Testing adhesives for New Micro Magic

Summary

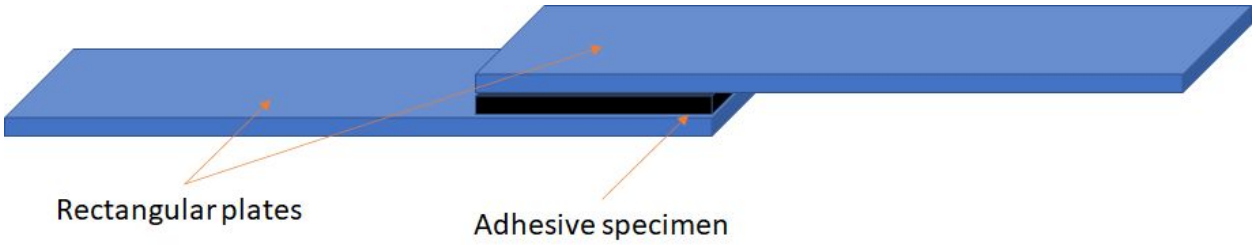
In this test a few different adhesives (=glues) are tested. The tests were conducted on materials supplied by Hacker, the manufacturer of the New Micro Magic.
All tested adhesives in this test (except UHU plast plus) are considered sufficient for gluing the PA12 keelbox to the hull. The connection will be marginally weaker than the combination in the Graupner Micro Magic.

Goal

The goal of this test was to determine what adhesive(s) are suitable to glue the keelbox of a NMM in the hull.mThe keelbox is made from PA12, manufactured with SLS additive manufacturing. There was suspicion this material could be more difficult to glue than the old ABS keel case. The hull is thermoformed from an ABS sheet.

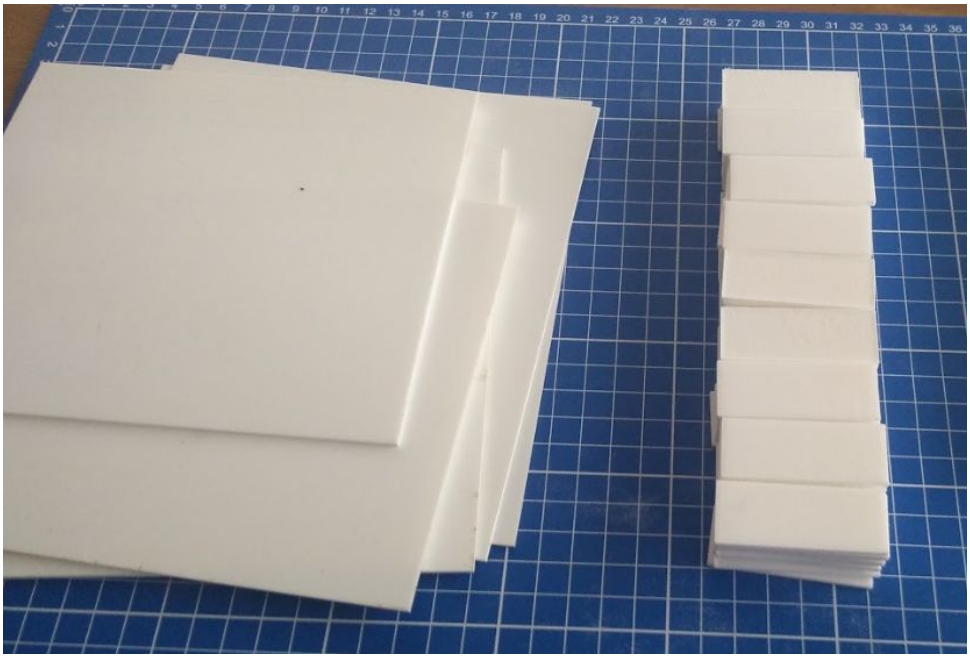
The method

Samples will be tested via the “shear lap” test method.
https://www.sciencedirect.com/topics/engineering/single-lap-shear-test
The single lap method was chosen, since this is a simple test to perform, and produces practically relevant information. The sample looks like this:



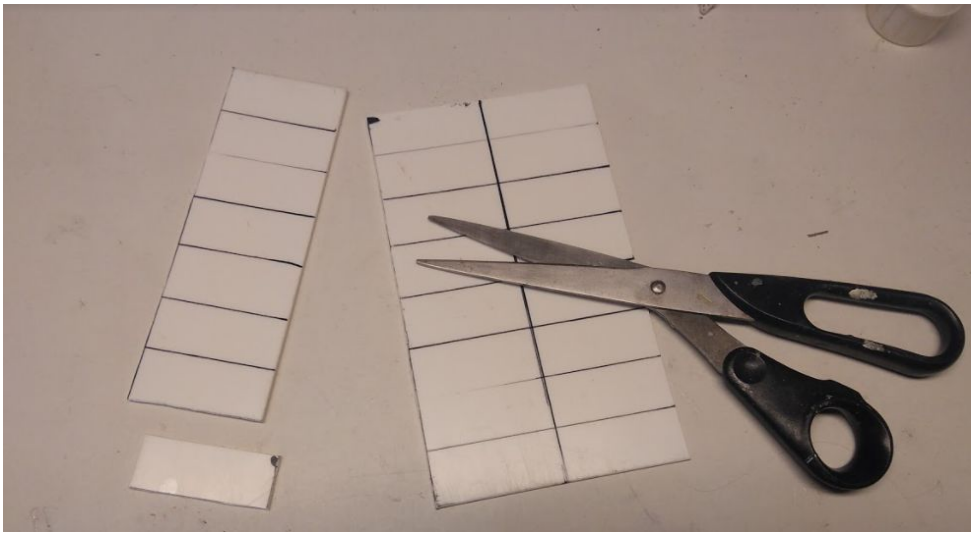
Test samples

Test strips of 20x50x2 mm were printed in the same material as the keelbox, which is PA12, also known as nylon. These samples were sent to us by Hacker, together with some ABS plates.



Test material

Test strips of similar size were cut out of the ABS sheet with scissors.



Cutting abs sheets

Test equipment

Tests are conducted with an Instron tensile tester with a load cell of 5000 N

Tested adhesives

The reference adhesive in this test, to which all adhesives will be compared to, is Bison Kombi Power (from now on abbreviated as BKP). This is a 2k PU (polyurethane) based adhesive, commonly used for keelboxes in the MM in the Netherlands, with a good reputation. Internationally it is less easy to obtain. 2k polyurethane alternatives are also not commonly found.

Bison Kombi Power

Another adhesive that was tested is “Hacker Super Glue Profi thick” (from now on abbreviated as HCAG). This is a cyanoacrylate based adhesive from cyberbond . A new and unproven adhesive in the MM scene, and will therefore be tested. This is used in the nMM ARTR, available from Hacker.acker.

Hacker Super Glue Profi thick

For further comparison, some other common used adhesives were tested:
Uhu Plus Endfest 300 (UPE) - 2k epoxy based adhesive

Uhu Plus Endfest 300

Pattex Stabilit Express (PSE) - 2k acrylic based adhesive

Pattex Stabilit Express

UHU plast special (UPS) was tested on its properties on ABS only. This is sometimes used for the deck - hull connection.

UHU plast special

Adhesion and cohesion

For an explanation of the terms “adhesion” and “cohesion” please check out the following link: https://www.adhesives.org/adhesives-sealants/science-of-adhesion/adhesion-cohesion
These terms will be used in the section below.

Test plan

For each combination, 4 samples were tested, to get some statistical information. One set was tested dry, one set was tested after a specific wetting procedure. Therefore 8 samples were be made of each combination.

The following combinations will be made:
ABS - BKP - ABS (4 samples, reference)
ABS - BKP - PA
ABS - CAG - PA
ABS - PSE - PA
ABS - UPE - PA
ABS - UPS - ABS

Sample preparation

Surface preparation is a key element in creating a strong bond. Therefore, the samples were prepared according to the following procedure:

1. Clean surface with Isopropyl alcohol
2. Sand surface with a coarse sand paper (80 grit)
3. Clean surface with Isopropyl alcohol
4. Glue and cure test sample according to manufacturer's recommendation
5. Cure 24 hours at room temperature

Sandpaper and ipa

6. Wetting schedule: submerge in water for 12 hours, dry for 12 hours, submerge 12 hours, dry 12 hours, submerge 6 hours, test

Preliminary test

To find out if the test as described above will give usable data, some preliminary tests were conducted with 3d printed PA from another supplier and ABS from the kit.

Sample in tensile tester

The tests showed that the adhesives surface could not be more than 100 mm2. More than that, and chances are that the sample will break before the adhesive. For a 20 mm wide strip, this resulted in an overlap of 5 mm.

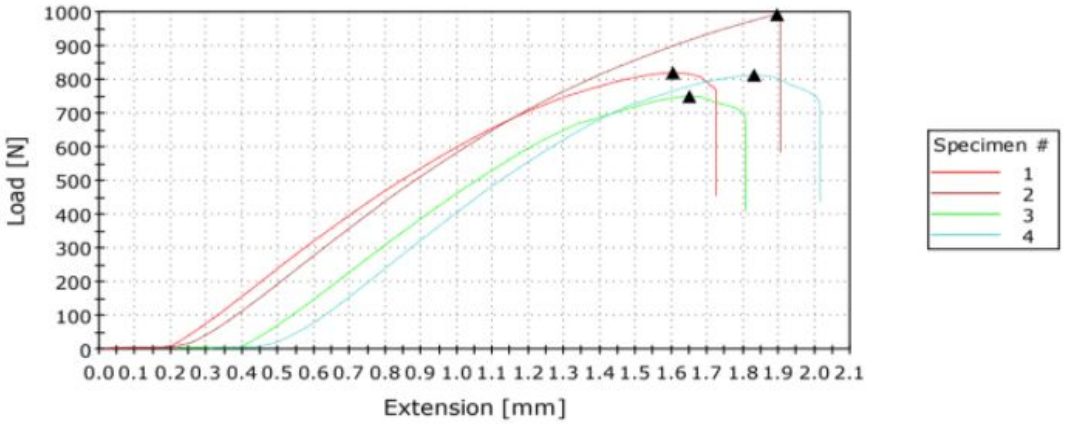
Sample where the material failed before the bond

Test results

All tests were performed under similar conditions.
The results are shown in the results below:

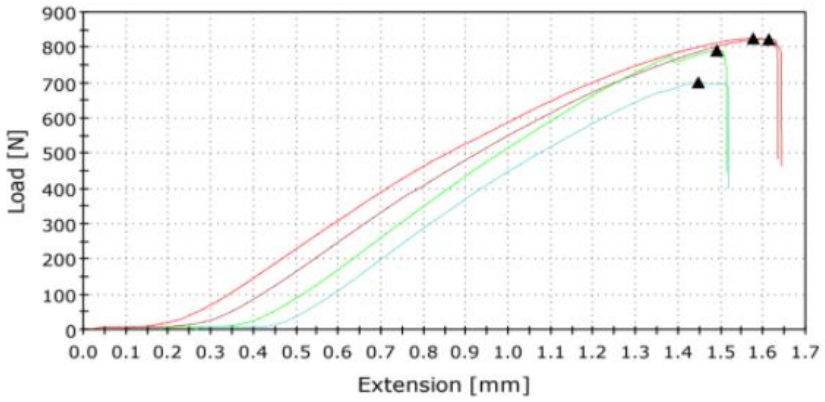
test #	mat. 1	adhesive	mat. 2	avg F [N]	st deviation	fail mode	remark
1234	ABS	BKP	ABS	840	11,76%	adhesion fail abs	reference, dry
5678	PA12	BKP	ABS	757,5	4,70%	adhesion fail pa12	dry
9 10 11 12	PA12	BKP	ABS	786,25	6,63%	adhesion fail pa12	48 hours in water
13 14 15 16	PA12	HCA	ABS	877,5	8,27%	adhesion fail pa12	dry
17 18 19 20	PA12	HCA	ABS	950	6,70%	material fail abs	48 hours in water
21 22 23 24	PA12	PSE	ABS	567,5	5,62%	adhesion fail pa12	dry
25 26 27 28	PA12	PSE	ABS	577,5	6,05%	adhesion fail pa12	48 hours in water
29 30 31 32	PA12	UPE300	ABS	416,25	4,44%	adhesion fail abs	dry
33 34 35 36	PA12	UPE300	ABS	590	14,43%	adhesion fail abs	48 hours in water
37 38 39 40	ABS	UPS	ABS	201,25	31,25%	cohesion fail UPS	very flexible
41 42	PA12	PCAG	ABS	690	4,35%	adhesion fail pa12	dry
43 44	PA12	9323	ABS	495	3,03%	adhesion fail abs	dry

It can be seen, that the way a lot of graupner MM's used to be glued in the Netherlands, results in a breaking strength of 840 N, and fails on the adhesion to ABS. Compared to the NMM material combination, strength is reduced by about 10%, due to the reduced adhesive to PA12.



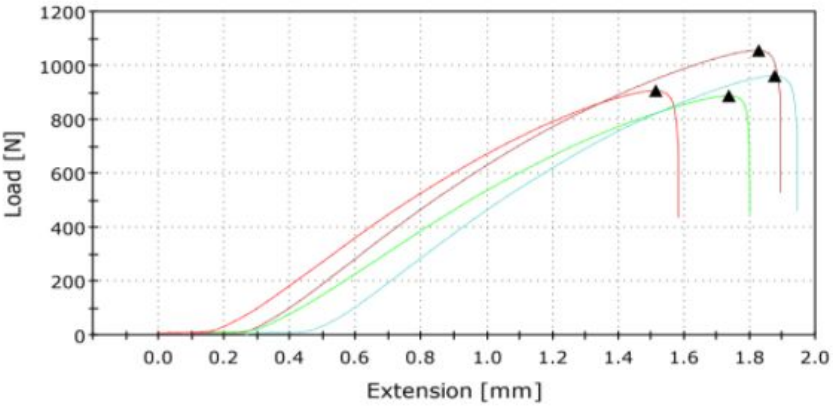
Force-deflection diagram test 1 2 3 4.

After 48 hours in and out of water, the average strength is 786 N. This is higher than in the dry samples. This trend can be seen with all wet samples. So wetting the samples does not have a negative effect on the strength. The higher strength could be explained by the fact that the dry samples were only cured 24 hours, while the wet samples were cured 24 hours + 48 hours. Longer curing time could result in higher strength, but this is just a hypothesis.



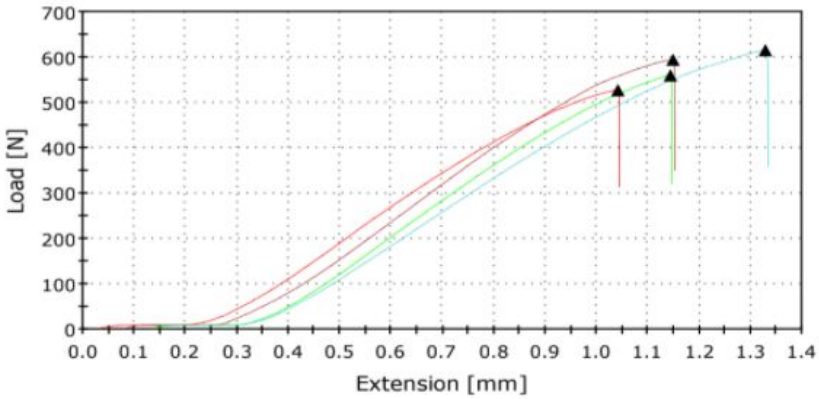
Force-deflection diagram test 9 10 11 12

The strongest adhesive in this test is the Hacker CA, with 877 N breaking strength. After wetting, the average breaking strength was 950 N. Note that the adhesive did not fail here, but the abs sample did. The breaking strength of the adhesive was greater than 950 N.

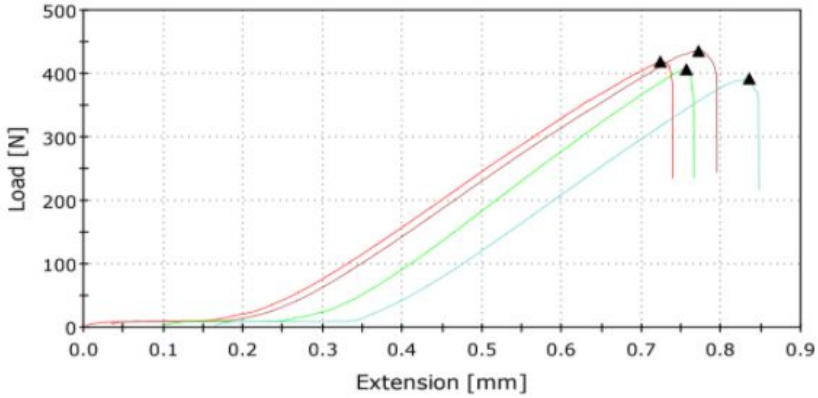


Force-deflection diagram test 17 18 19 20

Pattex stabilit Express and UU Endfest 300 performed ok, with average break strengths just below 600 N. This is considered to be sufficient for the application.

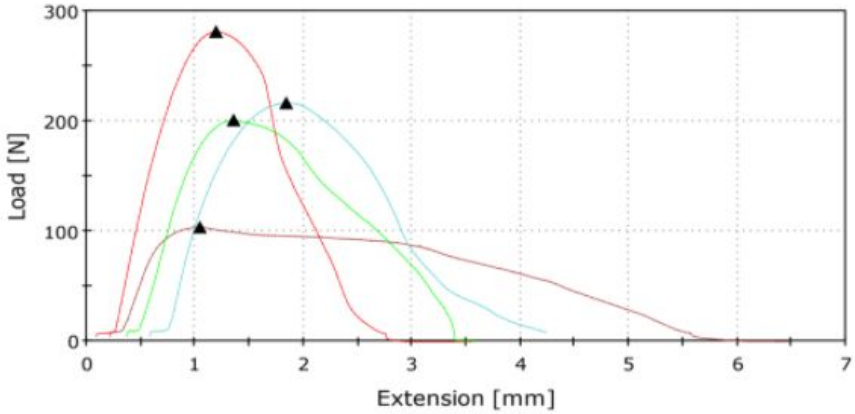


Force-deflection diagram test 25 26 27 28



Force-deflection diagram test 33 34 35 36

The lowest values were obtained with the ABS to ABS sample glued with UHU Plast special. This is not considered strong enough for the keel - hull connexion, but it has been used successfully for the deck hull connection. This adhesive is extremely flexible, failing only after millimeters of stretch, so it should be very impact resistant. It could also be used as an excellent sealant.



Force-deflection diagram test 37 38 39 40

Toughness

Toughness is the ability of a material to absorb energy and plastically deform without fracturing.
https://en.wikipedia.org/wiki/Toughness
A measure of toughness can be defined by the area under the stress-strain curve. From the curves from this test, no significant differences can be detected.

Test conclusion

Adhesion to PA12 with Bison Kombi Power is reduced with about 10% with respect to ABS. This is not much and should not lead to problems.
Hacker CA is stronger to PA12 then bkp was to abs.
Pattex stabilit Express and UU Endfest 300 were less strong, but probably still sufficient.

Based on the results from this test, there is no reason to assume the use of Hacker CA would be problematic in the usage of the keelbox-hull connection.