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# Round Stars, Part II

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**Introduction:**

In Part I of this series we looked at round star design, taking into consideration such things as formula compatibility, primes, timing and sizing. This month we take a look at the actual manufacture of round stars, examining the following aspects:

1) Types of cores
2) Solvents
3) Rolling Techniques
4) Screening
5) Priming
6) Drying

**Star Rolling Cores**

All round stars are made by rolling successive layers of composition over increasingly growing spheres. Naturally, the process must begin with small cores upon which to build from. There are a wide variety of cores that may be used, with different advantages and disadvantages to each. The following table lists the pros and cons of common cores:

| Core Type | Advantages | Disadvantages |
|---|---|---|
|  Lead shot (#8 or #6) | Lead shot rolls easier than any other core type. The heavy weight helps the cores pick up composition, and also helps maintain more size consistency during the early stages. | More costly than other core types. Sometimes the graphite may need to be removed so that composition will adhere to the surface, although some builders report no problems in this area. Fallout is thought to be another potential problem, although some believe that the shot vaporizes when the star burns up. |
| Millet (bird seed) | Probably the cheapest core type that can be used. | May require screening to remove grit if the pure variety can not be found. Due to the smooth husk of the millet seed, some report having to coat the millet with clay first before the composition will adhere. Like wheat paste, bugs also like to get into millet and slowly devour it over time. |

| | | |
|---|---|---|
|  Husked Millet (human grade) | More expensive than animal grade, but still very cheap. A 25 lb bag can be purchased from Whole Foods grocery stores for about $20. The size is smaller than normal millet, but the smooth surface has been removed, allowing composition to stick to the surface without any special preparation. | The small size may prove hard to work with for beginners learning to roll stars for the first time. If you don't have access to a Whole Foods store, it will also have to be mail ordered. Like wheat paste, bugs also like to get into millet and slowly devour it over time. |
| Molecular Sieves | Perfectly round, easy to roll, can be pre-soaked to make the initial coating process easier. | More costly than other core types, and can be hard to find when hobby suppliers are out of stock. |
| Pasta | Can usually be purchased locally. | Gets too sticky when first dampened unless pre-coated with something waterproof like NC lacquer. Known to swell when damp, causing finished stars to crack under some circumstances. |
| Tapioca | Good when large cores are needed for large stars, easy to roll. | Too large for most rolling. Can break apart when rolling. |
| Micro Stars | Easy to make. | Can result in irregular shaped stars depending on how the micro stars were made. Light weight can make rolling difficult for beginners learning how to roll. |
| Cut/Pumped Stars (1/4" size) | The slowest part of rolling, getting from core to about 1/4", is already complete. | Can result in irregular shaped stars unless rolling up to at least 1/2" size. May not produce accurately timed color changes. |
| No Cores | Ideal way to make micro stars under 3/16", since no core will leave more composition available to extend the burn time of the star. | Technique can be tricky to master. Sizing is very inconsistent. |

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**Solvents**

Rolling round stars involves a continuous cycle of spraying the stars with a wetting solution and then adding the composition. The type of solution used depends on the type of composition you are rolling. In a perfect world, each formula you ever came across would tell you what type of solvent to use when rolling the star. In reality, this information is not always provided.

**Water/Alcohol**

In most cases, a simple mixture of alcohol and water may be used for spraying the stars. The alcohol is used to help lower the surface tension, which reduces the tendancy for stars to stick together when they are in the early stages of rolling. The alcohol also speeds up the drying process, which helps prevent a condition in which the star surface dries before the core does. This problem, called "driven in" moisture, can result in stars that effectively never dry.

Since most compositions bound with water and alcohol contain dextrin, it must be noted that dextrin is only solvent in water and not alcohol. Using a solution that contains over 50% of alcohol can weaken the integrity of the star by reducing the binding power of the dextrin.

It is common to begin the star rolling process using a solution with a higher alcohol content like 40% in order to reduce the tendancy of small cores to stick together. This percentage is then cut back to around 15-20% once the stars grow close to 1/4". The more alcohol that is in the solution, the slower the stars will grow. This is why it becomes advantageous to cut back the alcohol level to the minimum amount necessary to prevent rolling problems and still aid in the drying process.

Another star rolling problem that alcohol helps reduce is a phenomenon known as "spiking." Spiking occurs when stars develop bumps on their surface that grow larger as the star is rolled, deforming the desired round shape into a lumpy mass resembling a raspberry. The problem occurs most frequently in compositions that contain very finely powdered ingredients such as ball milled meal, lampblack, air milled red gum and charcoal. The theory is that these fine powders create a "skin" layer that shrinks when dampened, causing tiny hills and valleys on the surface. The hills naturally collect more powder, while the valleys get none. Alcohol lowers the surface tension of the water, which in turn helps avoid the shrinkage problem.

Color resin stars that contain red gum need little or no alcohol in most cases. Up to 15-20% can be used to help break the surface tension, but too much alcohol will cause the resin to become too sticky to work with. This sticky layer has also been known to form a moisture barrier and cause the driven in condition.

In star formulas that contain nitrates in combination with fine aluminum powders, there is a tendancy for the nitrate-aluminum reaction to generate heat which further accelerates the reaction. The presence of alcohol in the solution helps to cool the mixture through evaporation, thus helping prevent a nitrate-aluminum reaction from heating up.

Dissolving 1% boric acid into your spray bottle will also help prevent the nitrate-aluminum reactions from occuring. Note that dissolving the boric acid into your solvent is more effective at preventing the reaction than screening the boric acid into the star composition itself. The boric acid dissolves slowly, however, so prepare the solution a few hours before it is needed.

**Alcohol/Acetone**

Some star formulas contain metals such as magnesium that simply can not be bound with water due to spontaneous combustion risks. These types of stars use parlon as both a chlorine donor and a binder when dissolved in acetone. The

parlon not only binds the star, it also coats the magnesium and protects it from moisture.

Alcohol is added to the acetone in order to slow down the rate of evaporation. Stars bound with acetone must not be dried in a tub or other container with a closed bottom and sides. Acetone fumes are heavier than air and will remain in the tub, preventing the stars from drying. Acetone fumes are also hazardous to your health as well as highly flammable, so rolling such solvents outside with a vapor mask is highly recommended.

**NC Lacquer/Acetone**

This type of binding solvent has a unique advantage in that it creates a moisture resistant star. It is typically used to apply buffer prime layers between incompatible layers such as ammonium perchlorate (AP) and nitrate compounds. If a nitrate formula were rolled directly onto an AP core, the water would carry dissolved nitrates into the AP core and create ammonium nitrate, effectively ruining the star. Using NC lacquer diluted to a sprayable consistency with acetone eliminates this problem.

This solvent can also be used to roll a prime layer onto a star which is hygroscopic, thus preventing the star from absorbing moisture in the air and ruining it.

Note that if NC is used to bind charcoal streamer stars, then the tailed effect will be greatly diminished, ruining the star. If used to apply the final prime layer, there is also a tendancy to create a fire-block which will prevent the star from igniting. In this case, a final meal prime must be applied over the NC layer using just water as the binder.

This solvent is a particularly troublesome one to deal with, as it destroys any rubber components of your sprayer, dries overly fast, has very strong fumes that require a vapor mask and heavy ventilation, causes stars to roll very slowly and leaves a mess in your star roller that must be washed out using acetone. In spite of all this, there are effects where its use can not be avoided.

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Figure 1: A home made star roller.

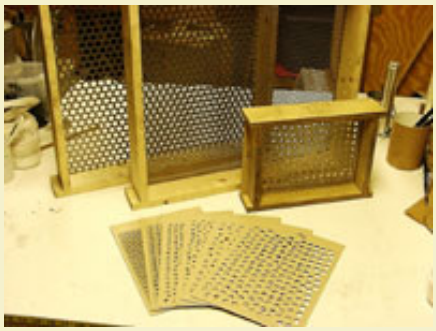

Figure 2: Sizing screens.

Figure 3: Various spray bottles.

**Getting Ready to Roll:**

This article deals specifically with rolling stars using a star rolling machine. While it is possible to manually roll stars in a large bowl by swirling them around for long periods of time, this method is tedious and impractical for making large quantities of stars. If you are interested in this manual method, David Bleser has produced a video that details the process, available from AFN.

The first thing you will need is a star rolling machine. This month's Tool Tip reviews several star rolling machines that can be purchased or fabricated.

Next you will need a set of screens so that you can produce accurately sized stars. The best star sorting screens use round holes instead of a wire mesh. Perforated sheet metal is available that contains a dense array of round holes, which can be framed into a box frame. You can also make your own screen by drilling as many holes as possible into plastic or aluminum pans. Common screen sizes are 3/16", 1/4", 3/8" and 1/2". I prefer to have additional screens that are 1/32" above these sizes for cases in which very accurate sizing is required. Figure 2 shows both the perforated metal screens and a small screen with interchangeable plastic sheets that were hand drilled for the various sizes.

You will also need a method of spraying a fine mist of solvent onto your stars as you roll them. Hand pumped spray bottles are the most common method when starting cores and making small to mid size batches. Hostile solvents such as NC lacquer and acetone require special spray bottles that will hold up to their tendancy to dissolve rubber grommets, o-rings and pump valves. Lysol and 409 household cleaner bottles seem to hold up well to these solvents.

When rolling larger batches of big stars, the amount of solvent that must be sprayed between powder applications becomes tedious to apply with a hand pump spray bottle. In this case a pump-up weed killer sprayer or compressed air paint spray gun works well. The compressor for the paint gun method must be turned way down to around 10psi in order to prevent the air output from from blowing the powder around in the roller and making a mess. Most weed sprayers do not produce a fine enough mist for working with small stars, making it easy to over wet them.

Before you begin you will need to measure out a volume of cores to start with. These may be your starting cores or stars that have already been rolled up to a certain size. A small amount of starting cores will produce a lot of stars, even if you are only making 3/8" stars. Generally 1/4 cup of cores is a good starting point. If you are using larger cores like tapioca or lead shot, then you can start with slightly more. Small cores like husked millet may

require slightly less. If you are expanding stars that have already been rolled up to a certain size, then you will want to start with quite a bit more. For example, if you are starting with 1/4" stars, then you might start with something like two cups of them. Only after experience using your own star roller will you get a feel for how many cores to start with.

If you are using hostile solvents such as acetone or NC lacquer, it is a good idea to strap on some latex gloves to avoid skin contact with these solvents. Use of latex gloves also keep your hands clean and make cleanup easier.

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**Rolling Techniques**

The techniques for rolling round stars include subtleties that make it one of the more difficult aspects of pyrotechnics to master. Each type of star comp has different rolling characteristics, and even different rolling machines take some getting used to. The techniques of star rolling are difficult to convey through text, and the reader must ultimately spend a good bit of time actually rolling stars before mastering the process.

Begin by pouring your cores into your roller and starting it up. Give them a small burst of spray from your spray bottle, which may cause some of them to stick to the sides and begin rotating all the way around with the drum. This will usually occur with small, light cores like husked millet or pasta cores. Lead shot or molecular sieves should not cause this problem. Whenever you over wet the stars and they stick to the walls or each other, use your hands to scrape them off the sides and roll the damp cores around between the palms of your hands to separate them and distribute the moisture.

Your first powder increments at this early stage should be very small. Just enough so that the stars pick up all the powder and appear dry on the surface. Continue to alternate between small bursts of spray and small increments of powder.

It helps to avoid spraying the walls of the roller at this early stage, as comp will adhere to the wet walls instead of the stars. This will then result in clumps of composition on the roller walls that continue to grow as the stars grow, robbing composition from them. When the stars are larger than 1/4", a technique can be used to transfer the comp stuck to the bucket walls back onto the stars by spraying the patches of comp directly and let the stars roll over them. The stars will eventually pick up the overly wet comp off the walls, cleaning up the mess.

When the stars are still small during the early stages, spraying the sides of the bucket will cause them to easily stick to the walls and over wet them. A second method of cleaning the bucket walls involves just scraping the mess off with your hands and throwing it into the rotating star pile. The star pile is then rolled between the palms of your hands in order to grind up the larger chunks, which will fragment into tiny pieces that become new star cores. If your stars fall apart while doing this, then you are rolling them too dry. Add more solvent between powder increments.

When you look closely at the rolling mass of stars, you will notice that the larger stars are seen on top and to the front of the pile. The smallest ones are at the bottom and can be seen at the back corner and along the rising edge. This is an unfortunate characteristic, since it means the largest stars are in the best position for acquiring water and powder, while the stars that truly need to catch up in size are stuck at the bottom of the heap. The social injustice of star rolling causes the rich to get richer!

In order to keep the stars from developing into drastically different sizes, there are a few techniques that can be used. One method is to sweep your hand under the pile of stars and turn them over right before spraying them, then quickly adding the next powder increment. This brings the small stars to the top, but they won't stay there for long.

Another method of keeping stars at the same size works for certain types of compositions and can only be used once the stars are about 1/4" or larger. The method involves spraying the sides of the roller where the stars will be rolling, such that the stars on the bottom of the pile will roll over the damp areas and pick up the water. The powder is then applied to the rising edge of the pile, where the smaller wet stars can be seen coming out from under the pile. This method is quite effective at maintaining equal star sizing, especially with larger stars, but will not work with compositions containing fine aluminum powders that easily stick to the roller walls.

When the stars are still below 3/16" diameter, there will be a lot more junk that won't roll up, such as large aluminum flake or parlon flakes, in addition to scraps of comp that are continuously forming new stars. This is due to the light weight of

the stars combined with the small radius that particles have a hard time sticking to. These problems are less when rolling with lead shot, since the extra weight helps the stars compact more composition onto themselves.

Once the stars reach 3/16", it is a good idea to empty them out of the roller and screen out all the smaller stuff. The small scraps can be used as cores later if you do not get the quantity of stars that you desired. The 3/16" and everything above that size is returned to the roller for continued rolling.

As you approach the destination size of your stars, you can use a circle template or a drill bit guide to check their diameter to see when you are getting close. Once you are almost there, it helps to stop spraying the stars any further and add an oversized powder increment. Let the stars roll with the pile of powder riding on top of them until they pick it all up. This excess powder will wick some of the moisture out of the star and reduce the drying time. If they pick it all up and still seem heavy and overly damp, add another increment and walk away for a while. The surface of the stars should not be shinney or wet to the touch. They also should not stick to each other when the star roller is turned off.

Once the stars reach 1/4" in size, it is a good time to stop there and dry them before continuing further. The stars are poured out onto newspaper or preferably a screen that is held in a drying rack.

You will often want to put aside a quantity of 1/4" stars for use in color changing stars, then continue rolling a portion of them up to larger sized color solid stars. Some builders recommend that the thickness of new composition you roll onto a dry core not exceed the radius of the core. This is to help keep the star from getting too wet at the center and risk becoming driven in. Thus, the maximum stopping points would be 1/4", 3/8", 9/16", 13/16" etc. However, in most cases you want a range of stars that increase by 1/8", so you would add 1/8" thickness per rolling session. Stars may also be rolled from a core to 3/8" with no problems, or from 1/2" to 3/4". It really depends on the type of composition you are rolling and how wet you roll your stars.

There is another method of star rolling that involves adding oversized powder increments as mentioned previously, then spraying the stars repeatedly until they pick it all up. My experience with this method is that, while it is faster, it is harder to maintain good size control. However, it is a method that is used in industry to produce large quantities of stars, and can be very productive when used with a dozen or more star rollers running in parallel. In this case, a single operator can move along the line, adding powder to one roller after the other without having to waste any time waiting for composition to pick up. By the time he gets to the last roller, the first one has finished picking up the composition and is ready for more.

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Figure 4: Closeup of slightly spiked prime surface.

Figure 5: Air drying rack.

Figure 6: Forced drying box.

**Screening:**
It is important that all the stars produced from a given batch of round stars be as close to the same size as possible. Not only does this help the stars stack nicely when loading them into the shell, it is critical for simultaneous color changes and burn outs.

It is often difficult to keep all the stars the same size through rolling technique alone, thus they must be periodically screened during manufacture. Samples must periodically be taken while rolling, choosing the biggest stars and using a circle template to see if they have reached the destination size. Whenever a noticeable amount of stars have reached the final size, they must be screened out to keep them from growing too large. You may need to screen your stars two or three times during a rolling session if larger stars insist on developing ahead of the other stars.

**Priming:**
All stars should be fully dried before adding the final meal prime layer. This is because good meal powder is very fine and dries into a dense crust, which can easily cause a star to become driven in if there is moisture locked in below the prime layer.

Stars may not always become driven in by adding the prime right away after rolling the stars, but waiting until they are dry will speed up the drying time. The prime layer usually only requires about one day to dry when applied to a dry star, whereas adding the prime to a wet star can increase the overall drying time by a week or more. The degree that this phenomenon occurs is proportional to how finely powdered the meal powder is.

Meal prime is best applied with 100% water, and the powder increments should be a little oversized so that the stars are overly dry. This is to intentionally cause spiking on the surface, which creates a rough texture that aids in ignition and helps prevent the star from being blown out at high speeds. The spiking should be noticeable but not excessive, as seen in Figure 4.

**Drying:**
While stars may be dried by placing them on trays lined with newspaper, a more effective method is to place them on a screen so that the stars are exposed to more air. Wooden frames fitted with window screen are commonly used for this purpose, or even window screens which already have the frame on them. The stars are best arranged into a single layer, as opposed to piling them into two or more layers. This insures that all stars dry at the same rate.

When drying stars on screens, the drying is most effective if the screens are suspended in mid air rather than sitting on a table. The drying rack pictured in Figure 5 allows many screens to be suspended while consuming a minimum of valuable shop space.

After stars have air dried for several days, they may be moved to a drying chamber to speed up the final drying. Such "dry boxes" usually consist of an enclosed screen rack with an internal dehumidifier, a slight heat source and a slight air flow. Figure 6 shows one such dry box being used to "force dry" stars, the term given to the process of speeding up the drying process using controlled conditions.

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## Round Stars, Part II...



Trying to force dry round stars usually results in problems unless they are allowed to air dry in the shade for at least a few days. They may then be dried in the sun or placed in a drying chamber. If a star is placed in the sun or drying chamber directly after being rolled, the first 1/16" of the star will be dry within a few hours, then the rest of the star will take weeks or even months to fully dry. Trying to save time in this way often backfires and increases the dry time substantially.

Stars may occassionally develop cracks in the surface during drying, which can be caused by force drying compositions which slightly shrink upon drying. If the surface completely dries while the underlying comp is still fairly damp, cracks may develop. This flaw can often be repaired by putting the stars back in the roller and rolling them while re-wetting the surface with water. This same technique can sometimes be used to salvage driven in stars as well, except in the case where NC lacquer was used to roll the stars.

Stars containing barium or potassium chlorate should not be dried in the sun at all. Ultraviolet rays from the sun can liberate chlorine dioxide which will break down the chlorate into chloric acid, creating the risk of spontaneous combustion.

Stars containing nitrates in combination with aluminum or magnalium should also not be dried in the sun in order to prevent the acceleration of any aluminum/nitrate reactions.

**Storage:**
The most common method of storing round stars prior to shell assembly is through the use of plastic ziplock bags. These are cheap and easily labeled, and this type of non-rigid container has the flexibility to allow many stars to be piled into a small box or magazine. The only drawback is the potential for static buildup in dry climates. Always place your hand inside the bags to feel for any static charges before loading.

While not as common among hobbyists, a safer and sturdier container for star storage should be made of paper or cardboard, such as spiral wound tubes with caps or brown shipping boxes.

**Related Articles:**
Round Stars, Part I
Star Roller Reviews

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