BUCKET PROP READMEFILE.DOC by Fred H. Rash 14Jan 2013

A well-known, simple, yet surprisingly effective method for making propellers for rubber models is the can or cylindrical prop. Cylindrical or can props are made by soaking thin sheets of balsa in hot water and molding or forming the blades on a cylinder or can with the prop blade tip pointed up and 15 to 20 degrees left of vertical. The wet blades can be dried at room temperature, dried in a conventional oven, or if the form permits, carefully dried in a microwave oven. The dried blades are then attached to spars or to the hub using a pitch gauge. The blade angles are usually chosen to match a helical pitch distribution as closely as possible for the entire length of the prop blade.

A bucket prop is molded on a bucket or tapered cylinder (or cut from a tapered cup) just as a cylindrical or can prop is molded on a cylinder or can. While there are many published plans showing prop blades cut from foam cups or yogurt or cottage cheese cups, I have seen few articles that describe how to design these propellers. Some references are listed below for anyone who is interested.

An Excel 2010 spreadsheet is provided to help design bucket props. In the light blue cells, fill in your desired prop diameter, prop pitch, and the inner tip or distance from the prop shaft to where the prop blade begins. The inner tip is typically 10-20% of the prop radius.

Next fill in the size of your cup or bucket form in the next column of light blue cells. The average diameter and height of the cup or bucket should be about the same as the prop radius or prop blade length. For indoor duration, frequently the best form will be fat, but more sharply tapered than a typical bucket. Enter the top diameter, bottom diameter, and the slant height (the almost vertical distance measured on the surface of the cup or bucket).

The spreadsheet will calculate the blade angle of the prop at 10 points along the prop radius. The blade angle measurement assumes that the prop blade is being attached to the hub and/or spars on a horizontal work board with a temporary vertical prop shaft. The blade angle is measured between the work board and the underside of the prop blade. The prop, if rotated in the intended direction, would advance up and away from the work board.

The spreadsheet will also adjust the left tilt angle on the bucket (theta) and slide the prop blade up and down between the top and bottom of the bucket form to the achieve the best fit of prop blade angles.

If “Solver” Add-In is active in your Excel program, click on Solver and the numbers in cells F9, F10, and F11 will all be adjusted to give the best fit of your desired prop blade to your available cup or bucket. This minimizes the error between the helical blade angle and the angle given by the form. The errors are squared and summed into cell F15. When nothing changes on clicking Solver, the prop blade is fitted as well as possible to the bucket form that you used.

If you can’t get Solver working, change the numbers in cells F9, F10, and F11 to minimize the error in cell F15. Watch the plot just to the right of these cells. You can optimize manually, but it will be considerably slower. You can find or make other conical forms, cups, or buckets, if your first selection did not give a good fit. A good fit will be obvious when looking at the plot (or the error sum).

Solver will be very useful for other applications and you may want to work hard to have it active.

INSTALLING THE SOLVER ADD-IN

Enable Macros to run in this spreadsheet. You will also need the Solver Add-Inand might need to find the Excel or Office CD to be sure that Solver is loaded and active.

If your computer has Excel 2010 (or Microsoft Office 2010), try these instructions for installing and using the Solver Add-In in Excel 2010:

http://office.microsoft.com/en-us/excel-help/load-the-solver-add-in-HP010021570.aspx

This will help install Solver. After that, it can be run by clicking on the Data Tab, looking in Analysis, and Solver should appear near the upper right of your spreadsheet. If you can get this far, clicking on Solver will quickly change variables (prop blade left tilt angle theta on form, distance from top or bottom of form, and pitch angle of prop tip on pitch gauge) to make the target blade angles and the actual blade angles on the bucket form converge. You still need to know what pitch and diameter and inner tip of the prop blade that you want, and you may have to try more than one candidate bucket, cylinder or conical form. Start with the average bucket diameter about the same as the prop radius.

Fit can or cylinder props by entering identical diameters for top and bottom of the bucket. A quick calculation shows that the prop tip always should be pointed toward the top (larger end) of the bucket; poorer prop designs result from the reverse. While this program assumes a helical prop as target, it will also optimize the fit to a non-helical pitch distribution if the target angles are known and are stuffed into the spreadsheet. Since this program assumes that the prop blade has the same width fore and aft of the spar, a flaring prop with more area ahead of the spar also can alter the fit of blade angles, but that calculation requires a more complex analysis than this one.

Some of you will mold blades on a conical form or cut foam blades out of a coffee cup.

So far as I can tell, all bucket or cone props differ slightly from helical props, but the error can be made small enough to ignore.

HISTORY

The first publication on cylindrical props known to me was Jim Baguley’s LAST RESORT design in 1960 (Ref. 1). There are many other instructions for can props such as Chernoff (Ref. 2, 3), Meuser (Ref. 4), Williams (Ref. 5), Tenny (Ref. 6), Garber (Ref. 7), and Linstrum (Ref. 8). A cork form with a cylindrical surface for molding indoor prop blades was sold by Jim Jones (Ref. 9).

The most definitive article that I have found on bucket or cone props appears in the National Free Flight Society Symposium Report for 1996 by AntiiJolma and Kai K. Halsas of Finland (Ref. 10).

Before I saw this, I provided a program to the NFFS Symposium Report for 1995 (Ref. 11). My BASIC program had some math errors. While some of my math was incorrect, the practical effect of the errors may or may not be significant, depending on the prop needed. Later I used the equation from Jolma and Halsas. Bucket or cone props are always compromises and approximations but fit the blade angles to a helical pitch distribution better than a can prop does. The goal is usually a quick, but not very dirty, prop design.

After all the above, I began to try to find out the origin of the cup prop concept since clearly I was a latecomer to the method. Email information from Don DeLoach, Dean McGinnes, and others helped in learning more about the history of the concept.

Don DeLoach's "Celtic" Bostonian article (Ref. 12) first made me aware of cup props. He emailed that the concept was originated by the late Jim Clem and first appeared in Al Backstrom'sMaboussinHemiptere Peanut, Model Aviation, April, 1987 (Ref. 13). The article by Al Backstrom first made this prop concept widely known and credits Jim Clem with originating the yogurt cup prop for Bostonian and Indoor Scale models.

This drawing of the cup prop appears to place the tip of the prop blade at the wrong end of the cup or bucket, but I should be reluctant to say that Jim Clem, who helped and encouraged me a lot, did it wrong. There may be subtleties in prop camber or blade shape or something else that I have missed. In any case, Dean McGinnes emailed that he found several years ago that the props with the blade tip at the larger end of the cup or bucket performed better.

Jolma and Antti found that a cone with a 30 degree angle was a useful "best" form for many props. I found that an average diameter of the bucket equal to the prop blade length was useful and helped eliminate props which gave an angular "fit" but had either excessive blade camber or hook. The two "answers" are similar.

REFERENCES

(1) Baguley, Jim: "LAST RESORT" design in Model Aircraft, 1960, pp. 154. This design began in 1956.

(2) Chernoff, Max: Form for Bent Propellers, 1964-65 Model Aeronautic Year Book, Edited by Frank Zaic, Model Aeronautic Publications, 1965, pp. 198-200.

(3) Chernoff, Max: A proposed method for designing low advance ratio propellers, NFFS Twenty-Fifth Annual Report 1992, pp. 15-22.

(4) Meuser, Bob: Can-Formed Prop Blades, NFFS Symposium, 1973, pp. 28-33 and Indoor News and Views, January 1993, pp. 18-20.

(5) Williams, Ron: Building & Flying Indoor Model Airplanes, Peregrine Smith Books, Salt Lake City, 1984, p. 258.

(6) Tenny, Bud: Indoor Column in Model Aviation, August 1988, p. 157 and October 1988, pp. 62, 168. Bill Henderson's version appeared in Bud Tenny's column for December 1989, pp. 76, 187.

(7) Garber, Lester W.: Designing & Building Indoor Propellers, April 1991, 2324 East 5th Street, Duluth, MN 55812, pp. 11-16.

(8) Linstrum, Dave: Free Flight News Column in Model Airplane News, July, 1980, pp. 61-62.

(9) A cork prop form with cylindrical surface and 3.1-inch radius was sold by Jim Jones, 36631 Ledgestone Dr., Clinton TWP, MI 48035. (Mine worked well until charred in the microwave.)

(10) Jolma, Antti and Halsas, Kai K.: "A Universal Forming Block For Propeller Blades," in the National Free Flight Society Symposium Report 1996, pp. B1-B6.

(11) Rash, Fred H.: "Bucket Prop Design Program", 1995 NFFS Symposium Report, pp. M1-M8.

(12) DeLoach, Don: Bostonian Celtic, Model Builder, March 1990.

(13) Backstrom, Al: MaboussinHemiptere Peanut, Model Aviation, April, 1987, pp. 63-65, 85, 88, 162. According to an email message from Don DeLoach, Jim Clem originated the yogurt cup prop for Bostonian and Indoor Scale models and this article first made this prop concept widely known.

(14) Thanks are due to John Barker in England and to Bill Gowen in Atlanta. John Barker showed me how to link command buttons, macros, and tools like Solver together while I had only used them separately. He also showed me that three cells could be optimized with a single call to Solver. Bill Gowen tested the spreadsheet. Then he altered the target blade angles in a copy of the spreadsheet to give the tip washout he wanted.