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FIBERGLASS LAMINATE BACKED CERAMIC ARMOR

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ABSTRACT OF THE DISCLOSURE

A fiberglass laminate which may be utilized in conjunction with a ceramic as a backing material, constructed of commercially available fiberglass cloth having a temporary or compatible size, and having applied in addition thereto a small amount of a silicone oil finish.

This invention relates to an improved high-impact-strength fiberglass laminate and more particularly to a fiberglass laminate which may be utilized in conjunction with a ceramic as a backing material.

Good adhesion between the glass and plastic matrix is obtained by the utilization agents which react with or bond strongly to the plastic matrix. The coupling agent is designated as applied to the fabric as a chemical surface treatment in the form of a "size" if it is applied as the fibers are formed. A "finish" is reference to surface treatment applied after the fibers are fabricated into yarn or woven fabric.

There are two general types of sizes: temporary and compatible. Temporary sizes are utilized in the production of yarns and fabrics. Temporary sizes generally contain such ingredients as dextrinized starch gum, hydrogenated vegetable oil, nonionic emulsifying agent, cationic lubricant gelatin, and polyvinyl alcohol. The above ingredients are commonly called starch-oil sizes. Commercial manufacture of fiberglass usually apply a starch-oil coating to the glass fibers as they are drawn from the spinneret. This lubricating coating prevents the individual fibers from abrading one another when they are woven into glass cloth. While the presence of a starch-oil size on the fabrics is beneficial for some applications, it is not compatible with some resins, does not wet-out well, and gives poor laminate wet strength retention. Consequently, the starch-oil size is usually removed by a burning-off process known as heat cleaning, which involves subjecting the material to a temperature of around 650° F., wherein most of the organic sizing is burned off. The usual commercial practice is then to apply a "finish" to the heat cleaned cloth which will allow for the formation of a chemical bond between the glass fibers and the resin matrix.

A compatible size or chemical bonding type of size typically contains a coupling agent, a lubricant and a film former. Compatible sizes are categorized by their coupling agent which is generally a silane or chrome complex.

For economic reasons as well as performance, a desirable type of glass fabric for use in armor backing is known in the trade as "woven roving." This material is relatively coarse and is not subjected to excess abrasion when it is in the loom and in the process of being formed into cloth. Hence, it is the usual commercial practice to apply a chemical bonding type of size to the glass fibers as they are drawn from the melt. This eliminates the heat cleaning and the reapplication of a finish.

Theoretical studies indicate that the ballistic performance of fiberglass laminates used in armor should improve if the individual glass fibers can absorb more projectile energy when they act individually than when they are resin-bonded to each other in a network. In an attempt to demonstrate this theoretical prediction, various investigators have applied a surface finish of silicone oil to commercial heat cleaned fiberglass cloth, the intention being to lubricate the individual fibers so that they can slip past one another when they decouple from the resin matrix. The ballistic performance of such silicone-treated laminates has been unexpectedly poor. Very little improvement has been noted in comparison with laminates which have not been treated with silicone oil.

I have discovered that if silicone oil is applied to commercially available glass fabric which still has the manufacturer's temporary or compatible size and which has not been heat cleaned, a significant improvement in ballistic performance of the resulting laminate is obtained.

It is an object of the present invention to provide and disclose an improved high-impact-strength fiberglass laminate.

It is a further object of the present invention to provide and disclose an improved high-impact-strength fiberglass laminate bonded to a ceramic.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims.

In a specific example to illustrate one aspect of the invention, fiberglass cloth, style 1543, which is a unidirectional cloth manufactured by Hexcel Corporation of Dublin, Calif., was utilized. The fiberglass cloth was made from fibers manufactured by Corning Glass Company, to which a starch-oil size has been applied. Silicone oil (Dow Corning, DC–200; 1000 centistokes) in an amount of 0.7% by weight was applied to the fiberglass cloth from a xylene solution in a commercial coating tower, which comprises conveying means and a dip tank, wherein the fiberglass cloth is conducted through the silicone containing solution in the dip tank. Laminates consisting of 34 plies were constructed from the treated cloth. The laminates were bonded to 0.34" thick alumina targets with an adhesive sold under the trademark of Glom-O-N, manufactured by Thermo Resist, Inc., Fullerton, Calif.

Table 1 below sets forth the effects of the surface finish of a fiberglass laminate on ballistic performance. Table 1 shows the effect of applying various amounts of silicone oil to fiberglass cloth having an original starch-oil finish, which has been subjected to heat treatment of around 650° F. All targets were 0.34" thick alumina backed with 34 ply fiberglass laminate. 0.30 caliber armor-piercing projectiles were utilized. The reference to V_{50} represents the average projectile velocity required to penetrate the target.

TABLE 1

	Wt. percent silicone oil	V_{50}
Test number:		
1		2,300
2	0.7	2,430
3	1.5	2,450

The ballistic evaluations above were repeated as shown in Table 2 below, with the exception that the fiberglass alumina back-up material was not subjected to heat cleaning in order to remove the starch-oil size.

TABLE 2

	Wt. percent silicone oil	V_{50}
Test number:		
1		2,650
2	0.7	2,900
3	1.5	2,650

Table 1 discloses that surface treatment with silicone oil has a negligible effect on the ballistic performance of cloth that has been heat-cleaned to remove the original starch-oil size. Test No. 1 of Table 2 shows the improved ballistic performance of a cloth which had not been heat-cleaned, and hence retained the original starch-oil size. This improved performance was obtained even in the absence of a silicone oil surface treatment as shown in Test No. 1. It appears that optimum ballistic performance is obtained by the application to the cloth of a maximum of around 0.7% by weight silicone oil. The application of 1.5% silicone oil resulted in decreased ballistic performance in comparison to the application of around 0.7% by weight.

In addition to the utilization of the fiberglass laminate in conjunction with a ceramic material, the high-impact-strength fiberglass laminate has other applications, e.g., lining the cabin of aircrafts.

In another aspect of the invention, fabric KC–2408 which is a woven roving of the type most useful for armor backing, was also evaluated. The results are set forth in Table 3 below. This fabric is normally available only with a silane type of chemical coupling agent applied at the time the glass fibers are drawn. The target and projectiles utilized in the evaluation were identical to those used in the tests set forth in Tables 1 and 2. Six plies of like woven roving fabric were required to make a laminate of a thickness equivalent to 34 plies of the 1543 cloth style.

TABLE 3

	Wt. percent silicone oil	V_{50}
Test number:		
1		2,400
2	0.7	2,800

In test no. 1 of Table 3, no silicone oil was applied to the fabric. An application of 0.7% by weight silicone oil resulted is improved ballistic performance as shown in test No 2.

Although I have described my invention with a certain degree of particularity, it is understood that the present disclosure has been made by way of example and that numerous changes may be resorted to without departing from the spirit and scope of the invention.

Having described my invention, I claim:

1. An armor material consisting of a ceramic material to which has been bonded a backing consisting of a fiberglass laminate, said fiberglass laminate being constructed of a plurality of plies having a starch-oil size and a ballistically effective amount of about 0.7% by weight of a silicone oil finish.

2. An armor material in accordance with claim 1 wherein the ceramic material is alumina.

References Cited

UNITED STATES PATENTS

3,683,828	8/1972	Alliegro et al.	161—404
3,702,593	11/1972	Fine	161—404
2,953,477	9/1960	Evans	161—93
3,046,243	7/1962	Santelli	117—126 GS
3,445,267	5/1969	Layne	117—126 GS
3,634,297	1/1972	Campbell	117—126 GS

OTHER REFERENCES

Industrial Glass Fabrics, Hess, Goldsmith & Co., June 1, 1964, p. 6.

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