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Tool Tip...

Gummed Tape Ball Shells

Figure 1: 1", 1.5" and 2" rolls of gummed tape.

Figure 2: A simple tape dispenser that wets the gum as it is dispensed.

Introduction:
The traditional pasting process of forming the outer casing of paper ball shells, which requires cutting thin strips of paper, breaking them in with paste and then painstakingly applying them one at a time for layer after layer, has always been a deterrent to those who don't have the time or patience to make paper ball shells. The entire process usually takes about 45 minutes just to make one 6" ball shell, and progressively longer as the shell size increases. Since paper casings have very high tensile strength while being very light weight, they invariably produce the most consistently symmetrical star patterns with a very low incidence of flower potting. While paper is the casing of choice for anyone wishing to make the highest quality ball shell, the time consuming and tedious nature of the pasting process drives many pyro hobbyists to use plastic shells instead. Plastic is far more finicky when trying to achieve consistent performance, as it requires a harder-hitting break charge that puts stars right on the edge of being blown blind. One gap in the glue joint or time fuse seal results in a flower pot. Even when everything goes well, plastic shells leave a field of sharp edged plastic shards that take many years to degrade and can be hazardous to the cattle that graze on many shoot sites. From an aesthetic viewpoint, plastic shells are also just plain ugly to look at and stink up your shop with the foul smell of solvents when building them.

In the quest for taking the tedium out of ball shell construction without resorting to plastic shells, the use of gummed tape to replace the layers of pasted paper has become quite popular in recent years. Gummed tape costs about the same as the equivalent sheets of virgin kraft paper, does not need to be cut into strips and is much cleaner and faster to apply. While gummed tape is not as strong as pasted virgin kraft paper, the burst charge is usually strengthened accordingly to compensate for this fact. A gummed tape shell that performs just as well as a traditionally pasted shell can thus be constructed in a fraction of the time. Now there is even a computer controlled bench-top pasting machine on the market for the pyro who has the money to spend, which automatically applies any number of tape layers to a whole range of shell sizes (known as the WASP3). Since gummed tape has been the commercial method of choice for domestic shell manufacturing for years, it is surprising that the WASP series of machines has not caught on more as a way to help compete against Chinese imports.

The method of gummed tape construction shown here is about the fastest manual method of making a paper shell that exists. A flash booster is used to reduce the required amount of tape layers to

Figure 3: Flash booster poured loosely into the shell after loading.

Figure 4: Setup for taping medium sized shells.

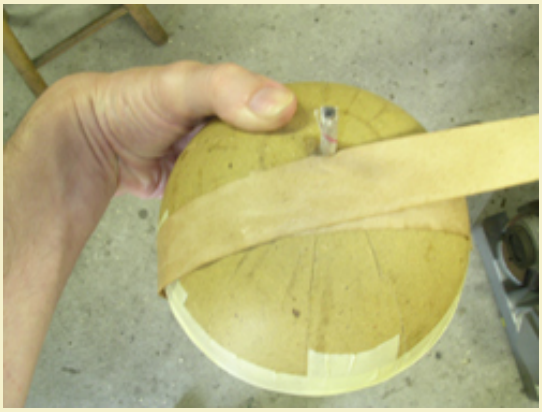

Figure 5: One loop around the shell.

about half, so you save both tape and time while spending a little more money on the burst charge. The tape dispenser and roller tools seen in this article can be built as described here. Gummed tape is ideal for shells 6" or larger, but tends to be more difficult with smaller shells since the tape does not lay down as well on a tight curve as pasted paper does. For smaller shells it is best to just stick with the traditional pasting method, which goes pretty quick on small shells anyway.

NOTE: due to the decreased number of layers and lowered strength of the gummed tape casing, vacu-form hemispheres can not be used to build this type of shell. The casing would be very susceptible to getting crushed from the lift force if using vacu-form hemispheres, so commercial hemispheres are required.

Loading the Shell

The shell is constructed just as it would be if you were going to paste it in with paper. If you normally use KP on rice hulls or puffed rice cereal, you can actually drop back to BP on rice hulls or puffed rice and save some money there. The flash booster has quite a kick to it, so the hull charge is mainly just for filler and to increase flame propagation. The flash used here is a mixture of potassium nitrate, aluminum and sulfur given here. While not as strong as a perchlorate flash, this mixture still has plenty of thump and all the same sensitivity to static, so take the same precautions.

The flash is simply poured loosely into the center of each hemisphere after it has been loaded, as seen in Figure 3. If the flash piles up too high at the center, it can be spread out as needed or you can tap the shell so that it settles. For a 6" shell, 20 to 25 grams of flash are used. For an 8" shell, 40 to 60 grams are used. I go with the low number on my shells, but it depends on how strong or thick your gummed tape is and how big you want the shell to break. Note that this flash booster is a critical component, and trying to substitute with KP or a few more layers of gummed tape isn't going to give good results. The hard break provided by the flash is the key to making these shells work, just like with plastic shells. The gummed tape is really just there to give a minimal amount of containment and help prevent the shell from being sheered in half during the lift.

The shell halves are closed in the standard way, using a sheet of tissue over one half to hold the contents from spilling while inverting it onto the other half. The excess tissue is torn away and the seam is taped closed with two continuous bands of masking tape.

Taping the Shell

If you have a good virgin kraft type of tape, you can actually get away with using 30lb tape, which lays down with less wrinkles than the 60lb tape being used here. I prefer the 60lb tape however, since it is easier to find average quality 60lb tape than high quality 30lb tape. The tape being used here is from Intertape Polymer, which was recommended to me by Jeff Doty (who also uses it to his own shells). For 6" shells the strips should be 1" wide, while 8" shells can use a 1-1/2" wide strip and larger shells can use 2" wide strips. As with pasting, the larger the shell is then the wider the strips can be without running into excessive wrinkling problems.


Figure 6: Strips crossing the opposite pole.


Figure 7: Several passes around the shell.


Figure 8: One complete layer before rolling out the wrinkles.

A tape dispenser similar to the one shown in Figure 2 is necessary when taping shells as described here. This dispenser will allow one continuous strip to spool out and pass through a container of water, passing between a set of sponges inside the container so that the gum side of the tape is wetted when it comes out the other side of the container. Instructions for building this tape dispenser can be found here.

The dispenser is clamped to the edge of a table as seen in Figure 4, while the shell is held by the worker in a standing position. For larger shells, the alternate setup using a tripod of roller bearings to hold the shell is used, as seen in Figure 15. This setup is discussed more below.

The tape is started to the right of the time fuse and looped around the shell so that it passes directly over the opposite pole. When the tape returns to the pole it started at, it must be guided a little off center, since the crossing points will be off to the right side of the time fuse. Figure 5 shows how the first loop looks when completed.

Each loop of tape will overlap the previous loop by one half at the equator, so as you begin the second loop it will start by covering the previous strip by 100% and then angle away from it so that by the time you reach the equator only 50% is covered. Then as the strip heads back up to the opposite pole, it is angled back in so that by the time it crosses the opposite pole it crosses directly over the previous strip. The concept is easy when you see it, but difficult to describe with words. Another way to think of this process is that you are basically "spiking" the shell using a strip of paper instead of string. So you would run the paper in a crossing pattern just like you would if you were spiking a canister shell.

Figure 6 shows show what the crossing point looks like on the opposite pole, while Figure 7 shows several loops completed. You will notice that since the paper overlaps more at the poles and less at the equator, you will get an egg shaped buildup of paper. However, the amount of buildup for just a single layers is not that noticeable, and will not effect the symmetry of the break because 1) you are only applying three layers, 2) the buildup points will be moved to a new location on each layer so that they are symmetrically distributed and 3) the shell is being hit hard with a flash break and is thus less sensitive to inconsistencies in the case wall.

Once the taping pattern has worked all the way around the shell and back to where it started, tear off the strip and roll the shell around on the table to get out the wrinkles. Figure 8 shows what a layer looks like before smoothing out the wrinkles. Note that there are more pronounced wrinkles on one half of the shell while the other half is a lot smoother. This is because one edge of the strip lays down flat as you apply it, while the other edge usually doesn't. To flatten out the wrinkles, simply hold the shell firmly against a table top while rolling it around. Figure 9 shows the first layer after flattening, which really isn't noticeably egg shapped.

The next layer is started with the poles located on the equator where the shell seam is. This layer is a little more tricky to apply, since you

Figure 9: First layer after rolling out the wrinkles.

Figure 10: Starting the second layer, using a reference line to help locate the proper poles.

Figure 11: Tearing the strip to work around the time fuse.

no longer have the shell seam or time fuse to help guide you. It helps to draw a line perpendicular to the direction you will be applying the strips, as seen in Figure 10. This line helps show where the crossing points should be, otherwise it is pretty easy for the poles to slowly drift out of place and really mess up the tape pattern. When doing the second and third layers, you also have to work the tape around the time fuse when the strip progression reaches it. The best way to do this is to just tear the strip in half right where it reaches the fuse, then replace it on the other side as seen in Figure 11.

The third and final layer is also located on the equator, but perpendicular to the previous layer as seen in Figure 12. Figure 13 shows the completed shell with circles around the spots where the crossing points overlap. This pattern places the buildup points at six equally spaced locations on the shell.

When using 60lb tape, three layers is about the most you can put on the shell before it will no longer fit in the mortar. This is because the crossover points at the poles will have so much buildup that they fully occupy the available clearance around the shell. There will still be space between the buildup points to route your shell leader down to the lift charge without worrying about the shell not fitting in the mortar, but care must be taken not to run the leader right over one of the humps.

Taping Larger Shells

When you start getting up to 8" shells and above, the weight of the shell becomes very tiresome to try and tape while holding it in your hands. The rolling fixture shown in Figure 15 allows you to rest the shell in this cradle and spin it as you work, making the process much easier. The plans for building this fixture can be found here.

When using a rolling jig to hold the shell, the time fuse can not be installed until after the taping is complete, since the fuse would continually get in the way of the roller bearings. Thus when loading the shell, the time fuse is not glued in place. Instead, a hollow tube with tissue paper glued over one end is hot glued over top of the time fuse hole. Once the shell is closed, a flat head nail is placed into the hole and covered with a piece of masking tape as seen in Figure 14. This allows you to find the fuse hole using a magnet after the shell has been taped in. If you don't have a nail head large enough to keep the nail from falling into the hole, you can put a washer under the head. The washer also provides some extra metal to help with the magnet detection.

Immediately after the shell is done being taped, the nail head is located with the magnet and marked with a circle. A sharp utility knife or Exacto blade is then used to cut out the circle so that the nail can be removed. Care must be taken to be sure you have the right spot, otherwise you will be cutting a hole in the side of your shell!

After the nail has been removed, 2Fg black powder is poured into the hole until the tube is filled to a level that allows the time fuse to stick out a at least 3/4" from the shell. The inside end of the time fuse can not be cross matched, so you will just cut it at a 45 degree

Figure 12: Starting the third layer, using another reference line to help keep the strips in the proper pattern.

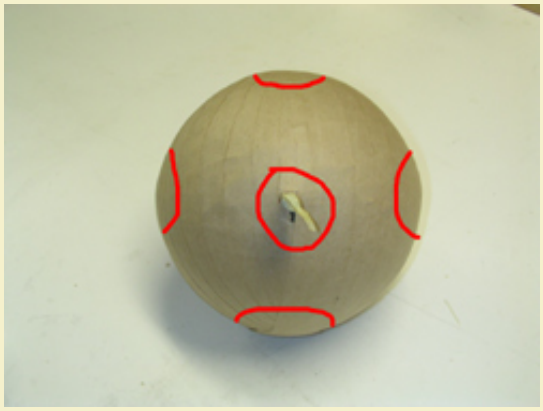

Figure 13: Completed shell, with red circles showing where the overlapping buildup points are located.

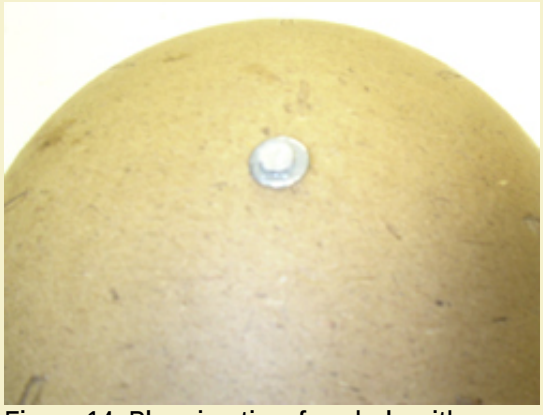

Figure 14: Plugging time fuse hole with a temporary nail before taping an 8" shell.

angle and push this solidly into the black powder grains. The timing interval will be measured from the center of the 45 degree cut, then the other side of the fuse will be cut at least 1/4" longer than the timing interval so that the outside end can be cross matched in the usual way.

Once the time fuse is inserted, a generous amount of hot melt glue is sealed around the base to make sure no fire sneaks in around the fuse and sets off the shell during lift. The glue should be coned up around the base of the fuse also, which helps keep it from being blown into the shell.

More Shells, Less Time

After some practice getting used to applying the continuous strip pattern, you will find that a shell that might have once taken 45 minutes to paste now only takes 10 minutes to tape and the performance is exactly the same! Even a die-hard traditionalist will have a hard time arguing against that kind of productivity gain. It is interesting to note that all the big 16 inch brocade shells that appeared in the 2006 PGI convention were gummed tape shells, so there is no size limitation with this method either. Personally, this is how I build all my shells 6" and up now. Once you experience the speed, you just can't go back to pasting!

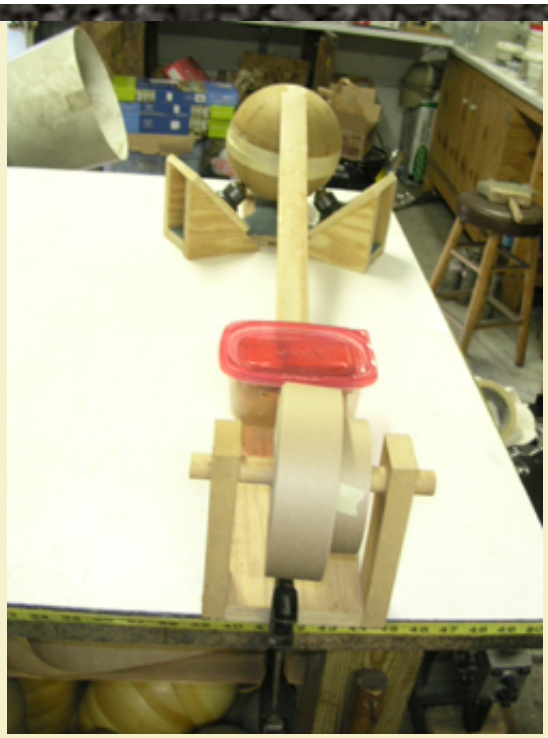

Figure 15: Taping setup with a rollnig jig to aid manipulation of an 8" shell.