Canopy Forming for Homebuilders

by Jim Miller, SAA 2256

Acrylic plastic-one trade name is Plexiglas — is the basic material used to make almost all aircraft windshields, windows and canopys.

The specifics of the various methods used to form flat sheets of plastic into usable, optically transparent and durable aircraft parts have mainly been closely held within the province of a few large manufacturers.

However, the techniques can be learned and utilized by the homebuilder. The techniques are almost always very labor intensive to set up, but are not necessarily of great cost or complexity. The K.I.S.S. principle certainly applies.

This article will hopefully entice others to chose to learn how to utilize a process generally defined as vacuum powered hot plastic slip forming. It is closely related to the deep drawing techniques used in the auto industry to cold form very large, but very thin, sheets of steel into finders, hoods, roofs and deck lids for today's beautiful automobiles. Why not adapt their techniques to make optically useful parts for our aircraft?

There are essentially three general methods of producing the compound curved transparent parts of our aircraft:

1. STRETCH FORMING - Where a sheet of heated plastic is pulled down or over, or allowed to collapse onto, an optically correct male form. The male form controls the inside contour of the plastic part desired.

The only real advantage of this process is that only a male form is needed.

The disadvantages are many, and include requiring the male form to be constructed strong enough to resist the large forces exerted by the mechanical equipment that is needed to stretch many lineal inches of plastic in one direction. That force may reach many tons.

Additionally, minor dirt particles on, or minor deviations of the molds exterior surface, will show up as optical defects (mark-off) on the concave inner surface of the part. Such defects are very difficult to remove by later efforts using abrasives and polishing products.

Other problems are excessive thinning of the plastic at the deepest portion of the formed part and the introduction of severe internal stresses that usually result in early failure when the part is exposed to sunlight.

2. FREE BLOWING - Where heated compressed air is used to stretch preheated flat plastic thru a shaped opening. The shape of the opening determines the lengthwise shape of the part which is otherwise a series of half circles. The diameter of these half circles is equal to the width of the opening in the form board. The maximum height that is practical is about one half of the width of the widest form board opening.

This process produces the very best optics because nothing but air touches the plastic while it is hot and pliable.

However, the final use of the formed part is usually just the front two thirds. The rear end must be cut off where it is wide enough to fit the fuselage aft of the cockpit. Thus a major portion of the original plastic sheet is wasted.

One of Jim's canopies installed on a Pitts S-1. Note that canopy was installed without using the full 24" of travel available in the ball bearing track.

Don and Ann Pelligreno's very rare Fairchild XNQ-1 showing the windshield and canopy Jim and his crew formed for this tandem seat military trainer. A plastic sheet measuring 6'x8'x¼" thick was required for installation. Aircraft was at SAA's first Get-Together at Frasca Field in 2002. The XNQ-1 will be at Frasca Field for SAA's third Get-Together.

Above – Plug for the Fairchild canopy. Part of the original canopy was used supported by foam and plaster plus plywood formers. Surface was brought back using multi color soft primer canopy shows and a block sanding technique. Right – The special oven required for the XNQ-1 canopy. Eight people were needed to complete this one-off project.

The process always results in major thinning of the top portion of the part. Frequently, the top may be only 25% of the thickness of the original sheet, and this requires starting from a much thicker sheet. It is not unusual to throw away 50% of the original weight of the sheet.

Cycle time to produce a part will frequently take several hours to mount the plastic, heat it, form it and let it slowly cool while maintaining appropriate pressure within the formed part so it does not change shape as it cools.

Other problems include the variation in thickness of the plastic sheet as supplied by the manufacturer, which can cause the half circle cross section to not have a symmetrical radius about the aircraft centerline.

The oven required for this process must be of extreme size and volume to allow the plastic and the long form boards to be accommodated.

3. SLIP FORMING OR DRAWING HOT PLASTIC INTO FEMALE MOLDS.

This process uses plastic sheets that are barely a few inches larger than the finished part's surface area. Also, very little thinning occurs. Also thinner sheets of plastic may be used. Both minimize material cost.

The finished mold made from the plug. Black areas are sealing surfaces where the plastic is sealed to the mold so that a vacuum can be created. One of the vacuum pumps used is at lower right.

The plastic sheet is heated in a small oven requiring only about 6000 watts of electricity — About what a kitchen range uses on Thanksgiving Day.

When the plastic is brought up to working temperature — about ten to twelve minutes in a 400 degree oven setting — the hot plastic sheet is removed from the oven and placed on the female mold cavity. The edges of the plastic are loosely sealed to the edges of the cavity and a vacuum is created within the mold cavity. A one quarter horse-power motor driving an automobile air conditioning compressor as a vacuum pump has been adequate for our work.

Atmospheric pressure very evenly and slowly pushes the plastic into the mold in thirty to sixty seconds. The operator throttles the rate at which the vacuum pump is allowed to remove the air from within the mold, stopping movement of the plastic just before the plastic is pushed tightly into the deepest part of the mold. If the plastic is held at this position for a few seconds, the plastic hardens and little or no mark-off is developed on the exterior of the formed part.

In the event that the operator lets the plastic touch the deepest part of the mold, significant mark off will occur. Fortunately, as this mark-off is only on the outside or convex surface of the part, the mark-off can be easily

removed from the part by use of abrasive paper and normal polishing techniques after the part is in use.

As the edges of the hot plastic sheet are allowed to slip slightly into the mold cavity as the plastic is pushed into the mold cavity by atmospheric pressure, the forming is accomplished by simple distortion of the sheet, with very little stretching occurring. This is the characteristic that minimizes the thinning of the plastic that occurs when other processes are used.

The obvious major advantage of this process is that it can create a uniform

Mold for Pitts S-1 canopy shows how sealing fixture fits into the mold. Foam provides uniform sealing pressure while allowing the plastic to slip into the mold.

A line-up of six completed Pitts canopies and windshields ready for shipment to builders throughout the country. In foreground is a BD-5 canopy that was not of good quality and the only one built. Photo taken in 1997.

JIM MILLER – ***First flight of his Taylor Titch was in January 1972. It was the challenge of making the canopy for this aircraft that led him to devising techniques that solved the canopy-making problems and eventually making canopies for many different aircraft — holding forums and sharing his hard won experience with fellow builders.***

Jim Miller, (EAA 6110, SAA 2256) at 70 is still an active supporter of the homebuilding movement (He has been since 1954). His hobby was kindled by a 1943 war bond drive when he got a 10 minute ride in a Civil Air Patrol Taylorcraft for buying a war bond with his paper route savings. He has always been concerned with making aviation affordable for the little guy on a fixed budget.

He has built or restored 28 aircraft since 1953. They have encompassed wood, tube and fabric, all metal and composite construction techniques. He is currently restoring a 1937 Ryan STA.

One project, an all wood Taylor Titch, was on the cover of the March 1974 issue of Sport Aviation after taking workmanship awards at Oshkosh ’72 and ’73. He has been a homebuilt judge at Oshkosh for thirty years, and a tech counselor since 1966.

He was a volunteer at the first Rockford Fly In, and has remained one since. His latest effort being successful in getting himself appointed as an amateur built DAR in January of this year.

He retired as Senior Professional Engineer in 1994. He had a colorful engineering career that encompassed the manufacture of Ford’s 2 passenger T-Bird and retractable hardtop in the 1950’s.

His career also included manufacturing nuclear weapons components, power mowers, electrical tools and cooling towers. He was involved with nuclear power plant design and construction just prior to his retirement.

He has written numerous “How to” articles published in Sport Aviation and Experimenter Magazines, with more in the works.

Aviation has always been his hobby. He has, for the most part, kept it barely self-supporting. But, as he says, “It has been my most rewarding endeavor”!!!

formed part to a predetermined shape that is repeatable. The shape also can be much deeper than it is wide.

Cycle time is only a few minutes per part if multiple sheets of plastic are heated in the same oven in proper sequence to avoid over heating.

The primary disadvantage of this process is the appearance of possibly unacceptable mark-off resulting from failure to control the final approach of the plastic to the mold.

Our experience is that using a shielded sixty watt trouble lamp, held by hand over the deepest part of the mold, allows the operator to observe the distance between a small balsa wood chip and its shadow on the mold to determine when to stop the movement of the plastic. The wood chip is placed on the plastic near the deepest point of the mold after the draw down movement is started — simple, but effective!!!!

This slip forming process has been our choice for nearly 40 years of fabricating many hundreds of single place Pitts S-1 and Acrosport canopy kits for homebuilders, as well as many custom jobs for my own projects and those of other builders. We have always strived to minimize costs. Our Pitts Windshield & Canopy Kits were originally sold for less than $200, which included the ball bearing tracks needed for installation.

The photos show the mold and oven that was make up to produce the T-28 sized canopy for the restoration of the Fairchild XNQ-1 by Don and Ann Pellegreno, then living in Story City, Iowa.

This project took a plastic sheet that measured 6 ft by 8 ft by 1/4 inch thick. This confirms that part size is limited only by the ability to heat and handle the hot plastic.

The equipment to manufacture a Pitts size canopy is readily portable by pick-up truck. In 1973, a friend transported it to Oshkosh. Daily demonstrations were made for those people who attended our forum. It is our intention to have the equipment at the 2004 SAA Fly In at Urbana, Illinois in June.

Plan to be there!!!

Flight of the Hawk

by Dewey Smith

The Geide Hawk, designed and built by retired Cessna engineer Dick Geide, made its first flight last summer and met or exceeded the designer's expectations. An exceptionally well thought-out design, actual construction time was about four years.

The homebuilt Hawk is a single place shoulder-wing monoplane powered by a Volkswagen engine. The fuselage is a welded steel tubing structure covering with Dacron, a more durable and builder-friendly fabric than the grade A cotton material used by builders for so many years. Length of the aircraft from spinner to rudder is 16 feet.

The wing structure is all wood with Dacron covering, workmanship is immaculate throughout, with much attention to detail both in design and construction. Wingspan is 21 feet.

The Hawk has a gross weight of 640 pounds, cruises at 93 miles per hour, and lands at 45 mph. The nine gallon tank and three gallons per hour fuel consumption gives the Hawk a range of about 250 miles, with some reserve. The Hawk is the third airplane Dick has built in the last 35 years.

Dick's first homebuilt, a very small VW-powered high-wing monoplane called the Headwind, was built in the 1960's, and I doubt that anyone has ever had so much fun for so many years with so small an airplane.

The second Geide homebuilt, the Geide Sport, was a parasol-wing monoplane (wing supported above the fuselage, allowing space for two open cockpits). With this two place airplane, Dick was able to share the fun of open-air flying with his family and friends... one at a time, of course.

The design and construction of small aircraft is a really creative endeavor, and flying such airplanes is a truly esthetic experience. It's real "seat of the pants" flying. We wish Dick many happy flying hours and many happy landings in the Geide Hawk.

The shoulder wing Geide Hawk is powered with a VW engine that gives the 21' span, single place aircraft a cruising speed of 93 mph. Below – Geide's first homebuilt was this Headwind he completed in the early 1960's. It provided hours of pure fun at very little cost.

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