Optical Polishing of Polystyrene Discs to Specific Dimensions

1.0: Purpose

To develop a polishing protocol which produces optically polished, dimensionally exact specimens of polystyrene. The polystyrene specimens should exhibit no surface scratches or deformation, exhibit parallelism between the two surfaces, and be as accurate to the final desired dimensions as 0.002" (50 µ). No induced specimen damage, deformation, or surface scratches should be produced during the specimen preparation process.

2.0: Experiment and Procedure

Polystyrene specimens of 2" diameter ranging in thickness were obtained for polishing experiments. Each specimen was first measured to determine the starting thickness and parallelism of the specimen. The following chart shows the measured values coupled with the desired values:

Sample	Initial Thickness (inches)	Desired Final Thickness (inches)
A	0.28	0.275
B	0.28	0.275
C	0.065	0.05
D	0.065	0.05
E	0.075	0.06
F	0.075	0.06
G	0.025	0.02

Specimens were to be prepared using the Model 155 Lapping and Polishing fixture in conjunction with the Model 920 Lapping and Polishing Machine. The Model 155 was selected for the specimen size requirement as well as the accuracy and precision it provides. The specimen mounting block was first planarized to the lapping wheel and the base of the lapping fixture by grinding on 320 grit SiC papers. This will ensure that a flat, parallel specimen is produced using the fixture. Following this planarization step the specimen was mounted to the specimen mounting block using double sided adhesive tape. No wax was used because the specimens were of a polymer type material, preventing the use of solvents for wax removal and heat for applying the waxes as is normally done for mounting specimens.

2.1: Equipment Setup

The equipment used for this process was a Model 920 Lapping and Polishing Machine equipped with a Model 92002 Workstation. The Model 92002 is a semi-automatic workstation which holds a lapping fixture in place while simultaneously turning the fixture during lapping. This helps create a uniformly polished surface and removes the operator from the machine, allowing the process to be automated. The Model 155 Lapping and Polishing fixture was used to hold the specimen and determine the amount of material being removed during each process step. A diagram of the equipment setup is shown below:

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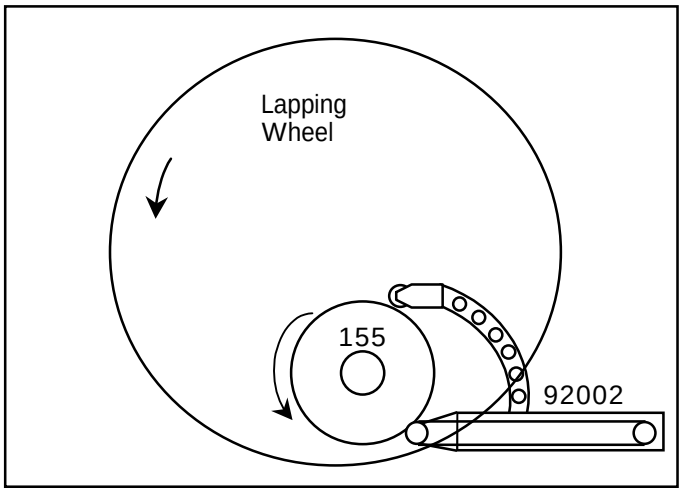

Figure 1: Illustration of the equipment setup used for this experiment. The Model 155 is rotated in the same direction as the lapping wheel, creating a uniform polish over the surface of the specimen. Both the fixture speed and lapping wheel speed are variable and additional load can be applied to the top of the Model 155, enhancing removal rate.

2.2: Polishing Protocol

Careful consideration of the polishing protocol was needed to ensure that a uniformly smooth specimen was produced without inducing any defects and to guarantee that the proper dimension is achieved on the specimen. The primary concerns for these softer plastic materials is deformation, polishing rate, and polishing uniformity. For this process, a polishing cloth which is short napped with firm backing is needed to prevent any non uniform polishing from occurring. All processes described below used a lapping wheel speed of 60 rpm and an arm speed of 7 on the dial setting. Each process step uses a dedicated polishing cloth for each abrasive grit size. This ensures no cross contamination is created which may hinder the polishing process.
Below is a description of the protocol used for these samples.

30 µ Al_2O_3 : The first step used was a rough grinding of aluminum oxide abrasive slurry on ShaneyPol Medium polishing cloth. This cloth is a firm backed pad without nap or flocked fibers to cause edge rounding. The Model 155 was set up to remove 0.001" (50µ) of material at this stage, Load: 100 grams; Total time: 15 minutes

22 µ Al_2O_3 : This step is used to polish out the 30 µ scratches and to remove more stock material. The same polishing cloth was used as with 30µ. The Model 155 was set up to remove 0.001" (50 µ) of material. Load: 100 grams; Total time: 20 minutes

5 µ Al_2O_3 : Polishing out the scratches created by the previous steps is done here to produce a smooth surface finish. . The same polishing cloth was used as with 22µ. The Model 155 was set to remove just under 0.001" (~ 20 µ). Load: 50 grams; Total time: 10 minutes.

0.05 µ Al_2O_3 : This is the final polishing step which produces the mirror finish. The polishing cloth used for this final step is a Synthetic Velvet cloth, with a short nap and thin fabric backing, producing a good polish and minimum edge rounding. Polishing time: 5 minutes.

Following this process on one side, the same process is repeated on the other side of the specimen, producing an identical surface finish on both sides. The primary area of difficulty is the removal of the specimen from the mounting block when the specimen is very thin. For the thicker specimens this was not a problem, but the thin sections had to be carefully removed using a very thin razor blade and mild soapy water to remove the adhesive residue from the surface of the specimen.

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3.0: Results

Following the protocol given above, high quality polishes of the surfaces of the polystyrene can be achieved with excellent tolerance to dimension. The chart below shows the measured planarity obtained with this procedure.

Desired Final Thickness (inches)	Final Thickness (inches)	Error (inches)
0.275	0.274	0.001
0.275	0.277	0.002
0.05	0.051	0.001
0.05	0.049	0.001
0.06	0.062	0.002
0.06	0.06	0
0.02	0.021	0.001

As can be seen in the chart above, almost all specimens were held to with a 0.001" tolerance, well within the required dimensional tolerance specified. The difference in value can be attributed to water absorption and changes in adhesion properties with the double sided adhesive and possible variation in polishing pad surfaces during polishing. In the future, the use of vacuum for specimen fixturing could possibly alleviate any deviation in thickness values. However, with the current setup it is very possible to produce high quality specimens of plastics which exhibit good dimensional accuracy and high quality optical polished surfaces.

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