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ONE PIECE WOVEN AIRBAG WITH COEXTRUDED FILM

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BACKGROUND

It is known to inflate an inflatable vehicle occupant protection device to help protect a vehicle occupant in the event of a vehicle collision. Examples of inflatable vehicle occupant protection devices include driver and passenger frontal airbags, side airbags, curtain airbags, inflatable seat belts, inflatable knee bolsters, and inflatable head liners.

Inflatable vehicle occupant protection devices can have a variety of constructions. For example, an inflatable vehicle occupant protection device can be constructed of overlying woven fabric panels that are interconnected by means, such as stitching or ultrasonic welding, to form connections or seams that help define an inflatable volume of the protection device. As another example, an inflatable vehicle occupant protection device can have a one-piece woven (OPW) construction in which overlying fabric panels are woven simultaneously. The panels are woven together to form connections or seams that help define an inflatable volume of the OPW protection device.

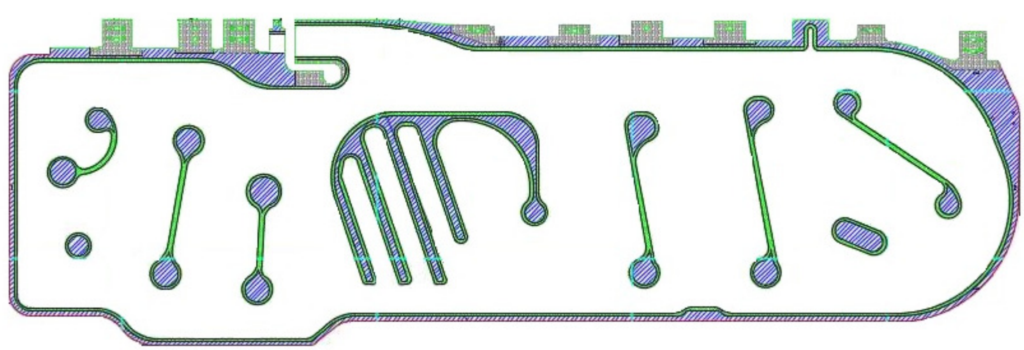
Woven airbags require sealing in order to block leakage of inflation fluid through the woven fabric panels. To achieve this, spray coatings and/or one or more laminated layers (*e.g.*, films) can be applied to the airbag. In one example, an OPW curtain airbag can include a barrier film layer for blocking inflation fluid leakage, and an adhesive film layer for securing the barrier film layer to the airbag. Additional laminate layers can be included. Of course, these film layers are applied to both sides, i.e., the inboard facing side and outboard facing side, of the curtain airbag.

To prepare the OPW airbag for the application of laminate film layers, the woven fabric can require some finishing or pre-treatment. For example, the woven fabric can be scoured to remove any dirt, impurities, or sizing added to the yarns to facilitate weaving. Sizing can also be applied after weaving. The OPW airbag can also be calendered, which involves the application of heat and pressure by passing the airbag between heated rollers. Further, the OPW airbag can be heat set, which involves a thermal process usually taking place in either a steam atmosphere or a dry heat environment. The effect of heat setting gives the woven fabric dimensional stability and other desirable attributes, such as increased volume, wrinkle resistance, and temperature resistance.

Problems that can affect the performance of a laminated woven airbag structure include de-lamination, which can result in fluid leakage that affects bag pressurization. This can occur, for example, if the airbag is exposed to excess moisture. Another problem that can occur is the barrier layer separating from the adhesive layer. This can occur, for example, in hot environments where the airbag is stored at extreme high temperatures that cause the adhesive layer to soften and weaken. Accordingly, care must be exercised to select laminate materials for the adhesive and barrier layers that will avoid these problems.

DESCRIPTION

A co-extruded co-polyester (Co-PET) film is laminated to a one piece woven (OPW) curtain airbag. An example of the OPW curtain airbag is shown below and illustrates the peripheral and interior connections where the overlying woven panels are interwoven to define the inflatable chamber configuration of the OPW airbag.



Example OPW Curtain Airbag Configuration

In the example configuration, the OPW curtain airbag can be woven with 470 dtex polyester (PET) yarn. The resulting polyester airbag fabric is highly durable, has an improved wrinkle resistance, and a high tenacity. Polyester is less vulnerable to shrinkage in comparison to other yarns, is very resistant to abrasion, and is not affected by moisture. These characteristics are passed on to the OPW curtain airbag.

Advantageously, the Co-PET OPW curtain airbag laminate can be configured to be applied to a non-scoured OPW curtain airbag. This eliminates a scouring step, which is typically required in OPW airbag constructions. According to one example laminate construction, the OPW curtain airbag laminate can be a multilayered film that is co-extruded to form a laminate structure having an average thickness of about 42 µm. The co-extruded multilayer film consists of a barrier layer of DSM Arnitel EM550, a middle layer of DSM Arnitel PM381 and an adhesive layer of DuPont Hytrel 4056. The film can also contain anti-oxidants recommended by DSM and DuPont at a level of 2% by weight.

Laminated OPW Airbag Construction and Production

Current OPW sealing technologies have both technical and cost related drawbacks. The objective of this project is to develop a new co-extruded film that can fulfill our primary customer requirements and will be cost attractive at the bag level. Since this is a film, it should also be applicable to seal both conventional and X-tether OPW configurations.

Most important requirements :

- Allow for lamination to non-scoured OPW material (with PET yarn).
- Similar or improved performance compared with current sealing technologies (weight, stiffness, air-holding, etc.).
- Minimum film width = 2.5 meters, preferably > 3.0 meters.
- Lower cost at the bag level than current bag lamination technologies.

The co-extruded laminate is designed such that the adhesive layer has a lower melt temperature than the barrier layer. The lamination temperature is set between these 2 temperatures so that the adhesive layer melts and adheres to the curtain airbag during lamination. Technical issues that can occur with laminate film structures that include adhesive and barrier film layers can include:

- De-lamination at high temperature.
- De-lamination due to moisture (*i.e.*, salt spray test).
- Degradation due to Hydrolysis.
- Cold cracking.

It has been discovered that a thermoplastic co-polyester elastomer resin developed by DuPont (Hytrel 4056) worked quite well as an adhesive layer. It has a relatively low melt temperature for these materials. This is combined this with a DSM product (Arnitel EM550) for the barrier layer which is also a thermoplastic co-polyester elastomer. This material has a significantly higher melt temperature and, therefore, is very compatible with the Hytrel 4056 adhesive layer. Specifications for these co-polyester films are shown below:

Hytrel 4056 Adhesive Layer

Thermal properties	Value	Unit	Test Standard
Melting temperature, 10°C/min	152	°C	ISO 11357-1/-3
Glass transition temperature, 10°C/min	-50	°C	ISO 11357-1/-2
Temp. of deflection under load, 0.45 MPa	48	°C	ISO 75-1/-2
Vicat softening temperature, 50°C/h, 10N	109	°C	ISO 306

Arnitel EM550 Barrier Layer

Thermal properties	Value		
Melting temperature (10°C/min)	207	°C	ISO 11357-1/-3
Vicat softening temperature (50°C/h 50N)	90	°C	ISO 306
Coeff. of linear therm. expansion (parallel)	1.5	E-4/°C	ISO 11359-1/-2
Coeff. of linear therm. expansion (normal)	1.5	E-4/°C	ISO 11359-1/-2
Burning Behav. at 1.5 mm nom. thickn.	HB	class	IEC 60695-11-10
Thickness tested	1.6	mm	IEC 60695-11-10
UL recognition	Yes	-	-

The co-extruded film was produced using 5 layer blown extrusion line with a 1.3 meter width. A third polyester resin (Arnitel PM381) was added between the Hytrel 4056 adhesive layer and the Arnitel EM550 barrier layer as a tie layer to assist in film processing. Also an anti-block was added to the adhesive layer to improve handling/processing. To test lamination methods, four rolls of OPW curtain airbags were air-jet woven, without sizing, and heat set, without scouring. Two of the OPW airbag rolls were laminated with the co-extruded film using a hot oil drum and two rolls were laminated on a flat bed machine. The lamination methods in both cases proved to be successful.

Testing

To test the efficacy of the laminations batch testing was performed. The laminate was a Co-extruded CoPET film with a target thickness of 46 µm, and included a DuPont Hytrel 4056 adhesive layer and a DSM Arnitel EM550 barrier layer. No heat stabilizer package was used. OPW Curtain airbags were woven with a standard PET 470dtex/f96 flat yarn. The OPW curtain airbags were produced on an air-jet loom with a warp density of 42.4. Warps were unsized and the roll was laminated loom-state. The curtain airbags were laser cut with the following nominal dimensions:

- Nominal curtain length = 157.0cm
- Nominal curtain height = 50.2cm
- Remaining pressure > 40 kPa

The OPW curtain airbags were used to build left-hand (LH) and right hand (RH) modules for testing. Sequential testing was performed on six LH and six RH modules. Three LH modules and three RH modules were sequential tested at -30° C with a minimum soak time of two hours and a deployment window of two minutes maximum. Three LH modules and three RH modules were sequential tested at +85° C with a minimum soak time of two hours and a deployment window of two minutes maximum. The sequential tests included the following:

- Dynamic Shock
- Vibration
- Thermal Shock
- Humidity Resistance
- Salt Spray
- Service Durability
- Squeak/Rattle/Noise Resistance
- High G/Low G Deployment

Additionally, low humidity heat age testing was completed on four LH modules and four RH modules at +107C° for 408 hours with up to 20% relative humidity. High humidity heat age testing was completed on two LH modules and two RH modules at +70C° with 95% relative humidity for 408 hours.

No post deployment integrity issues were observed with any of the curtains. The Co-PET lamination of loom-state woven OPW curtain airbags therefore proved to be successful.

Results

The multilayer Co-PET laminate film performed exceptionally. The film exhibited a peel force adhesion to loom-state OPW curtain airbag PET fabric of > 1.0 N/mm. When pressure testing an OPW curtain laminated with the Co-PET laminate film at 85° C, the film remained fixed until the pressure reaches no less than 75% of the maximum burst strength of the woven curtain (as tested at ambient conditions). While exhibiting excellent peel force adhesion, the high melt point (150° C) of the adhesive film layer is well above the maximum deployment temperatures typically included in customer specifications (typically 90° C maximum).