

Development of Carbon Fiber Cushion for Aircraft Seat

OsakaGasChemicals, Co.,Ltd.
Engineering and Development Dept.
General Manager, Junichi Fujita

Introduction

In this paper, we introduce a new type cushion for the aircraft. The outline of the cushion using the carbon fiber, and characteristics of this cushion are explained respectively.

Incombustibility, durability and lightness are required for the aircraft cushion.

- Light weight, Incombustibility (less toxic gases in burning), Comfortableness, Permeability of moisture

At present, most of the cushion for the aircraft is occupied by polyurethane foam because of its availability and moderate cushion performance. The polyurethane foam is clearing combustion test by giving flameproof finish, and using incombustible material for glazing material of the cushion. However, there is a problem of generating some toxic gas, when the polyurethane burnt. From the viewpoint of durability and lightness, the polyurethane cushion has no serious problem at present. However, it is beneficial to the customer airlines if more improvement can be achieved in this area, especially weight and flammability. At present, the polyurethane foam is disposed as industrial waste, but in near future, such method will become difficult, and seems to require that the recycling is also possible on the cushion.

By these situations, the development of the new cushion mainly using polyester fiber is advanced which replaces polyurethane foam in each place.

We have advanced the development of the cushion from the viewpoint of incombustibility, strength, lightness and chemical stability of the carbon fiber. Because we already established production and selling of pitch based carbon fiber. As the result, we succeeded in the development of the cushion using carbon fiber, with durability, lightness, and excellent incombustibility.

1.1 Properties of carbon fiber

It is unique that curled pitch-based carbon fiber which the Osaka Gas group is maker and seller, and the bulky shape is easy to be made. It is suitable as a material for the cushion.(Fig.1)

The other manufacturer does not have this feature of carbon fiber.

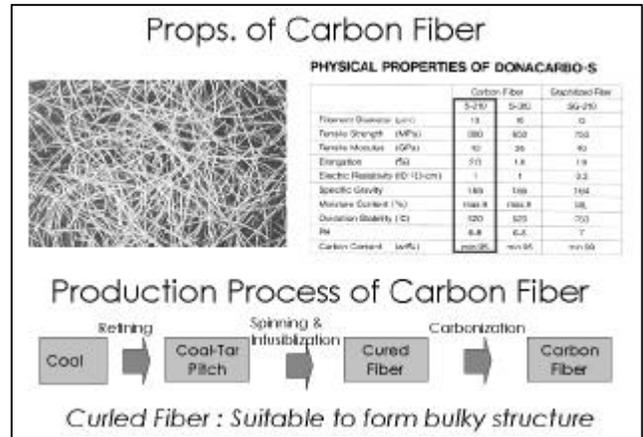


Fig.1 Properties of Carbon Fiber

1.2 Variation of carbon fiber

The pitch-based carbon fiber, which the Osaka Gas group produced, had various shapes such as web, mat, chopped, felt, and paper. We examined these materials by various methods, and we searched the performance as a cushion. (Fig.2)

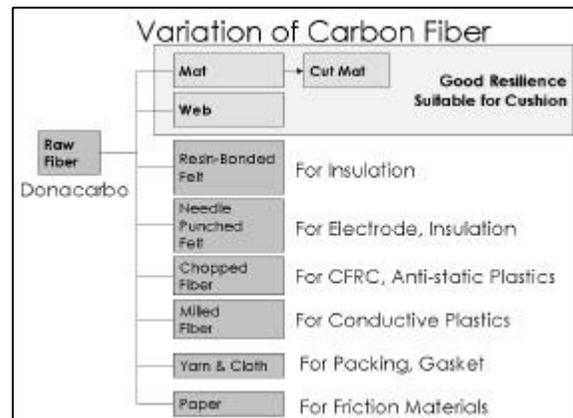


Fig.2 Variation of Carbon Fiber

1.3 Carbon fiber cushion

The material which compression formed the impregnated web and/or impregnated cut-mat with polyurethane binder, was found promising as cushion. For the binder, phenol and polyester resin were also examined, we chose the polyurethane binder considering hardening methods and time.

2. The evaluation method for cushion

We adopted the evaluation methods shown in figure 3, to choose laminated web and cut mat as forming method of the carbon fiber cushion.

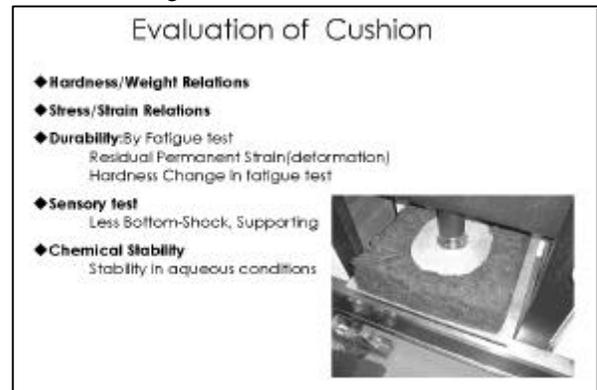


Fig.3 Evaluation of Cushion

2.1 Stress-strain relationship

The relationship between stress and strain in applying force on the cushion is thought to be an index of comfort to sit on. Carbon fiber cushion and urethane cushion showed quite different relationship between stress and strain. The carbon fiber cushion began to distort in small stress in the initial stage, and the incremental strain decreases from the middle point. In contrast with carbon fiber, the polyurethane foam was hard to distort in the initial stage, and quickly increased strain was observed subsequently. In interesting fact, the carbon fiber cushion shows intermediate property of spring cushion and urethane cushion. (Fig.4)

The final evaluation was performed by sensory test. In the parallel test, the difference between polyurethane and carbon fiber cushion was detectable, however, in the individual test, the clear

difference difficult to point out. The hardness also concerned in comfort to sit on.

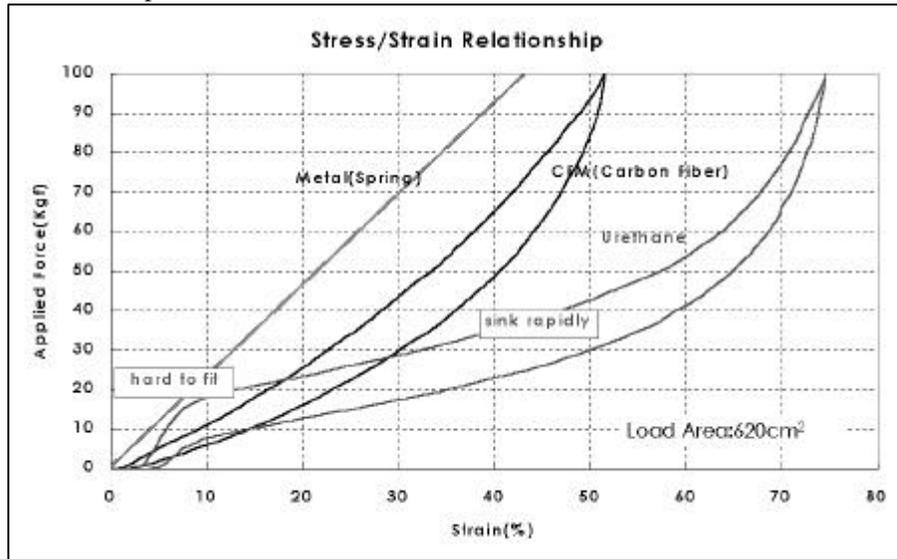


Fig.4 Stress/Strain Relationship

2.2 Fatigue test and residual permanent strain

Residual permanent strain derived from the thickness change in receiving reciprocal compressive stress, and it is used as the index which shows the cushion durability.

This figure showed the thickness change of the cushion vs. stroke. The fatigue test was performed 1,500,000 times at the 77kg load. No thickness change of the cushion found both laminated web and cut mat method. It was interesting that the laminated web showed the tendency to increase thickness.(Fig.5)

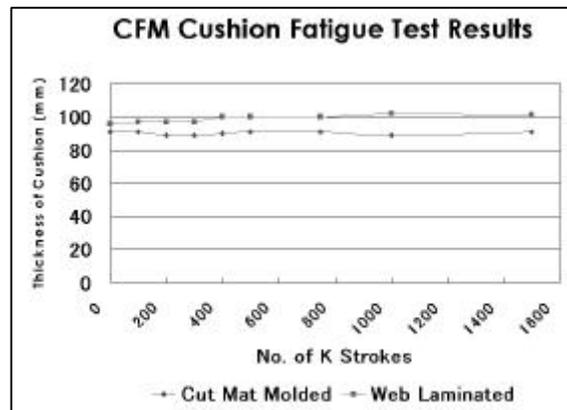


Fig.5 CFM Cushion Fatigue Test Results

2.3 The change of resilience force in fatigue test

The resilience force of the cushion is derived from the amount of strain at any fixed load. It is thought to be as synonym of the hardness. In the fatigue test, resilience force of carbon fiber cushion decreased at the initial stage, and did not change afterwards. It seems to be a cause that the additional restraining force of the binder decreased after the repeated compression. Laminated web showed smaller decreasing of the resilience force than the cut-mat method.

2.4 Stress-strain relationship

The hardness of the cushion was evaluated by the load for generating a fixed strain. Stress-strain curve, which explained before, can be utilized. On the hardness of the cushion, the requirement is variable in the user. The hardness of the carbon fiber cushion was fundamentally controlled by adjusting the quantity and the orientation of the carbon fiber.

2.5 The lightness of the cushion

In comparison with the weight of carbon fiber cushion and polyurethane cushion, carbon fiber realized 20%~60% lighter cushion, at similar hardness.

The weight is different even in the forming method of the carbon fiber cushion. It is possible to produce more lightly cushion adopting cut mat method, compared to laminated web method.

2.6 Comfort

As mentioned in 2.1, stress-strain relation of the carbon fiber cushion, it was distorted in small stress in the initial stage, and it was explained that the incremental strain decreased from the middle point. These characteristics produced the good result to the cushion-ness, namely the amenity. The figure 6 showed typical example of the pressure mapping, the pressure is dispersed, and not locally concentrated in the carbon fiber cushion. So-called "bottom sensation" is reduced.

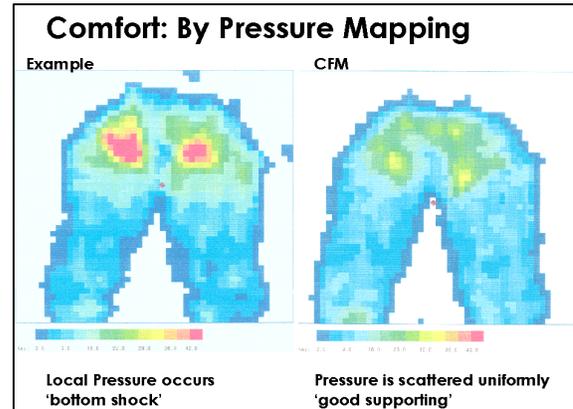


Fig.6 Pressure Mapping

2.7 Incombustibility

It was confirmed that developed carbon fiber cushion was incombustible in the combustion test by sheet manufacturer in Europe and Japan.

2.8 Chemical stability

The carbon fiber is excellent in the chemical stability, and it does not hydrolyze like the polyurethane.

There is no significant difference in laboratory test under normal condition, between carbon fiber cushion and polyurethane cushion.

However, serious difference revealed in aqueous conditions. There was no change on the carbon fiber, though polyurethane was damaged and its restoring force significantly decreased after soaking in hot aqueous solutions.

2.9 Recycling features

The carbon fiber is excellent in the chemical stability, and degeneration and degradation do not happen in long-term use. Therefore, carbon fiber cushion by laminated web and cut mat method is possible to reuse as a raw material for the cushion again. We also confirmed that it can be recycled as anti-static resin composite material.

Carbon fiber cushion molded using laminated web and cut mat method. There are the merit and demerit by choosing which method, and of course it is possible to adopt the molding technique by the application of the cushion.

3. Conclusion

We consider that the laminated web is suitable for the aircraft application by lightness and stability of the hardness. At present, carbon fiber cushion is under practical test as a chair in some airline actually. It rises from the urethane cushion cost-concerned, and it is considered that there is sufficiently cost performance as a cushion, when lightness, recycling, incombustibility and animety, etc. are totaled.