Team Project 1:

An investigation into the spin casting process

Group # 3

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What we’ll be talking about

- What is spin casting?
- Describing the Surface
- Dynamics of the System
- Applications/Advantages
- Alternatives
- Conclusion

What is spin casting?

It is a process in which liquefied material is fixed on a spinning surface taking advantage of the generated forces to take a desired form.

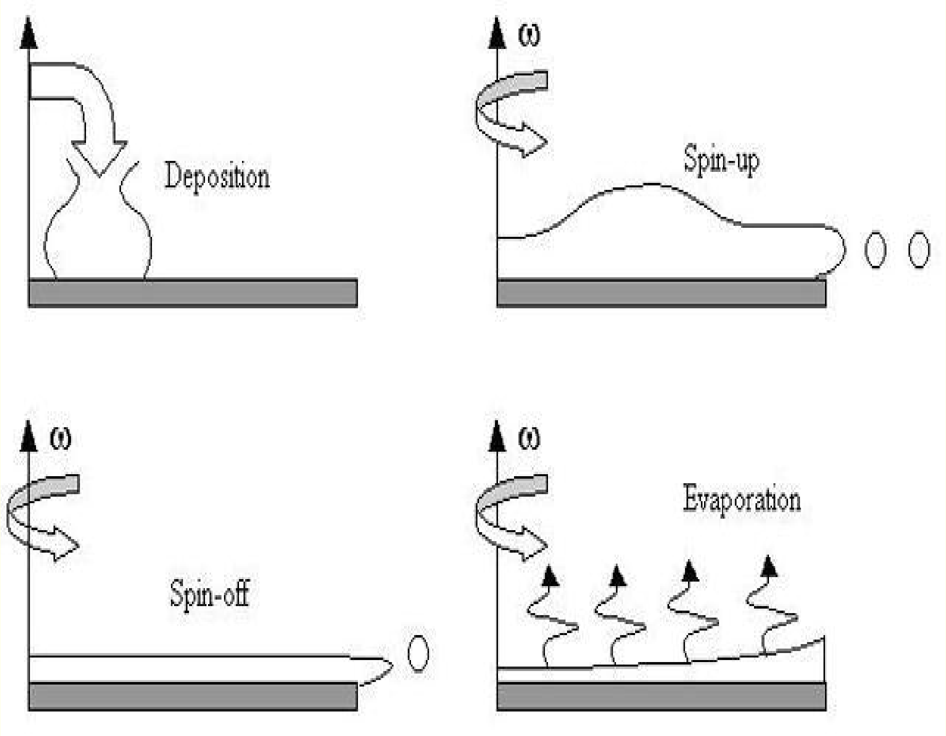
There are basically two ways in which spin casting is utilized

•Form Molding

•Parabolic Surface Construction

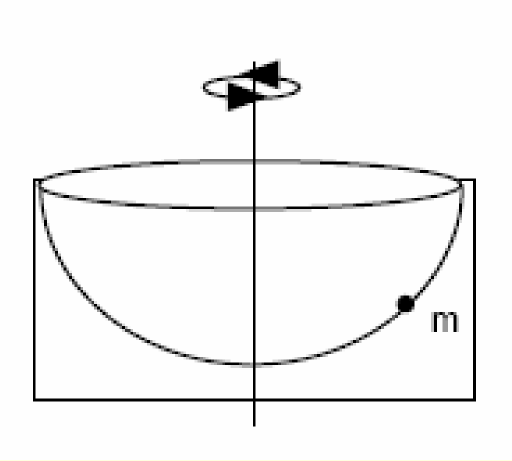
The Process

- *Deposition* – liquid introduced from elevated position
- *Spin-up* – liquid flows and covers entire surface
- *Spin-off* – excess liquid is removed by rotational forces
- *Evaporation* – as system reaches equilibrium, molecules are pushed outwards and gases are released, generating a parabolic surface

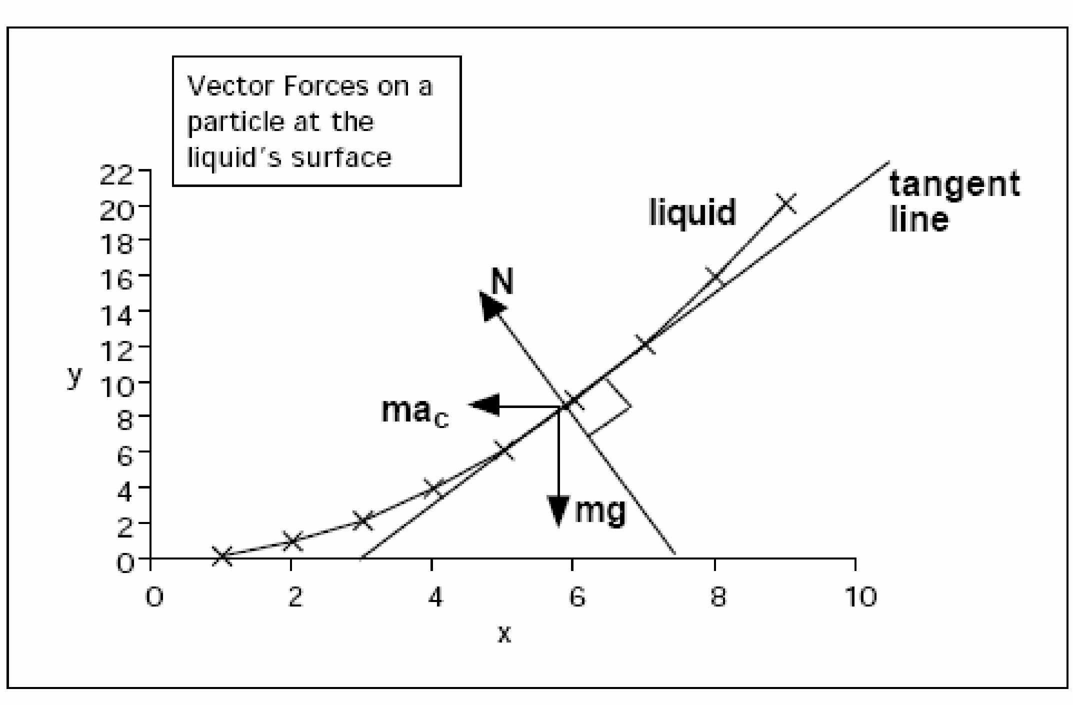


Describing the Surface

- Consider (m) a particle
- Forces in equilibrium
- Acting forces are
  - weight
  - centrifugal force



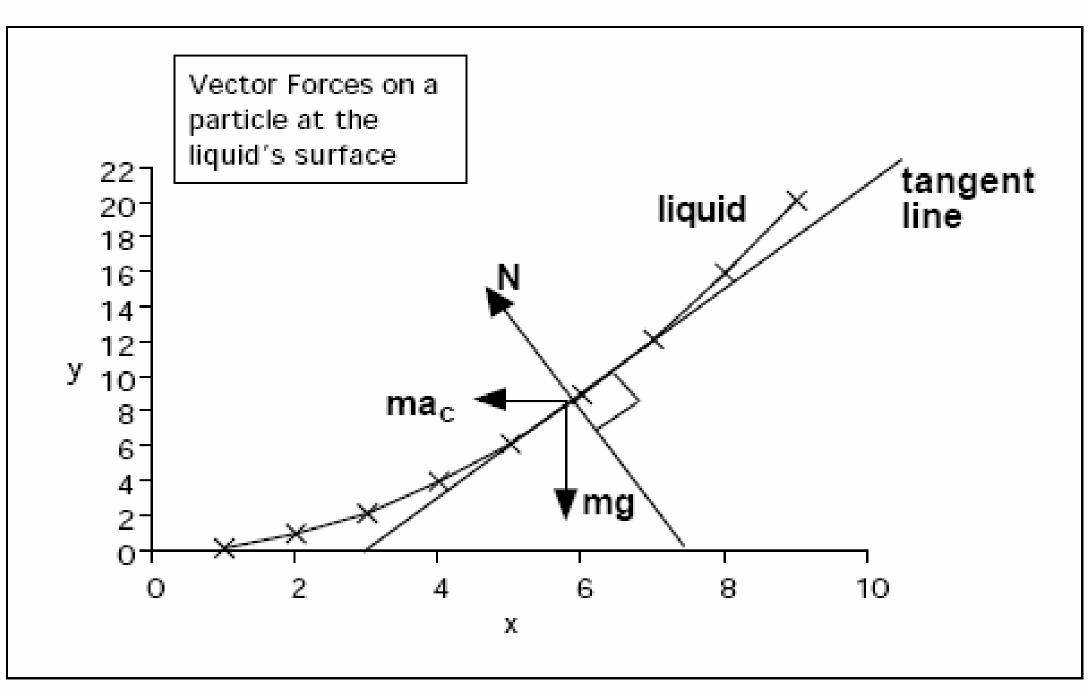
Describing the Surface: Diagram of Forces



The forces represented are

- Weight (mg)
- Normal Force (N)
- Centripetal Force (ma_c)

Describing the Surface: Explanation of forces



- Set mg as the rise
- Set ma_c as the run
- Slope of normal vector can be represented as $-mg/ma_c$

Describing the Surface: Equation Derivation

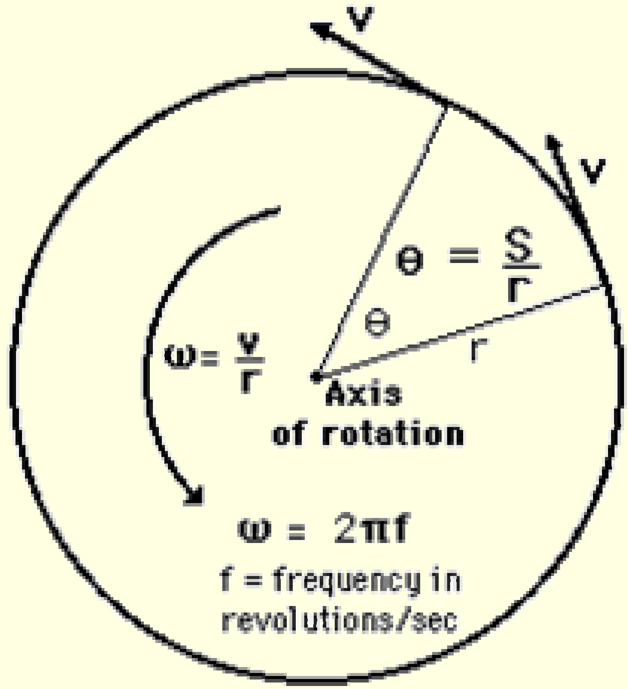
We can then represent the slope as

$$\frac{dx}{dy} = \frac{a_c}{g}$$

The centripetal force a_c is determined by the equation

$$a_c = \omega^2 x$$

Describing the Surface: Equation Derivation (cont.)



Angular velocity can be considered to be a vector quantity, with direction along the axis of rotation in the **right hand rule** direction.

Angular velocity is the rate of change of angular displacement

It can be represented by

$$\omega = \frac{v}{r}$$

Where v = velocity of rotation and r = radius

Describing the Surface: Equation Derivation (cont.)

So now we represent the slope by

$$\frac{\omega^2 x}{g}$$

Integrating we find the position function:

$$\int \frac{\omega^2 x}{g} dx = \frac{\omega^2}{g} \int x dx = \frac{\omega^2 x^2}{2g} + C$$

We can eliminate the constant, C, by placing the origin at the surface of the liquid

Describing the Surface: Equation Derivation (cont.)

The general equation for a parabola centered around the y-axis:

$$x^2 = 4py$$

Can be rewritten as

$$y = \frac{x^2}{4p}$$

Describing the Surface: Equation Derivation (conc.)

Setting the equations equal to one another we have

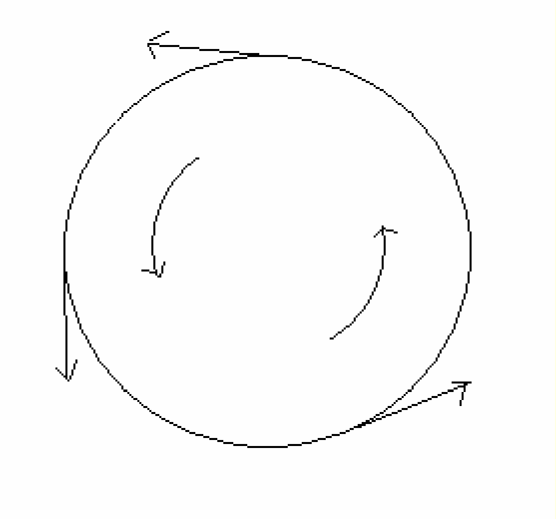
$$\frac{\omega^2 x^2}{2g} = \frac{x^2}{4p}$$

We see that the surface is accurately modeled by the equation of a parabola

Strength of Centrifugal Casting

The strength of something that is cast in a centrifuge is increased dramatically because of the centripetal forces that act on the system. As opposed to fabrication without rotation, in a mold of sorts, for instance, centrifugal casting applies forces horizontally as well as the naturally applied vertical forces of gravity.

Diagram of Forces Acting Upon the System



As the centripetal forces push outwards on all sides of the system, the density of the system becomes greater, creating a greater **tensile strength** and **yield strength** in the atoms of the system.

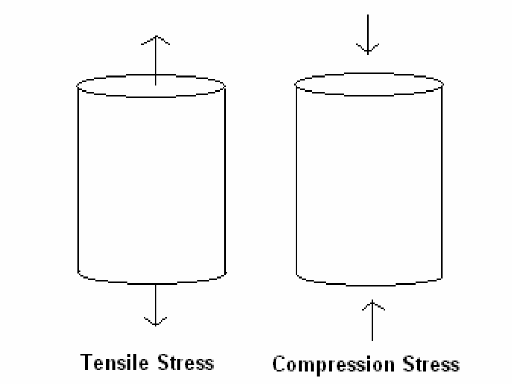
This, in its application to parabolic mirrors used in telescopic applications, is very much a good thing because of the extreme forces that are acting on the system. For example, were a telescope to reenter the atmosphere, it would undergo pressures upwards of 10 g units, or ten times the amount of force that a normal object on the surface of earth would undergo. Strength, therefore, becomes an essential issue in deciding what methodology to use in the construction of these mirrors.

Strength of Centrifugal Casting (cont.)

The theory of a system's strength (tension, compression, rigidity, etc.) can be said to be basically quantified by a system's **yield strength**, which is defined as the amount of stress a system can "absorb" before becoming permanently deformed.

STRESS = MODULUS X STRAIN

Where the modulus is the constant of proportionality over the range of uses for a material. The tensile stress and compression stress are what mainly concerns the construction of a parabolic mirror. Tensile stress and compression stress can be illustrated as follows:



The above model can also be arranged to be applied in the horizontal direction.

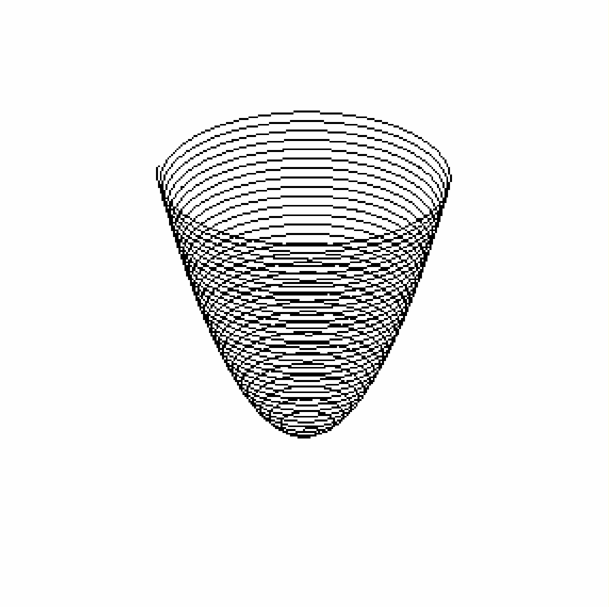
Young's modulus is the modulus for tensile and compressive stresses and is represented in engineering by 'E':

Where F is force, A is area (force per area), and (Delta 'L') / L is the dimensionless quantity strain.

Strength of Centrifugal Casting (conc.)

To apply the theory to the parabolic mirror, we can say, for example, that since we know the approximate density of glass (2600 kg/m^3), it can be shown that centrifugal casting increases this density by upwards of 30%. That percentage would numerically put the density at 3380 kg/m^3. Because of the proportionality of the properties of strength, we can also say that the yield strength would be increased by 30%.

This is all achieved by spinning an aqueous molten version of the glass in a centrifuge, applying uniform forces to it, thereby increasing, significantly, the overall strength of the system.



Common Materials Used in Spin Casting

- Metals
- Molten glass
- Thermoplastics
- Thermoset Plastics

Comparison of Processing Methods

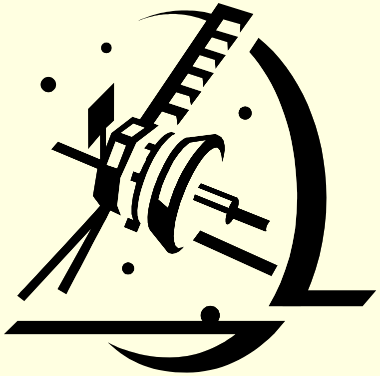
Process	Spin Casting	Die Casting	Plaster Mold Casting	Sand Casting	Lost-Wax Casting	Permanent Mold Casting
Type of Casting Materials	Zinc, Tin/Lead, Polyurethane, polyester, epoxy, pattern wax	Zinc, Aluminum, Magnesium	Most Nonferrous Metals	Most Foundry Castable Metals	Most Foundry Castable Metals	Zinc, Magnesium, Aluminum
Average Cost of Mold Tooling	$35 - $250	$10,000 - $250,000	$1,000 - $25,000	$500 -$10,000	$1,000 - $25,000	$5,000 -$125,000+
Casting Tolerance	Very close	Closest	Close	Lowest	Very close	Loose
Ability to make design changes	Easiest	Very Difficult	Difficult	Easy	Very difficult	Difficult
Per Part Cost	Very Low	Lowest	Very High	Very Low	Highest	Low
Usual Secondary Machining Required	Very little or None	Lowest or none	Low	Highest	Very Little or None	Low
Usual Initial Parts Lead Time Required	4hrs. – 2 days	12-24 wks.	6-12 wks.	4-12 wks.	8-16 wks.	12-24 wks.

Applications of Spin Casting

Telescope Mirrors

Light Magnification

Satellites



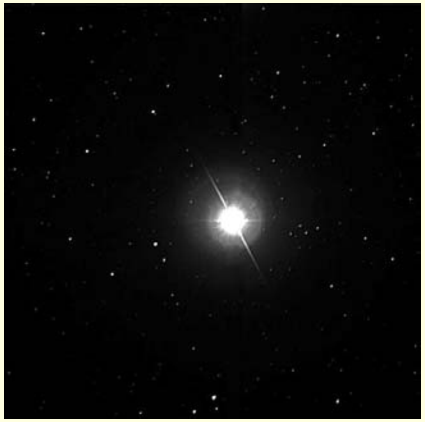
Advantages of Spin Casting

- More Efficient = Less money
  - Less machining→ Decrease Lost Product
  - Less labor
- Easily adaptable
  - Adapt to design changes
- More accurate

Interferometry as an Alternative

- The benefits of spin casting are many, yet there is a promising new technology

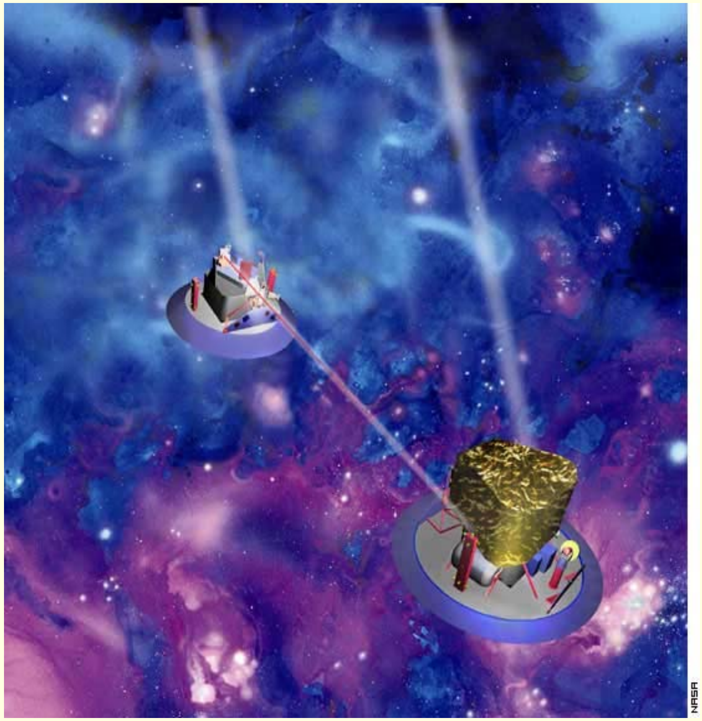
INTERFEROMETRY



- It is a virtual dish made of sensors deployed in a circular array that send data back to a central receiver.
- The process works on the interaction of light waves, called interference.
- Their interaction can be used to cancel out the blinding glare of bright stars or to measure distances and angles precisely.
- The word interferometry itself illustrates this idea: interfere + measure = interfer-o-metry.

Advantage of Interferometry

- This is beneficial when applied to large objects such as distant stars.
- To observe a planet the size of Earth using a conventional telescope would require a mirror as wide as a football field -- and it would have to be deployed in space.
- That is obviously impractical!
- Interferometry techniques would allow us to observe that same planet without having to produce such a large mirror.



Conclusion (Our Recommendation)

- We support continued research in the development of spin casting technology
- We also recommend that Interferometry technolgies be researched and evaluated for future application.

Sources

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- http://medusa.as.arizona.edu/mlab/advant.html
- http://www.tekcast.com/compare.htm
- http://www.astronomyteacher.com
- http://www.compliantlab.sdsmt.edu/awlad/introduction.htm

Any Questions