Screw Pull-out Tests, Various Materials - Jim Scholfield 9/26/12

Our recent investigations on Rapid Prototyping prompted these tests.

I tapped 6-32 holes in several materials to evaluate pull-out forces and calculate shear strengths.

Materials checked: PVC, ABS, Delrin, UHMW(Blk), Polycarbonate, Sheet Acrylic, VisiJet Crystal(Projet 3500), GoEngineering Fused Dep. material and a fused dep. ABS based material used for a LRAUV mast.

Procedure: Using best shop practices, drilled and tapped 2-3, 6-32 holes in the various materials. Holes bored at least 2 diameters away from edges except the Visjet piece which was a provided earmuff frame with many cast spaces and edges.

The test system was an Omega DP 41 S with max. value hold coupled to a LC 101-200 (200 Lb.) load cell. System was cal'ed against known weight. The load cell was fitted with spherical ball ends and small shackles to eliminate misalignment side forces.

The test pieces had 6-32 eyebolts installed with 3 to 5 turns of engagement. (More turns often yielded forces in excess of range of load cell.) System vertically aligned in a mill with the driven knee increasing tension at 0.002"/sec. Material pulled to failure, max load recorded.

Material	Test#	Lbs. force	Turns	Shear Area	Shear Stress, ksi	
PVC	1	180	3	0.0294	6.1	threads failed
	2	173	3	"	5.9	"
ABS	1	104	3	"	3.5	"
	2	118	3	"	4.0	"
	2	201	5	0.0492	4.1	"
Delrin	1	262	3	"	8.9	"
	2	230	3	"	7.8	"
UHMW	1	88	3	"	3.0	"
	2	96	3	"	3.3	"
Polycarbonate	1	166	3	0.0294	5.6	thread failure
	2	201	3	"	6.8	"
	3	184	3	"	6.3	"
Acrylic	1	238	3	"	8.1	cone shaped mat'l failure

	2	218	3	"	7.4	"
Fused Depos.	1	81	3	0.0294	2.7	Thread failure
(ABS based)	2	76	3	"	2.6	thread failure
ProJet (UV cure	1	120	3	0.0294	4.1	cone shaped mat'l failure
VisiJet Crystal)	2	150	5	0.0492	3.0	"
GoEng., F. Dep	1	158	3	0.0294	5.4	Thread failure
(polycarbonate	2	176	3	0.0294	5.9	"
based mat'l)	3	188	4	0.0393	4.8	"

Assumption: Base Material is softer than the screw so shear area(failure area) is major Dia. of screw x ht. of engagement (0.75). 0.75 from a formula I have in my notebooks to more correctly represent the shear failure path. There are several approaches to shear from screw thread failure tests and I liked the reasoning and simplicity of this one.

Calculations: 6-32 major diameter=0.134"(measured), 1"/32 = 0.03125 inch/thrd

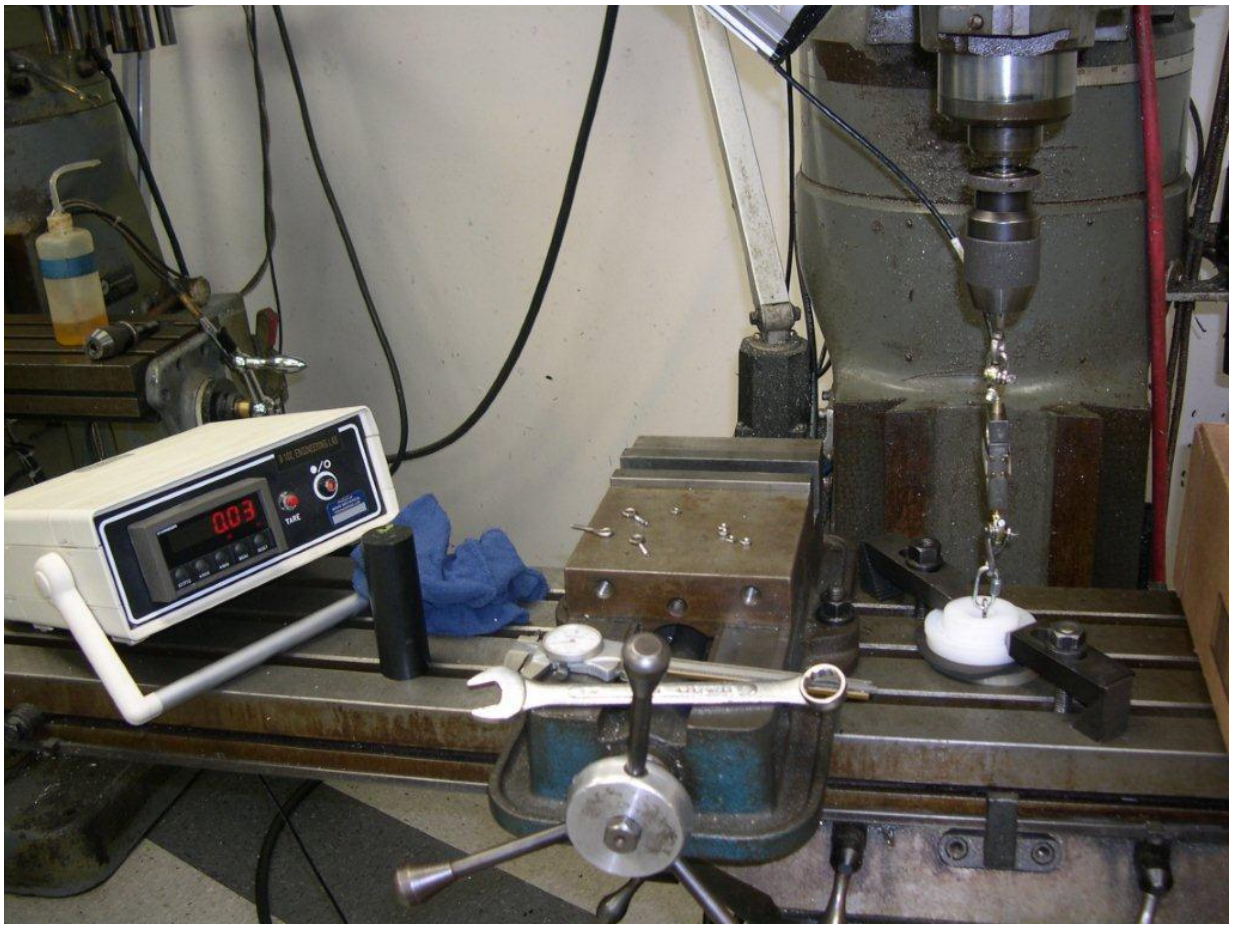
Shear area = 3.14 d x h, where d = 0.134" and h = 3T x 0.03125(.75) = 0.070" or 5T =0.117"

3T area = 0. 0294 sq.in.; 4T area = 0.0393 sq.in.; 5T area = 0.0492 sq.in.

Shear stress = Tensile load-Lbs/ Shear area

Published Shear stresses--Delrin 9.5 ksi; Acrylic (cast)- 9 ksi; Polycarbonate-5.4 ksi

My results are +-20% from published figures which seem reasonable considering the small thread engagement area used. It seems reasonable to look at relative differences as being representative of the materials tested. The VisiJet material in particular was stated as having a low (7%) elongation at tensile failure so a brittle (cone shaped) type failure was expected. The GoEngineer polycarbonate based material came out very close to published strengths for commonly available polycarbonate and much better than ABS based fused deposition parts.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