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SAFE STEERING WHEEL AIRBAG REMOVAL USING ACTIVE DISASSEMBLY

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1. Introduction

The objective of active disassembly is to allow a product casing to forcibly separate under a thermal trigger, allowing the internal components to be recovered. Actuator solutions have typically been made from shape memory alloys (SMA) such as Copper/ Zinc/Aluminium, or Nickel/ Titanium. These can be formed into tiny devices of a single moving part. Looking like a coiled spring, they can sit totally inert inside a product casing and will reliably extend under a certain temperature stimulus [Figure 1].

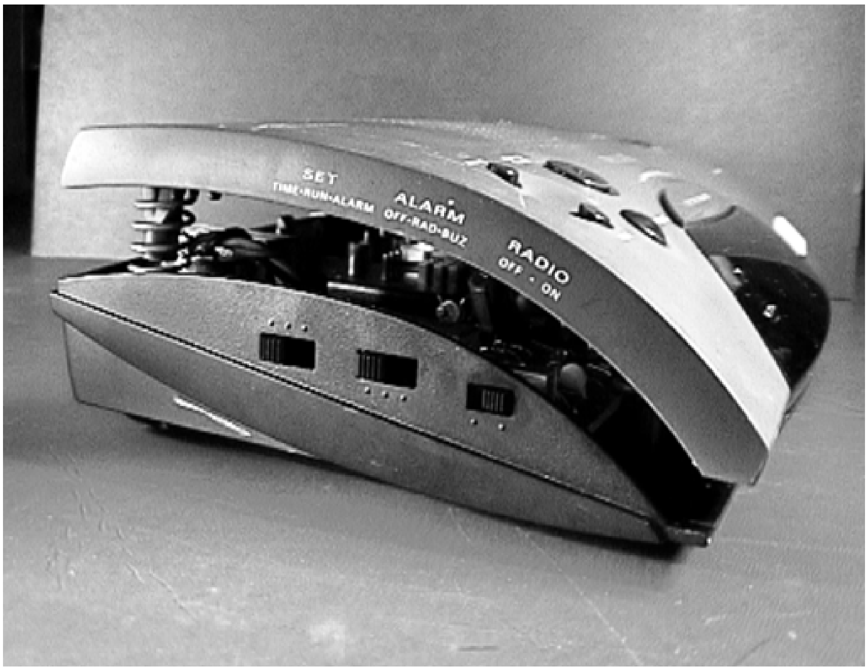

Figure 1. A Radio Casing Split By SMA Actuators Embedded in the Corners

1.1 Principle Objectives

The aim of this investigation is to assess the viability of incorporating active disassembly into automobiles. Particular attention will be paid to the Supplementary Restraint Systems (SRS) found in automotive steering wheels.

Once a vehicle reaches the end of its life, its final destination is the vehicle dismantlers' yard. Here it will have to be drained of all its fluids in accordance with the end of life vehicle directive before it is disassembled for parts, and ultimately crushed. This is in order to prevent contaminated shredder residue, when the crushed vehicle is then shredded for recycling and metal reclamation. However, with the ever-growing numbers of airbags in our vehicles, airbags are becoming a problem in the recycling infrastructure. "50% of airbags from shredded vehicles detonate in the shredder and 50% remain live. Of these live airbags, 50% end up in the ferrous waste stream and 50% end up with the non-ferrous material that is then sorted on a manual sorting line. This is potentially a very dangerous situation, as the airbag charge can trigger on the sorting line with disastrous results" [Wilkins 2001].

In the interests of safety, both for the vehicle dismantling technicians and for the workers on a sorting line, the removal of the airbag unit is critical. When the vehicle is initially depolluted at the vehicle-dismantling yard, it is already in a suitable position to have the supplementary restraint systems removed. By incorporating active disassembly technology, it is possible to safely remove an airbag unit by using a simple hot probe. This releases a shape memory alloy clip. This fastening solution retains the tamper-proof characteristics desired for a critical safety system. However, the removal tool is robust and simple enough to survive in a high throughput workshop, and to be operated by semi-skilled technicians. At the same time, the procedure is not so obvious that it would be conducted by unlicensed individuals. Airbag removal utilising Active disassembly also yields a decreased disassembly time when compared to conventional dismantling techniques.

There are economic benefits too. Actively removed airbags can be made available for resale via the vehicle dismantling network. Installation of vehicle depollution stations has produced a great strain on the vehicle recycling network, and allowing the ELVs to generate significant revenue is difficult. Active airbag removal provides this opportunity. The insurance industry is also feeling the impact from the airbag revolution. The price of replacement of the airbag, coupled with the damage that the actual airbag can do to a vehicle means that late model accident damaged vehicles are often written off due to expensive part replacement [Lemurzone 2000]. Introducing reclaimed airbags into the infrastructure could help decrease the extent of claim costs incurred across the industry.

1.2 Supplementary benefits

In keeping with the spirit of the ELV directive, any technological advances should facilitate simpler vehicle recycling. By making the steering wheel assembly simple to remove at the vehicle depollution station, the instrument panel in turn becomes simpler to remove. The instrument panel contains a high mix of materials, as well as containing potentially high impact parts. This assembly will become critical to remove for recycling as late model vehicles often contain items such as LCD panels. Active disassembly research in this area has already commenced [Chiodo et al 2000]. It will become prohibited to landfill larger LCDs under the forthcoming WEEE directive. Once active disassembly for steering wheel mounted supplementary restraint systems becomes established, it will be easier to implement active disassembly in the instrument panel. Furthermore, the process employs non-standard tooling for dismantling ensuring additional security against removing such an explosive device.

2. Prototype Construction

The prototype steering wheel assembly was based around a modified 1997 Ford Escort unit.

The internal airbag assembly remained intact and its position was not modified. The modifications were limited to the wheel hub itself. The hexagonal socket in the hub centre remained intact to provide positive wheel location on the end of the steering column. The hub was drilled perpendicular to the column axis to allow access for a hot probe [Figure 2].

The main 'active disassembly' component is the replacement of the M10 bolt that was originally used to secure the wheel. This bolt incorporates a flange on the bolt head to prevent the wheel pulling off the column. The smart bolt is a plain shank headless M10, with an SMA ribbon wrapped into a groove around the shank [Figure 3]. When this plane shank bolt is screwed into the end of the steering column, the SMA collar presses on the steering wheel hub keeping the wheel located. In effect, the retaining force is now provided by an SMA collar as opposed to the bolt flange.

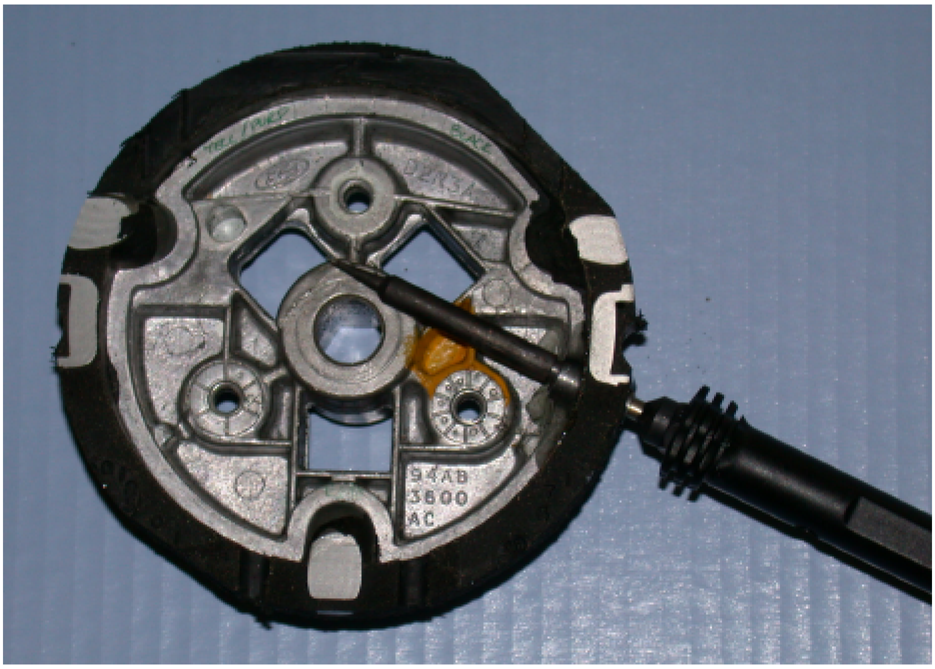

Figure 2. Steering wheel hub incorporating a hole to facilitate the insertion of a hot probe. The hot probe is shown penetrating the hub wall to make contact with the hub centre fixings

Once the wheel is assembled onto the column it cannot be pulled off. The joint interface has mechanical integrity. The joint will remain inert within the vehicle until the SMA is heated beyond its transition temperature of 110 degrees Celsius.

The assembly will not trigger during the normal life of the car, and meets the relevant Ford engineering specification [Ford 1996]. This and related control factors have been considered in related active disassembly work [Chiodo et al 1998].

Figure 3. The Steering Column, Plain Shank Bolt, and the SMA Collar that wraps around it

3. Joint disassembly

There are many differing ways of heating the SMA collar to facilitate disassembly. These include hot air, and direct electrical heating. These were both discarded. Direct electrical heating would require the addition of extra components into the wheel assembly, compromising its design efficiency. Hot air and convective heating was also discarded due to the time taken for a hot air blower to warm the assembly, and the time taken for the heat to penetrate the assembly. The pyrotechnic charge inside the airbag must also avoid being heated.

3.1 Active steering wheel removal

Disassembly of this joint is achieved with heat exposure provided by a hot probe. This is inserted through the hole in the side of the steering wheel hub so that it comes into contact with the SMA collar. The collar undergoes its shape change, releasing itself from the locating groove in the special M10 bolt. The whole steering wheel and airbag assembly can then be lifted from the column. The airbag triggering wire (yellow by international standard) can be unplugged. Any others for the horn or radio controls can simply be cut. The pyrotechnic device remains at a low temperature throughout this operation. This is because the large air space within the steering wheel hub is not able to be sufficiently heated by the low power (15 watt) thermal probe.

4. Results

The shape memory clip unrolled satisfactorily when heated with the hot probe. However, applying uniform heat to the entire clip for uniform shape change was not possible. This was due to the fact that the contact area of the probe onto the clip surface was very small. To get the whole clip to release, the hot probe had to be pulled and pushed in its socket, to cause some rotation of the clip about the special bolt. This area therefore requires some optimisation. Upon contact of the hot probe with the SMA clip, a shape change occurs almost instantaneously (probe temperature ~ 250^{0}c) in the immediate vicinity, but as the probe had to be manipulated to contact the whole clip, the overall release time in this instance was around one minute.

5. Conclusions and Further Work

This prototype was constructed primarily to prove the feasibility of making Shape Memory Alloy fastening systems that can release automotive components under a certain triggering stimulus. From this exercise, their suitability and integrity has been proved. However, in constructing this prototype, very thin SMA ribbon was used. This necessitated making the groove on the special M10 bolt very shallow, so that there would be enough material to overlap (to therefore locate) the wheel to the special bolt. For a production device, much thicker (6mm thick) SMA strip would need to be used. This would still be more than capable of recovering enough strain to induce a suitable shape change allowing the collar to fall free of its groove. NiTi alloy is able to reliably recover 6% strain.

The second area where improvement is required is in the heating of the SMA collar. Direct thermal conduction clearly provides very rapid heating of the clip to the required temperature, but the problem still remains to heat the whole clip. By incorporating teeth on the outer edge of the SMA collar, and on the hot probe, probe insertion can rotate the collar [Figure 4]. This should also increase the surface area contact between the probe and the clip providing reliable heating.

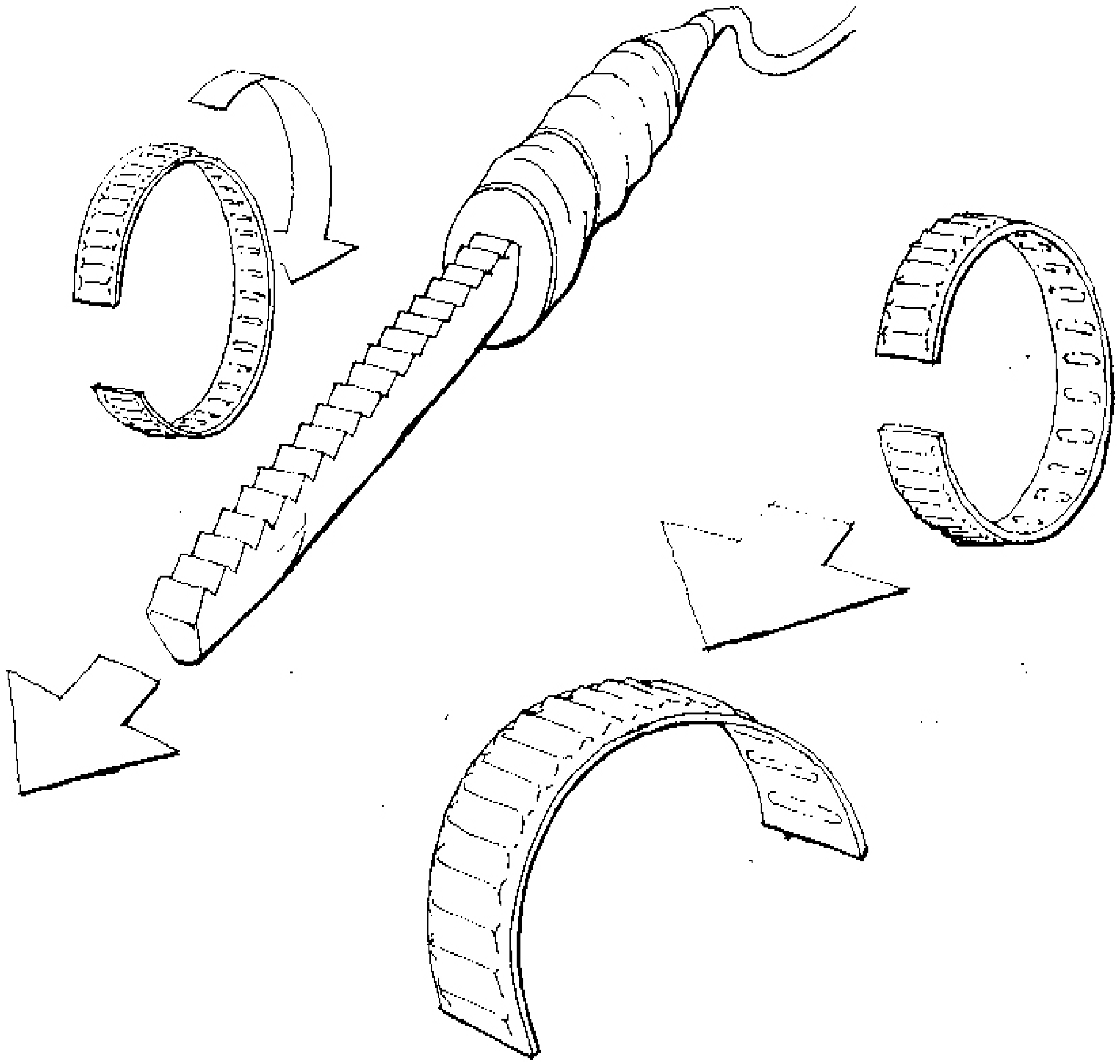

Figure 4. The D- section probe can only be inserted in one position due to its shape. The teeth on the flat of the probe rotate the clip so that the entire clip is heated. The shape change of the clip is illustrated to the right. The clip uncoils when heated so that it may be removed from the steering column

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References

Chiodo et al, "Eco-Design for Active Disassembly Using Smart Materials". In, SMST 1997 Proceedings of the Second International Conference on Shape Memory and Superelastic Technologies. Ed. Pelton et al. SMST, California USA, 1997, Pp 269-274.

Chiodo, et al, "Investigations of Generic Self Disassembly Using Shape Memory Alloys", in IEEE Int'l Symposium on Electronics and the Environment - ISEE - , Oak Brook, Chicago, Il, USA., 4 - 6 May 1998, Pp. 82 - 87.

Chiodo, et al, "Isolating LCD's at End-of-Life using Active Disassembly Technology: A Feasibility Study", in Proceedings of the IEEE International Symposium on Electronics and the Environment. San Francisco. California. Institute of Electrical & Electronics Engineers', . May 8-10, 2000 Pp. 318 - 323.
Ford Engineering Material Specification, WSS-M14P4-E, 1996. Pp3-5.
Lemurzone., Airbag pages, http://www.lemurzone.com/airbag/cost.htm. 2000
Wilkins, D., European Metal Recycling (EMR) Ltd, London UK, 2001.

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