

From: The Crawford Hill VHF Club
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Subject: Spin Casting a Paraboloidal Reflector

Introduction

The fabrication of an accurate paraboloidal reflector depends primarily on its required size and application. For EME, the operating environment must also be a considered factor. Wind loading and ice loading are important factors which effect the size of the reflector and type of surface material used. Large reflectors, 10 feet (3 meters) or more in diameter almost always requires some form of trussed rib arrangement for high strength-to-weight ratio. The addition of circular members will enhance the surface accuracy.

Smaller reflectors can be made using a reverse mold technique in which a reverse mold is constructed of some stable material which can be worked into a paraboloidal shape with a template and pivot axle. Such molds can be made of cement or plaster but require surface finishing to achieve accuracy. The actual working reflector is then molded over the surface in the form of a thin layer of Fibreglas or other durable material, with a suitable parting agent coating the mold. Some form of rib or honeycomb back-up structure is usually required for strength. The inner surface (reflector surface) must then be coated with a conductive material such as Silver paint or aluminum foil. This method can result in good surface accuracy if the mold has been prepared accurately.

This report describes an alternative method of achieving a very high accuracy paraboloidal reflector with very high surface accuracy. The method is called spin casting and has been around for a long time. While primarily used to fabricate small reflectors (even optical reflectors), it has been used to make reflectors up to 14 feet in diameter !

Surface accuracy considerations have been discussed in Report # 5 and should be consulted to realize that it is a factor which is difficult to accurately determine on a self fabricated reflector, and that it is a serious problem in fabricating high efficiency antennas. This problem becomes acute as higher frequency bands are used both for amateur EME and terrestrial microwave communications.

Spin Casting

The basic physics of spin casting a paraboloid is that when a container of liquid is rotated about its vertical axis, gravity and centrifugal forces will act on the liquid in such a way as to form a perfect paraboloid at the surface of the liquid **. This remarkable property can be employed to form a high accuracy

** Roberson, J.A. and Crowe, C.T., Engineering Fluid Mechanics, Houghton Mifflin Co., Boston, 1975, p. 119.

paraboloidal reflector by using a material which is initially liquid, but will harden in a reasonable period of time. One such material is acrylic casting resin available in any hobby shop or art supply house.

The relationship between the spinning speed and the parabolic shape is simply

$$\text{focal length in feet} = 1468.14 / (\text{spin r.p.m.})^2,$$

regardless of the material used as long as it is a homogenous fluid during the spin forming period.

The spin speed must be held very constant during the time it takes the casting material to harden. The container may be any convenient circular shape, however in the interest of saving expensive casting resin and reducing weight, the container might be in the form of a crude paraboloid. In fact, this spin casting method can be readily used to restore the surface accuracy of a damaged dish.

The spinning mechanism should be vibration free and have some inertia to help keep the spinning smooth and constant. A spin speed monitor which can be used to control the drive motor is desirable although not essential.

Typically rotational speeds of less than 100 rpm will be required. For example, a 45 rpm old record player turntable will produce a focal length of 0.73 feet. To obtain a paraboloid with f/d of 0.5 will require a container about 18 inches in diameter.

When the spin casting is complete, the surface may be coated with a conductive material to obtain a radio reflector. Coating can be with Silver paint (sprayed on but very expensive), or copper or aluminum foil cemented to the surface with any good adhesive. Ordinary household aluminum cooking foil applied with a contact cement is entirely adequate and may be hand rolled to take out wrinkles, and slit to remove air pockets.

If the initial attempt at spin casting produces an unsatisfactory surface, for whatever reason, the entire operation may be repeated with a thin layer of the same material. It is usually desirable to start the spin forming process with the material at the bottom of the container (bowl) but not necessary. The material may be slowly poured onto the container surface from center to edge as long as the material is fluid during this process. Experience will dictate how fast to introduce material on the surface.

Although the acrylic casting resin (with hardner) is a very suitable material, it is expensive and is also exothermic. This means that if a large quantity is mixed with the hardening agent, allowance should be made for heat dissipation. Spread the material as soon as it is mixed thoroughly, and spread leftover material over a wide area to avoid possible fire and or explosion due to rapid heating.

An alternative material is non-shrinking plaster also available at art supply houses. Primarily used for statue molding, this material can be used for spin casting by making a slurry that has the consistency of heavy cream. It sets relatively slowly (about 5 to 10 minutes for a noticeable set) and may require up to an

hour or more to completely harden.

For a large paraboloid, plaster will be heavy and will have to be sealed to prevent weathering. It may also be advisable to place reinforcing rods or screening material within the casting to add strength.

Additional Remarks

Spin casting of reflectors for antennas finds its chief application at microwave frequencies of perhaps 4000 mc/s and higher where surface accuracy requirements are stringent and cannot be readily realized by other methods of home fabrication. Commercial spun dishes (not spin casting) can have good accuracy but are limited by the mold used to spin-form the malleable material into shape.

For amateur application, spin casting can be used for reflectors in the 2 to 4 foot diameter range at X-band (10,000 mc/s) and higher to achieve excellent surface accuracy and thus highest aperture efficiency from parabolic reflector antennas.

Larger diameter reflectors will be heavy and of course be of solid surface with the full impact of wind loading. Larger spin cast reflectors should be fabricated as a thin shell, perhaps 1/8 to 1/4 inch thick, and backed up with a trussed rib and hub assembly for strength.

Fine optical surfaces have been formed by spin casting but special precautions must be taken to obtain the required surface accuracy. These include a very stable spin mechanism, completely free of vibration. The casting resin must be carefully prepared to avoid contaminants and excessive air bubbles. Spinning must be done in a clean-air environment free of dust, lint and low in water vapor content. The reflecting surface may be coated with fine optical silvering used in telescope reflector surfacing.

Optical reflectors of a foot or so in diameter can be used at optical and infrared wavelengths to give fantastic gain. At these extremely short wavelengths, this size antenna will produce a virtually collimated beam over many miles and can provide long line-of-sight reliable transmission paths with very low transmitter power requirements. Such paths are ideal for high security links but easily wiped out by heavy weather conditions, fog, rain, sleet, snow, etc.