FFI

Structural polymer reinforcements, 2009-00271

Project within Fordons- och trafiksäkerhet

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Content

FFI in short

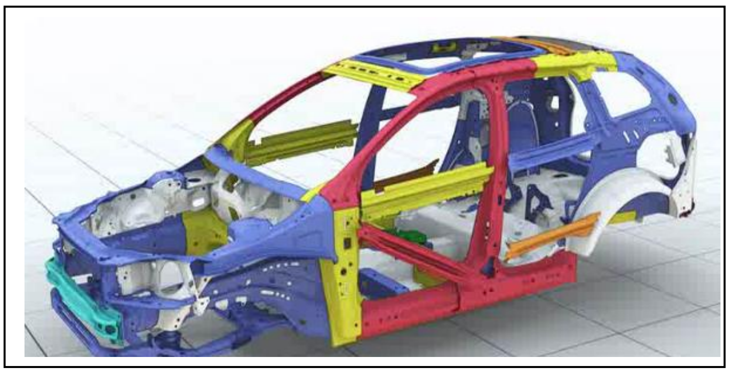
FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi

1. Executive summary

The project has studied two uses for structural polymer reinforcements. The first is the use of polymeric reinforcements in the upper structure to obtain structural integrity of the car with increased weight due to hybrid drive. The goal is to minimizing the increase in body weight and cost of hybrid cars. In comparison with alternative solutions a weight- and cost reduction.

The second is the use of polymer reinforcements, to a greater extent, to differentiate the strength of the platform and upper structure, even in corrosive environment. Especially interesting when the crash weight increases due to car size and hybridization. The goal is with the use of structural polymer reinforcements minimize impacts in a-shop due to the varied impact weight and minimize cost.



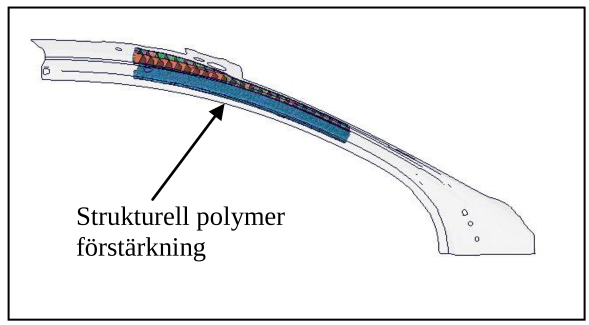


Fig. 1.Structural polymer reinforcement in back-up structure, a-pillar.

- CAE analysis was performed to see the potential of reinforcing only the weak sections in the a-pillar and in the sill. In frontal crash analysis, offset deformable barrier at 45 mph, large deformation was obtained both in the a-pillar upper and in the sill without using any extra reinforcements. With structural polymer reinforcement in a-pillar and a steel reinforcement in the sill, minimal deformations achieved and structural integrity was obtained.

- Initially a potential use of the structural polymer reinforcements was to use them as energy absorber. In the load case frontal crash the front side members was reinforced in the bending areas with structural polymer reinforcements. The goal was to increase the energy absorption during the deflection of the beams. The calculations showed a slight increase in total energy absorption in frontal structure in the load case frontal crash. The absorbed energy increase was not sufficiently to avoid further reinforcement.

- Dynamic three-point bending test was performed at component level. The section increased the strength but with a very brittle behaviour. The section that is completely filled with polymer can not cope with large deformations without cracks in the steel. The material of the steel is boron steel that has low elongation values but very high yield and tensile strength. In side impact, this load case can arise.

- Static axial test was performed at system level to simulate frontal crash. The test object was a part of the upper a-pillar. Thick end plates were welded to the test beam to prevent deforming the ends. The end where the load imposed was allowed to rotate freely. The results showed a high increase in the strength at the static axial load case. The structural polymer reinforcement will do the deformation considerably tougher.
The energy absorption was increased significantly. The maximum force increased by about 30 %.

- All new products at Volvo cars require an environmental assessment. At Volvo Car, the environmental assessment is performed by Feelgood. The assessment takes into account many aspects including handling the product in the factory. The polymer reinforcement includes a number of components of a chemical nature. Especially, it is the substance that expands in the oven that is important to assess. The result from the environmental assessment of the structural polymer reinforcement is as follows - it can be handled in the factory without any special protective equipment except gloves.

- Corrosion tests have been conducted with polymer reinforcements attached to steel plates. The tests have been performed using zinc-coated sheet and coated boron steel both with and without EC paint. The test performed was a 12-week trial in the corrosion cabinet (CETP 00:00-L-467, corresponding to long-term test), line corrosion and underneath corrosion. The result is accepted in all cases.

- Tests have also been performed for adhesion, crater and the contamination. All these tests were successfully approved.

- Several physical frontal impacts, ODB40 (offset deformable barrier 40 mph), have been performed. Reference cars were up-weighted to correspond to the weight of hybrid cars. The result was clearly accepted in the a-pillar area. Structural integrity was achieved and the a-pillar deformed in principle not at all.

2. Background

The complete car weight (impact weight) can vary up to 300 kg, depending on powertrain and battery for HEV (hybrid electric vehicle). Even in non-HEV-car crash weight will vary, affecting the robustness of the crash test results. Designing for the higher crash load will give punishment in both cost and weight. By instead using structural polymer reinforcements in e.g. frontal structure, it is quite possible to reach a solution that is both more economical and more weight effective.

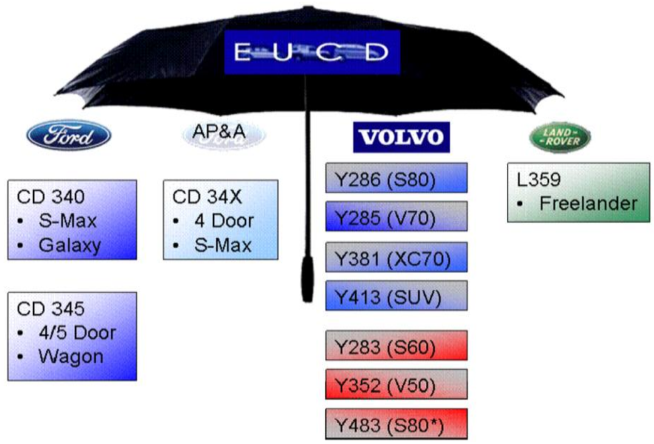


Fig. 2. Platform EUCD

With today's high requirements for crash safety and robustness, and demands for reduced fuel consumption and CO_2 emissions, high weight will give large negative effects. The competitors in the automotive industry are focus strongly in reducing the weight of car and car body.
To remain world leader in crash safety the heaviest car is not allowed to be the target level for all cars. The first approach was to apply the polymer reinforcements in frontal crash load case. There are great potentials to strengthen the body structure in only the week sections - in the front side member, side member extensions and a-pillars. The use of polymer reinforcements in front crash has the potential of weight reduction by 2-5 kg in comparison with steel reinforcements or increased thickness.

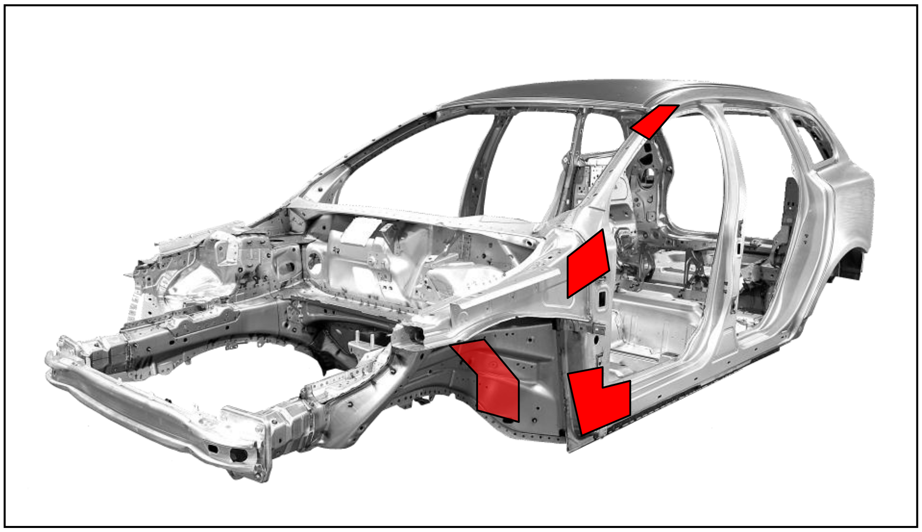


Fig. 3. Potential areas for structural polymer reinforcements in front crash.

3. Objective

The complete car weight (impact weight) can vary up to 300 kg, depending on powertrain and batteries for HEV (hybrid electric vehicle). Even in non-HEV-car crash weight varies, affecting the robustness of the collision outcome. Designing for the higher crash load will give punishment in both cost and weight.
The objective is to use structural polymer reinforcements in mainly frontal crash, and to show that it is possible to reach a solution that is both economical and effective weight compared to a steel solution. The structural polymer reinforcements will contribute to robust structural integrity.

4. Project realization

The project was carried out at Volvo Car Corporation for the period January 2009 to December 2011. The project was performed with support from SIKA in same extent. SIKA is a manufacturer of structural polymers, sound seals, adhesives etc.

5. Results and deliverables

5.1 Delivery to FFI-goals

The project contributions to the FFI-goals are focused on world-leading crash safety and robustness - and reducing the environmental impact & CO2 emission.

The project will contribute also to the following of the FFI- goals:

- contribute to the development of "nollvisionsfordon", i.e. vehicles with an optimal combination of active and passive systems that reduce the number of accidents and the consequences of the accidents that do occur.
- increases the industry possibilities in competitively manner carry on with knowledge-based production in Sweden. Through continued production of competitive vehicles.
- contribute to continued competitive automotive industry in Sweden. By developing and manufacturing vehicles that meet future environmental requirements
- implement relevant industrial development actions. By focusing on environmentally sensitive technology solutions.
- leading to industrial technology and competence development.
- contribute to the security of employment, growth and strengthened R & D activities. Through the development of competitive vehicles that meet market demands.
- Improve utilization of R & D results to realize concrete production improvements. By working closely with applications with a very high momentum and implementation level.

6. Dissemination and publications

6.1 Knowledge and results dissemination

The project shows by adopt in the prerequisites polymer reinforcements in the car body development, it is possible the design heavier cars on the same platform, with world-leading crash safety and robustness, and lower weight compared to reinforcements in steel.

The results are directly implementable in coming product programs that have varying car weight due to e.g. HEV, car size, etc. CATIA models and CAE-models are available for the projects. Design guidelines for use in future projects. The results in the project indicate that with maintained world-leading crash safety and robustness a weight reduction can be achieved compared to steel solution.

6.2 Publications

No official reports are published. A number of internal reports are produced.

7. Conclusions and future research

The use of structural polymer reinforcements is a good alternative when there is an existing car body process. Such as variations in the platform or car variant (HEV). Cost of tools is relatively low for polymer reinforcements while the part price is higher than for steel reinforcement. The big economic gain is that the process not needs to be changed.

To use structural polymer reinforcements as efficient energy absorber in the body structure lot of development is needed. The structural polymer reinforcement must be both energy-absorbing and capable of increasing section strength with a robust behaviour. Frontal crash analysis is very dependent on material models and crack criteria. In crash the structural polymer will crack and absorb energy. For this use to remain interesting, further study and development of material models is necessary.

8. Participating parties and contact person

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