THREE ROLL MILL 101
WHAT IS A THREE ROLL MILL

A three roll mill has three horizontally positioned rollers. Each roller rotates in an opposite direction from the adjacent roller with a tiny gap between them, creating tremendous shear force that can finely disperse, mix, refine or homogenize viscous materials.
WHAT IT IS AND WHAT IT IS NOT

A three roll mill is a dispersing tool, not generally a size reduction tool. Fine particles tend to agglomerate and a three roll mill applies powerful shear force to break apart those agglomerations. As a result, the final fineness depends on the original particle size of the dry ingredients. The exceptions are crispy materials such as sugar and whole milk powder that can be easily crushed. For nano-particles, the final fineness could be less than 1 micron. For ink application, the final fineness is usually below 5-10 microns. For chocolate products, the final fineness is around 20-30 microns.

For particle size reduction, on the other hand, Torrey Hills planetary ball mills create extremely strong impact force to break apart the existing chucks/small particles.
VISCOSITY REQUIREMENT

Three roll mill works best for the blending and dispersion of viscous materials containing binders such as oil and epoxy. Theoretically they are able to handle materials with viscosity ranging from 200cP to 2,000,000cP.

Torrey Hills has done many experiments to test different viscosities. The strong motor power enables the fast processing of thick and tacky materials. On the low end of viscosity, Torrey Hills team even tried to feed water to the rollers. Surprisingly, when the roller gap was adjusted close enough, the water came off the receiving end without dripping onto the collection pan underneath the rollers.
STRUCTURE OF A THREE ROLL MILL

- **Rollers** – The most important parts on a three roll mill are the three rollers. Materials are fed between the Slow Roller and the Mid Roller.

- **End Plates** – They gather feeding materials in the feeding area and prevent the materials from leaking sideways.

- **Discharge Apron** – A doctor blade is installed on the edge of the apron to scrape processed material from the fast roller.

- **Screw Adjuster** – This is how the four hand wheels adjust the 2 roller gaps. Turn the hand wheels to either enlarge or reduce roller gaps. There is a lock device to keep the roller gap constant during operation.
THREE ROLL MILL OPERATION

• STEP 1: Make sure end plates and receiving apron is securely installed
• STEP 2: Adjust roller gaps to desired level (usually between 20 and 150 microns) and lock hand wheels in place
• STEP 3: Starting from a slower speed, push the start button to get the rollers running
• STEP 4: Feed materials through the gap between the slow roller and the middle roller.
• STEP 5: Collect the material from the receiving apron
• Step 6: Use STOP button the stop the machine as needed
• STEP 7: Run the material 2-3 times till the desired fineness is achieved.
• STEP 8: Stop the machine and clean up.
SUMMARY OF APPLICATIONS

- Electronic Thick Film Inks
- High Performance Ceramics
- Plastic Polymers
- Plastic Compounds
- Cosmetics
- Coatings
- Adhesives
- Plastisols
- Carbon/Graphite
- Resins
- Silicone
- Paints
- Printing inks
- Pharmaceuticals
- Chemicals
- Glass
- Dental Composites
- Pigment
- Sealants
- Chocolates
Some cosmetic products, such as lipstick, nail polish, and mascara, rely on the use of a three roll mill for highly homogeneous and finely dispersed structure. Many types of mills providing high shear force are generally adopted machines in the cosmetic industry. Among these, the three roll mill is the preferred mill since its advantages of uniformly applied shear force on the whole ingredients and adjustable product capacity by different designed size.
The lipsticks are generally manufactured in four stages: (1) pigment milling, (2) combination of pigment phase into the base, (3) molding, and (4) flaming.

Milling is to break up pigment agglomeration rather than to reduce particle size. A good rule of thumb of the pigment/oil ratio is to use two parts of oil for one part of pigment. The resultant paste can be passed through three roll mill till the satisfactory particle size (usually 20 micron).
NAIL POLISH

The process of nail polish involves high-shear mixing. Pigment dispersion is the most important step. The finer the pigment is ground, the higher the gloss achieved, and the more stable the finished product. The required pigment is blended with nitrocellulose in a mix of bentone solution and plasticizer. The resultant is then ground through a three-roll mill, dried and “chipped” (i.e. split up into solid fragments). The color chips are blended in the desired shades and dissolved in the nitrocellulose solution (lacquer) using a high-shear mixing blade (Cowles) under flame-proof conditions. The other solvents and additives are added when a uniform color has been achieved. Following this, the bentone is added and the viscosity adjusted by addition of lacquer or thinners.
Ointments are viscous semisolid preparations for external application to the skin or mucous membranes. They are usually medicated and can be applied in order to heal, soothe or protect. To incorporate solid into the ointment base, a three roll mill, commonly called an ointment mill in this industry, is often used to ensure that the final product will not be gritty. The particle size of a powder or crystalline material is usually reduced before incorporation. If preparing a large quantity of ointment, here are the 2 simple steps that can greatly increase your output and produce smooth and elegant ointments.
THICK FILM PASTE

A thick film ink comprises main functional powder, glass frit, transitional metal oxide, dispersing agent, and organic medium, which is typically solvent and organic binder, serves as a vehicle to disperse the main functional powder.

The ingredients (the particulate inorganic solids and the organic medium) of the paste are first weighed together in a container. The components are then vigorously mixed to form a uniform blend and then passed through three-roll mill to achieve a good dispersion of particles.
INKS

Basically, the manufacture of inks is just a mixing process. Pigments, vehicle (varnish) and additives have to be synthesized separately and mixed together to form ink.

Tools to achieve dispersion include three roll mills, ball mills and bead mills for the final dispersion. Three roll mills are most commonly in the production of screen printing, pad printing, UV, and glass/ceramic inks, since they are more viscous in nature. For liquid inks, other types of mills should be used since the solvent would evaporate.
NANO PARTICLE DISPERSION

The strong tendency for nanoparticles to form clumps and clusters (“agglomerates”) is a serious technological problem that impedes the effective use of nanoparticles in many applications. For example, the nanoclay aggregates (as large as 10μm) could result in reduction of strength in nanoclay/epoxy composites.

Three roll milling is a dispersion technique that employs both shear flow and extensional flow created by rotating rolls of different speed to mix and disperse CNT, CNF, Graphene, or other nanoscale particles into polymers or other viscous matrixes. It is a very appealing process that benefits the environment by eliminating the solvent. Because of the powerful shear force, the mixer can reach a higher degree of intercalation/exfoliation within a short period of time.
CHOCOLATE

The initial grinding of the cocoa beans turns out a product that is made up of small particles of the nib suspended in oil. It is a thick syrup known as chocolate liquor. Time.

The next step is refining, during which the liquor is further ground between sets of revolving metal drums. The widely used machine is roll mill (3 or 5 rolls). It has been recorded that the three roll mill was used to mill chocolate as early as 1915. The ultimate goal is to reduce the size of the particles in the liquor to about .001 inch (.00254 centimeters).
ADHESIVES

Typical solid components of adhesives are fillers, catalysts, or hardeners. Three roll mills or multi-shaft mixers with high speed dispersing blades are used to disperse solids into low viscosity components. The high shearing action helps break up solid agglomerates and ensure that the fillers are completely well out and uniformly distributed in the resin. Thorough mixing in a three roll mill minimizes the occlusion of air during mixing, which makes it an outstanding tool in adhesive making.
ROLLER MATERIAL

The selection of roller material depends on the application. For most application such as cosmetics, chocolates, adhesives, and printing inks, stainless steel rollers will work just fine. They are commonly cheaper than other types of rollers.

For applications where metallic contamination is a concern, or when one or more ingredients would react with metal, porcelain/ceramic type of rollers are recommended. Examples include some thick film pastes, dielectric inks, and pharmacy ointments.
COOLING AND HEATING

- It is very common for rollers to get warm after a prolonged period of continuous running. When the surface temperature exceeds 70°C, damage to the gear system might occur. Under such circumstances, active water cooling is recommended.
- In some applications, active heating is required to keep material at a certain consistency to make sure it can be successfully processed with a three roll mill.
- The rollers of all Torrey Hills three roll mills are cored for both cooling and heating.
As you can see in the illustration, water is first pumped into the built-in water tank on the machine, usually with a submersible type pump (so that it can be placed in a larger water container for recycling). This cooling water goes in through the pink tunnel and flows into the blind hole inside the roller. The blind hole is designed with a slight slope so that water eventually flows back into the water tank.

There is a water outlet through which warm water gets out of the tank. The water recycles in and out of the larger water container, such as a bucket, and does its job keeping the desired temperature. Be sure to adjust the water flow by controlling the pump to keep the liquid level constant in the water tank. The same system can be used to heat up the rollers if hot liquid is pumped into the rollers.
water is not the most desired liquid for cooling purpose. We recommend the use of at least 50/50 coolant and water. Coolant with anti-corrosion additives, such as this one, includes a corrosion inhibitor that balances the negative acidic effects that can develop over time in antifreeze and water solutions. It also stabilizes the pH level which helps reduce rust and prevents electrolysis, mineral deposits and pre-existing scale build-up from forming resulting in potential core damage for long term protection.
SAFETY FEATURES

1. Emergency Stop Button
2. Emergency Pull Cord (Trip Switch)
**MAINTENANCE**

- Thee roll mill is a rugged machine and can last for a long time with proper care.
- All machines come pre-lubricated. Lubrication is required usually after the machine has been running for 120 hours to protect the gear system.
- Common types of spare part include doctor blade and end plates.
## 2.5x5 LAB MODEL

<table>
<thead>
<tr>
<th>Parameter / Type</th>
<th>Model T65 (#2.5 x 5)</th>
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<tbody>
<tr>
<td>Diameter of Roller</td>
<td>2.5&quot; (65mm)</td>
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<tr>
<td>Length of Roller</td>
<td>5.0&quot; (127mm)</td>
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<tr>
<td>Roller Speed Ratio (Fixed)</td>
<td>1:2:4</td>
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<tr>
<td>Speed of Roller RPM</td>
<td></td>
</tr>
<tr>
<td>Slow Roller RPM</td>
<td>0~108</td>
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<tr>
<td>Mid Roller RPM</td>
<td>0~216</td>
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<tr>
<td>Fast Roller RPM</td>
<td>0~432</td>
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<tr>
<td>Motor Power</td>
<td>3/4HP / .55kW</td>
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<tr>
<td>Weight</td>
<td>165 pounds</td>
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<tr>
<td>Dimensions</td>
<td>24&quot;x14&quot;x15&quot; (619mmx356mmx381mm)</td>
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</table>
FEATURES

• Standard Three roll mill rollers are precision ground 420J2 stainless steel to prevent rust or erosion. The hardness is rated at HR50-60 for reliable long-life usage.
• Ceramic rollers are made from cold iso-static pressed and fired 99.5% alumina, and ground to 5µm concentricity and 0.5µm surface finish.
• Rolls are cored for either cooling for heating.
• Revolutionary mechanical driving system delivers high shear force with minimum operating noise.
• Maximised the power, dispersing efficiency, and throughput. Throughput is than most competitors’ models.
• Variable speed control allows adjustable/slower speed runs.
• Emergency pull cord on top of the machine as an extra safety feature.
• Easily adjustable Teflon end plates.
• Unit includes a free standing base allowing easy mobility.
• Easily accessible stop and start buttons.
6X12 MODEL

- Higher Throughput Production Model
- Hardened Steel or Ceramic Rollers
- Preferred Model for Pharmacy Compounding and Cosmetics Pilot Productions
- Highly Praised by DSO – Singapore’s defense research agency
### SPECIFICATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>6x12 Three Roll Mill Model</th>
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<tbody>
<tr>
<td>Roller Material</td>
<td>Hardened Cold Cast Steel</td>
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<tr>
<td>Diameter of Roller</td>
<td>6” (142mm)</td>
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<td>Length of Roller</td>
<td>12 &quot; (305mm)</td>
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<td>Roller Speed Ratio (Fixed)</td>
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<td>Speed of Roller RPM</td>
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<tr>
<td>Slow Roller</td>
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<td>Mid Roller</td>
<td>94</td>
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<td>Fast Roller</td>
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<td>Motor Power</td>
<td>3HP /2.2kW</td>
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<tr>
<td>Weight</td>
<td>1100 lbs (500kg)</td>
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<tr>
<td>Dimensions</td>
<td>33 &quot;x33&quot;x35&quot; (840mmx840mmx890mm)</td>
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### BRAND COMPARISONS

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<thead>
<tr>
<th>Parameters</th>
<th>THT 2.5x5</th>
<th>Exakt 50</th>
<th>Exakt 80</th>
<th>THT 6x12</th>
<th>Exakt 120</th>
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<tr>
<td>Roller diameter</td>
<td>65</td>
<td>50</td>
<td>80</td>
<td>155</td>
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<td>Roller length</td>
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<td>150</td>
<td>250</td>
<td>305</td>
<td>450</td>
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<td>Roller speed ratio</td>
<td>4:2:1</td>
<td>3.3:1.8:1</td>
<td>3.3:1.8:2</td>
<td>5.4:2.4:1</td>
<td>2.9:1.7:1</td>
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<td>Single speed motor (kW)</td>
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<td>0.12</td>
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<td>Weight (approx. Kg)</td>
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<td>12</td>
<td>50</td>
<td>500</td>
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<td>Length (mm)</td>
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<td>320</td>
<td>560</td>
<td>840</td>
<td>820</td>
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<tr>
<td>Depth (mm)</td>
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<td>280</td>
<td>400</td>
<td>840</td>
<td>650</td>
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<tr>
<td>Performance (approx, l / h)</td>
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<td>7</td>
<td>up to 20</td>
<td>up to 40</td>
<td>30-45</td>
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