Optimum Aluminium Sheet Alloy for Panel Manufacture

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Abstract

Ayres Composite Panels produces AYRLITE® composite panels which consist of a variety of aluminium honeycomb panels combined with specialised assembly systems. The panels suit a selection of applications including the interior fit-out of marine craft, rail cars and other recreational vehicles.
Currently Ayres Composite Panels employs 0.5mm 5052 H38 Aluminium sheet for the exterior skin of the AYRLITE® honeycomb panels which was recommended by clients but never known to be optimum. The project involved the study of various other aluminium sheets to obtain the optimum aluminium sheeting that maintains the cost and corrosion resistance properties of the 5052 alloy while improving the panel's impact resistance. This was achieved through obtaining sample alloy sheets, which will be made into honeycomb panels before being tested with an impact test rig. The alloys mechanical properties were also investigated to establish a relationship between physical properties and impact performance. Improving the panel's impact resistance would lead to a higher quality product and may lead to wider applications or business opportunities for Ayres Composite Panels.
The investigation found that the panel manufacturing process has negligible effect on the alloy skin's mechanical properties and that the optimum panel skin alloy when considering price is the 5052 H38 that is currently in use.

1. Introduction

The impact performance of the AYRLITE® aluminium honeycomb panels was unknown. The objective of the project was to quantify the effects of skin alloys and their thicknesses on the impact resistance of the panels. Findings from the study would allow Ayres Composite Panels to make informed decisions when choosing a suitable alloy skin. A panel with superior impact resistance or lighter overall weight may also result.

The 5052 H38 alloy currently used by Ayres Composite Panels was recommended to the company by clients. Its performance in terms of resisting impact indentation had never been evaluated. There is very little information published on the impact resistance of sheet metal in honeycomb panels.

This project aims to form a base of knowledge of some of the factors that affect the impact indentation resistance of aluminium skinned AYRLITE®. The goal for the project is to provide Ayres Composite Panels with the knowledge to create improved products that may lead to commercial gains.

2. Research Plan

2.1 Materials Selection and Sample Fabrication

Aluminium alloys suitable for testing were selected using the following criteria: Alloys must be available through Ayres Composite Panels suppliers. The alloys should be similar in cost to the currently used 5052 H38. Alloys that meet or exceed the corrosion resistance of 5052 H38 in a marine environment were then selected. Alloys with higher ultimate tensile strength and/or yield strength than 5052 H38 were desirable as they may have improved impact resistance. Using these criteria the following alloys were sourced for testing.

Alloy	Hardness	Thickness (mm)
5005	H34	o.6, 1.
5052	H38	0.3, 0.5, 0.8, 1.
5182	H19	0.3
5754	H42	0.4, 2.
3003	H44	0.4

Table 1 The selection of alloys used for testing.

The individual alloy sheets sourced for impact testing will all be manufactured into a single 10mm thick, 2.4m x 1.2m, AYRLITE® composite panel. The panel will be backed with a single 2.4m x 1.2m x 0.5mm 5052 H38 aluminium sheet. The backing sheet has negligible influence on the impact resistance of the test sheet. This can be seen by the negligible deformation of the backing sheet even when a 0.3mm sheet is used. Each alloy is then cut into 10cm x 10cm test squares.

Tensile and hardness samples are punched from the various alloy sheets by workshop technicians at the University of Western Australia Mechanical Engineering Workshop. Details of the tensile and hardness samples can be found under ‘mechanical testing’ below.

2.2 Mechanical Testing

The performances of the panels and aluminium alloy skin alloys will be evaluated in three tests:
Impact Testing: Conducted as per ASTM D5420-98a, the standard test method for impact resistance of flat, rigid specimen by means of a striker impacted by a falling weight. The impact test rig is simply designed to create a repeatable and comparable impact on the sample panel. Each alloy was impact tested using four different weights dropped from 1500mm. The alloy currently being used by Ayres Composite Panels (5052 H38) was impact tested in a range of thicknesses. The maximum impact depth is measured using a dial indicator. A profile of the impacted area is constructed using measurements taken in one millimetre increments from the centre of the impact outwards. Results from impact testing will be used to compare the impact performance of the selected skin alloys and thicknesses.

Tensile Test: The tensile test samples are blanked out of the various aluminium sheet alloys sourced for the project. The area over which deformation occurs is approximately 70mm x 12mm. Thickness varied depending on the sample alloy. Each alloy was tested as it was received and after being heated to mimic the AYRLITE® manufacturing process. The alloy currently being used by Ayres Composite Panels (5052 H38) will undergo further testing using higher oven temperatures and longer heating times.

Hardness Test: Vickers's hardness testing was conducted on the wide ends of the tensile test specimens before the tensile test has been completed. In this way both hardness and tensile testing can be performed on the same samples while producing valid results. As they are the same samples, hardness testing underwent identical heat treatment as the tensile tests before the experiment is conducted.

3. Results and Discussion

3.1 Material Testing

The results of the material testing have been summarised in table 2.

Material	Quoted Yield Stress (MPa)	Tested Yield Stress (MPa)	Quoted Ultimate Tensile Stress (MPa)	Tested Ultimate Tensile Stress (MPa)	Quoted Vickers Hardness (HV)	Tested Vickers Hardness (HV)	Maximum % Elongation
3003H44	145	175	160	175	46	56.4	5.56
3003H44 HT		167		175.1		55.3	6.42
5005H34	145	137	160	178	46	54.6	10.16
5005H34 HT		138		178		52.2	10.34
5052H38	250	254	290	304	85	89.6	7.81
5052H38 HT		238		298		88.2	9.52
5182H19	310	291.9		355	110	105	8.37
5182H19 HT		302		367		105	11.11
5754H42	185	162	270	251	75	72.7	15.6
5754H42 HT		162		251		66	15.1

Table 2 A summary of quoted and tested alloy properties where 'HT' represents heat treated alloys.

Quoted values are taken from www.aluselect.com as this is the source of alloy information used by Ayres Composite Panels. Blank table entries indicate that there is no online information available.

The results of the material testing followed reasonably closely to the values quoted on AluSelect (EAA 2001). The comparison between the alloys as received and heat treated samples shows the panel manufacture process does not have a significant effect on the skin alloy's mechanical properties. This result would be expected as the 5000 series aluminium alloys are strain or work hardened instead of being age or precipitate hardened. They are non-heat treatable in that they cannot be made harder though heat treatment (George 1997). It is possible to anneal or soften the alloys at temperatures above 340^{o}C but this is far above the temperatures experienced during the panel manufacture process (MatWeb 2009).

3.2 Impact Testing

3.2.1 Skin Thickness Investigation Results

The skin alloy currently in use, 5052H38, was impact tested in 0.3mm, 0.5mm, 0.8mm and 1mm. The 120g and 260g indenters were used to create these results as heavier indenters were too destructive to provide results for the thinner panel skins. The profiles where measured and results for the 260g indenter are shown in figure 1 below.

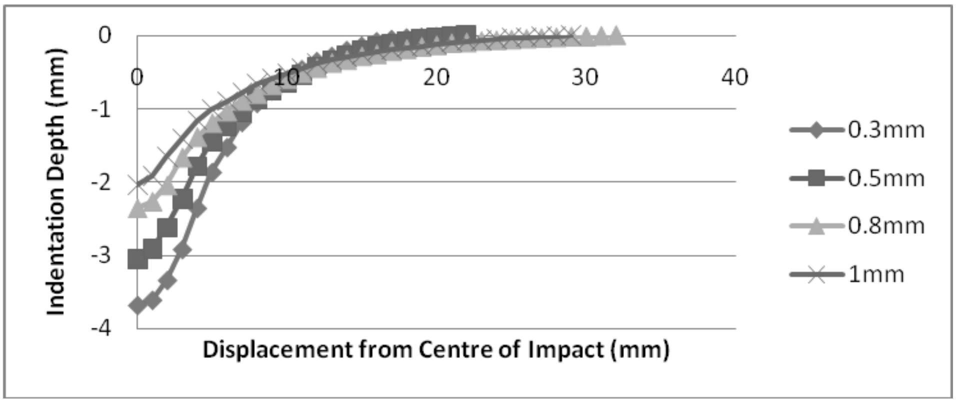

Figure 1 Impact profiles for 5052H38, 260g indenter.

The impact profiles show that thicker panel skins are able to spread the impact load across the aluminium honeycomb core material. This means that thick skins will produce shallow but wide profiles while thin skins will produce a deeper but more localised deformation.

The maximum impact depth was plotted against panel skin thickness and is shown below in figure 2.

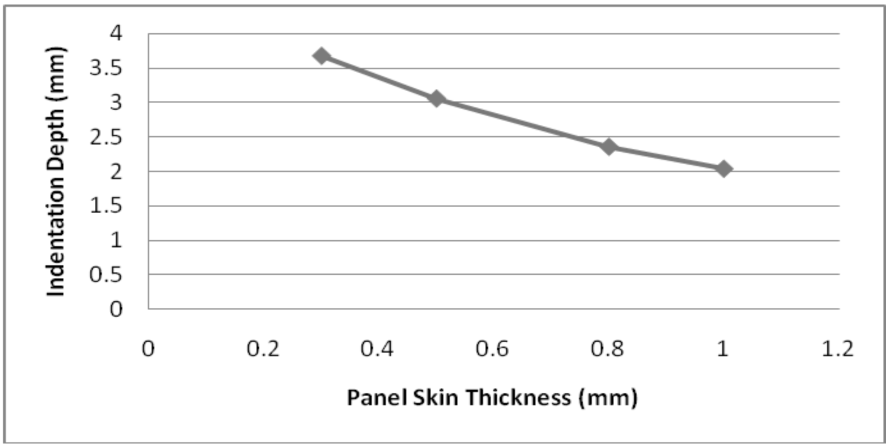

Figure 2 5052H38 Indentation depth versus panel skin thickness for a 260g indenter.

Over the range of thicknesses currently employed the relationship is very nearly linear. Although there seems to be an exponential trend to the data this is not defined clearly enough to show a clear optimum thickness. The curve generated using this data is used later to gain an estimation of impact performance of the other sample alloys

3.2.2 Skin Alloy Investigation Results

The relationship obtained in the skin thickness investigation was used to estimate the impact performance of the various sample alloys in comparison to 0.5mm 5052H38. This process is shown in figure 3.

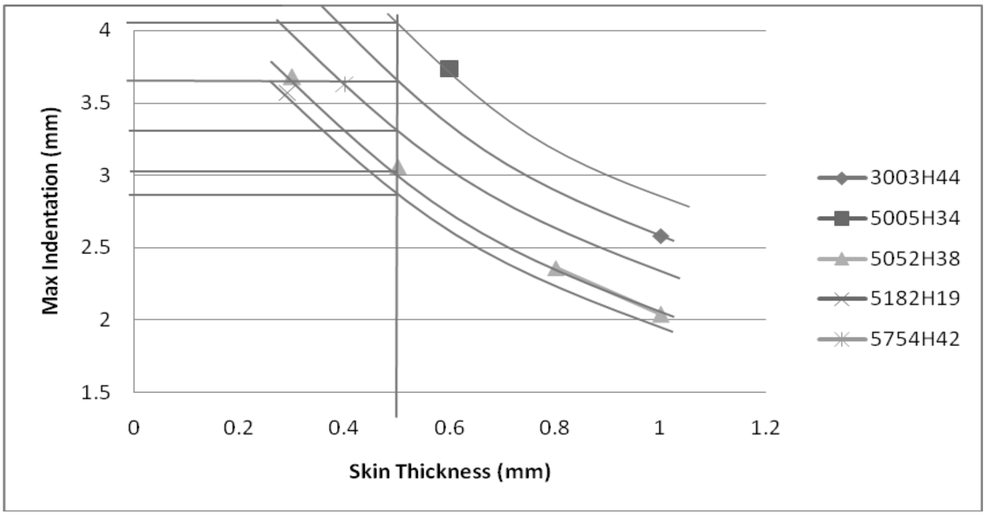

Figure 3 Skin thickness versus indentation for various alloys using a 260g indenter.

For a dent to be formed in the honeycomb panel the skin must undergo a permanent deformation. Therefore it is predicted a skin alloy with a high yield stress, the limit of non permanent deformation, should leave a shallower deformation by spreading the impact load across the honeycomb core. Using the material properties found during tensile testing and the estimated impact depths for a 0.5mm skinned panel from figure 3, estimated indentation was plotted against yield stress and shown in figure 4.

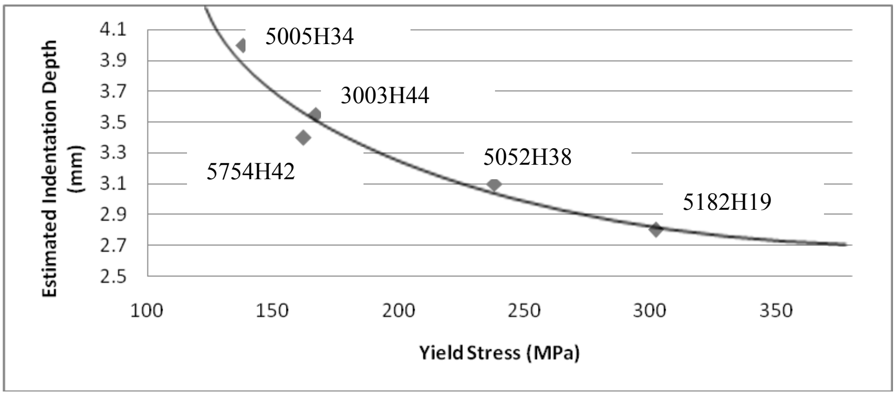

Figure 4 Estimated indentation versus yield stress for a 260g indenter on 0.5mm skin.

The data shows a clear trend between indentation depth and yield stress. A line of best fit shows the relationship to be exponential with little return in impact resistance for alloys with yield stresses above 300 MPa.

Alloy	Quoted Yield Stress (Mpa)	Sheet thickness (mm)	% of Current Price	% Impact Performance	Weight Saving Per Panel (g)
5052H38	250	0.5	100	100	0
5083H39	370	0.5	149	114.5	60
5083H39	370	0.4	119	100	1590
5182H39	320	0.5	119	110.3	60
5754H34	315	0.5	147	109.7	0

Table 2 Summary of price and predicted performance of available alloys.

4. Conclusions and Future Work

The results of testing to date show that the manufacture process has negligible effect on the mechanical properties of the skin alloys. Over the range of thicknesses practical for use in panel manufacture the relationship between skin thickness and impact resistance is almost linear. When considering price and performance 5052H38 is the clear optimum alloy due to its comparatively low price. Ultimate impact performance improvement of 14.5% would come from 5083H39 which has the highest yield strength of 370MPa but at a cost increase of 50%. Almost all of the initial aims of the project have been achieved with the investigation into panel manufacture oven dwell time currently continuing. Future work to be included in the final thesis will include an investigation into the effects of core thickness on impact resistance.

5. References

European Aluminium Association. (2001), AluSelect. Available from: <http://aluminium.matter.org.uk/aluselect/> [3rd April 2009]

MatWeb. (2009), MatWeb: Material Property Data. Available from: <http://www.matweb.com/index.aspx> [21st April 2009]

George S. (1997), Materials Handbook, 14th edn. McGraw Hill, Sydney.