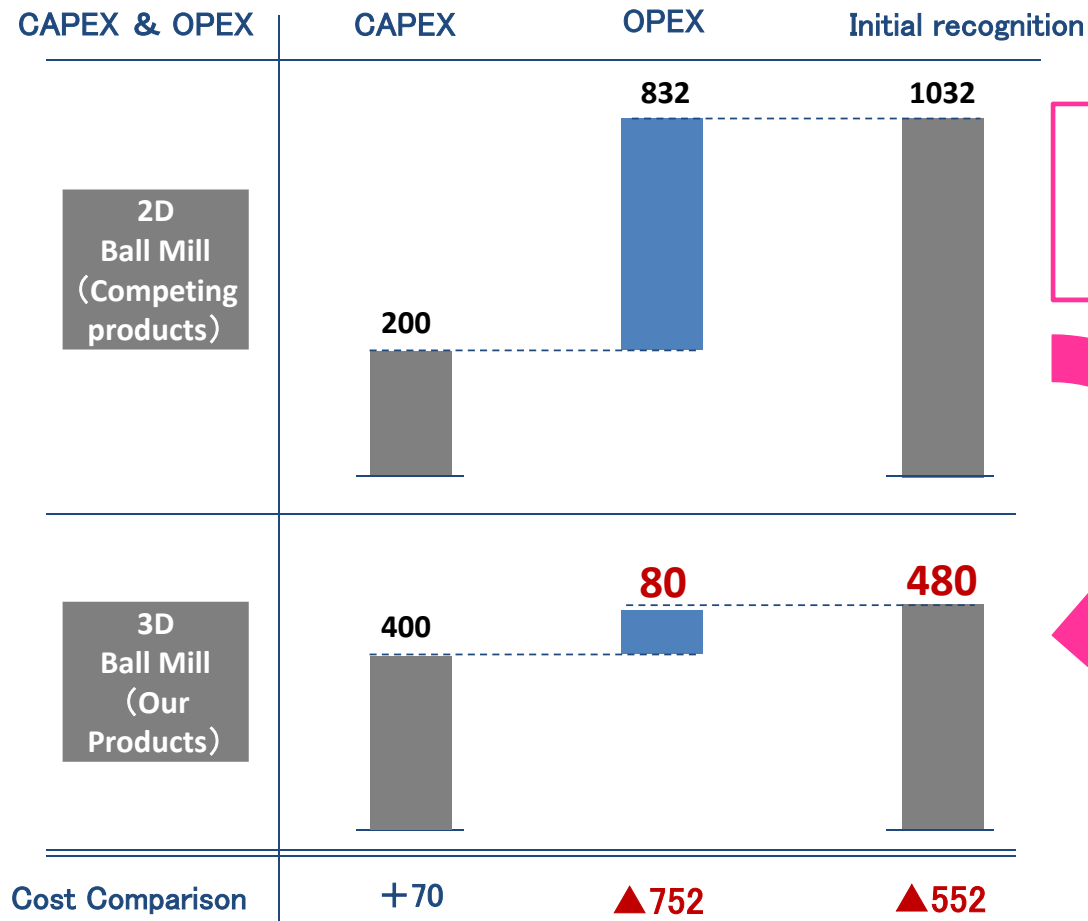


**Bimodal distribution with the peaks of 0.45 and 3.2 μm**

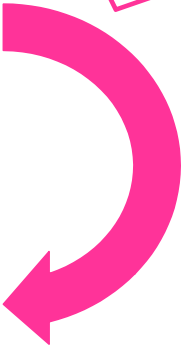
Refinement occurs some extent with increasing primary peak height and decreasing secondary peak height accompanying peak shift to small diameter (6 ⇒ 3.2 μm)

**【Total cost】**

2D motion, when mixing, fine particles move to the bottom. There are cohesion and irregular problems. Therefore, after cohesion, work to unravel substances occurs. (Researchers' labor costs are expensive.) In the high-speed 3D motion, the fine particles always move around the inside of the container at the time of mixing, and do not give cohesion time.



In the first year, approx. 54% total cost reduction has been achieved.



**NAGAO SYSTEM**

## 【Results】

The experiment results, the effect of the 3D Ball Mill(3D Reactor) becomes determination. There are large number of results in the delivery to the companies , the governments , the universities.

### Customer testimonials

- Material cohered after fine grinding and was troubled.  
It was settled in the 3D Ball Mill (3D Reactor).  
**Major car company A**
- The realization of non-critical rotation is revolutionary.  
It is possible to demonstrate exercise effect to the utmost!  
**NIMS The manager of Development Center is Dr. H**
- Ideal for uniform mixing of materials with different specific gravity and viscosity.  
Successful synthesis of multiple silicone.  
**Professor M Shinshu University**
- Successful mixing of organic matter with a lot of thermal change.  
**Major food company (Company C)**

### Sales performance

#### ■ Administration(Government)

- ✓ Tokyo University
- ✓ Kyoto University
- ✓ Hokkaido University
- ✓ Kyushu University
- ✓ Tohoku University
- ✓ AIST
- ✓ NIMS

#### ■ Private enterprise

- ✓ Major car companies
- ✓ Major electrical equipment companies
- ✓ Major glass companies
- ✓ Major chemical companies
- ✓ Major pharmaceutical products companies
- ✓ Major paint companies

### Media coverage



TV Tokyo WBS 2010.1



J-GoodTech 2015.2

END

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