

The application of the continuous basalt fiber in the war industry and civil application

The following address is come from the general manager: XianQi Hu, Hengdian group Shanghai Russia & Gold basalt fiber co., ltd.

Ladies & gentleman:

The continuous basalt fiber is a kind of high-tech fiber which was discovered by Russia after 30 years' research & development. Because of its high performance, cost effectiveness, the wide application & the promising future, especially in recently years, there are continuous basalt fiber's batch production in our national country. Therefore, the forum we are holding now for the basalt fiber's discussion research & development has the great realistic significance.

Several years ago I had the honor to become the head of the thesis of the 863 project (continuous basalt fiber & composites) So I have the opportunity to know the basalt fiber before than you. I would like to take this opportunity to share our research achievement & information with you. Especially, the applications in the war industry field and civil field.

Today, I would like to discuss the following 4 problems with you.

- 1): what is the continuous basalt fiber?
- 2): what fields is the basalt fiber's excellent performance in?
- 3): what are the main applications in the war industry & common industrial field?
- 4): How to treat the basalt fiber's development in our country?

1 : what is the continuous basalt fiber ?

The Continuous Basalt Fiber is short for CBF, which is make use of the natural volcanic rock as the raw material and put them in the furnace under 1450⁰-1500⁰ after being crushed into powder and then which are produced by the platinum rhodium drawing filament laminate. Compared to the carbon fiber, Aramid fiber & (UHMWPE), which has many unique advantages. Such as the physical property, the high temperature resistance, continuous work from -269⁰ to 700⁰, good acid & alkali -resistance, the good UV resistance, the low hygroscopic property, the environmental resistance. And sound insulation, high temperature filterability, radiation resistance and the excellent wave -adsorption and wave-penetration and so on. Many sorts of composites which are use of the basalt fiber as the reinforced material can be used many fields such as fire, environmental protection, aerospace, armament, automobiles & vessels' manufacture, infrastructural material and so on. For these the continuous basalt fiber was rewarded the 21 century's new material.

The continuous basalt fiber (CBF) is a kind of high performance nonmetal inorganic fiber, which is made from the natural volcanic rock (including basalt rock, andesite rock and other mineral substance) In recent years which become more popular among the material fields and clients because of its comprehensive performance and cost effective.

Here, it is necessary to introduce to you the basalt's research background. In the 20century 60s', the Russia Department of Defense gave the command to develop the basalt fiber. According to the 1973's Russia news report: the basalt fiber which select the natural ores was widely used, which main referred to the super fine filament. In the 60-70's under the commands of the Russia department of Defense all the Russia glass fiber reinforced plastic and the branch of Ukrnine glass fiber academe set about the research and development. For that the Ukrnine constructural material industrial department commence the special BIREQIE heat resistance and sound insulation research union, whose main duty was to research the basalt fiber and the basalt products' production line. The scientific lab of the union commence to develop and research the basalt fiber in 1972 , which once had developed the more than 20 kinds of basalt fiber Manufacturing Technical Flow.

In the 1985, the basalt fiber's research was completed and made the industrial production can be realized. About 20 years past since the basalt fiber's successful development and mass production in the world. During that time, our national constructural research academe and NanKing glass fiber research & design academe once devoted themselves to the research & development of the continuous basalt fiber, results was disappointed. The "one-step" process, which is as same as the Ukraine and Russia ,which with natural volcanic rock as the raw material without any additive was applied in the production should be that time after it was listed the national 863 project. The 863 project was undertaken by the ShengZhen Russia & Gold carbon material co., ltd. After that the technological achievement was bought and set up the "HengDian Group Shanghai Russia & Gold Basalt Fiber Co., Ltd. In which the technological achievement was transferred and make the mass production realize. Consequently, today's discussion concerning the basalt fiber's prompt and application have the certain the realistic condition and foundation.

In these recent years, our national scientific and technology department pay much attention to the basalt fiber's research. Our counselor of our embassy in Russia HuangTao had once sent the report (21 century new material-basalt fiber) to our nation in July 2001. The national scientific & technology had the basalt fiber and composites listed the National High-tech Research & Development 863 program, National High technology industrialization Torch program and National Middle & Small Scale Science & Technology Business Innovation Fund Program.

2 : What fields is the basalt fiber's excellent performance in?

After knowing the excellent performance, we can defiantly how to prompt and apply them in the different fields. As we know, no any kind of fiber is all-function including the high-tech fiber and other any fiber. That is to say, "Whatever is, is right" fiber has its special performance and application market. What are the properties of the continuous basalt fiber? In general, the continuous basalt fiber is a kind of green industrial material of the 21 century. It has the good comprehensive performance and high cost effectiveness. Which is the other fiber

can't be followed.

2.1 The excellent high-temperature resistance.

The application temperature range of the basalt fibre:-269⁰C—700⁰C(the highest temperature is 960⁰C) but the glass fiber is -60-450⁰C. The soften point is 960⁰C .The breakage strength is 85% under 400⁰C; The breakage strength can keep 80% under 600⁰C. If these basalt fiber be treated in advance at 780-820 it can work normal without shrinkage at 860, even the excellent silicate cotton can only keep the strength 50%-60%, and the glass fiber will be completed destroyed The carbon fiber has the weak oxidative stability, which will produce the CO & CO₂ at 300⁰ but the ultimate application of the counterpoint Aramid is only 250⁰

2.2 The excellent tensile strength

The tensile strength of the continuous basalt fiber 3800-4800MPa more than the bundle carbon fiber, Aramid fiber, PBI fiber, steel fiber, boron fiber, alumina fiber and equal to S glass fiber.

2.3 Be well compatible with silicate

The basalt fiber, which is made use of the volcanic rock as the raw material is high resistance to acid & alkali. The testing shows that this basalt fiber has the excellent duration and stability in saturation Ca(OH)₂ and cement. This basalt fiber can replace the reinforcing steel bar as the reinforced material.

The basalt fiber which depend on its excellent tensile strength, cutting strength, the natural affinity with cement, concert and the resistance to alkali has shown its individual advantage & potential development.

2.4 The obvious chemical stability

The K₂O, Mgo, TiO₂ which are contented in the basalt fiber are very important contents for improving the resistance corrosion and water-resistance. The fiber loss after 3 hours' boil the comparison between CBF and E glass fiber as following: the CBF fiber loss weight is 0.2%, but the E glass fiber is 0.7%; in 2N NaOH, the former is 2.75% and the last is 6.0%; in 2N HCl, the former is 2.2% but the last is 38.9%. The acid resistance is higher than ECR glass fiber of the acid resistance glass reinforced material.

2.5 The excellent heat vibration stability

Its heat vibration stability is unchanged at 500⁰C, the original weight loss is less than 2%, and its weight loss less than 3% at 900⁰C.

2.6 The excellent electric insulation

The CBF has good electric insulation. Its volume electrical resistance is higher a order of Magnitude than E Glass fiber. CBF contents the conductive oxides less than 20%. This electric oxide is not made use as the insulation material but after the special treatment with sizing, its dielectric loss angle is lower 50% than Glass fiber and can be used as the novel heat & electric resistance.

2.7 The excellent wave absorption and transparency

We have tested under 8-18GHz with the laminate of CBF reinforced resin base 180x180, the thickness is 4mm, the resin system is HD03. From that we find this fact. This material has not any wave absorption additive, but why it has the propriety of wave absorption? From the analysis we know this basalt fiber contents

20% oxide including Feo₂ & TiO₂, if we adjust the contents adding absorbent and wave absorption coating in the resin system, maybe the wave absorption will be much better.

3: What are the main application in the war industry & common industrial field?

Firstly, we should focus the CBF application on the constructional reinforcement, protective products resistant to high temperature and fire, air filtration, environment protection, electrical insulation, petrochemical industry fields, sports fields, automobile & vessels manufacturing and so on.

The American Texas basalt fiber industrial union had pointed out that this basalt fiber is the low cost alternative of the carbon fiber, which has wide application fields. More importantly, because it comes from the natural ore without any additive, until now, it is a kind of green industrial fiber which has no environment pollution, no carcinogenic material. The American, as the advocator of the environmental protection will try their best to develop the no pollution green industrial material. So the continuous basalt fiber attracts much attention from the reinforcement field and get the rapid development.

The high-tech fiber is the foundational material in the defense construction and is the prop in the high-tech industrial development. It directly influences the construction of defensive technological industry & the upgrade of the national economy. CBF is the fourth high-tech fiber after carbon fiber, Aramid fiber, UHMWPE. CBF is a very important high-tech fiber especially in defense & war industry in 21 century and a new material which symbols the strategic layout in the defense industry.

Continuous basalt fiber as reinforcement can be made many excellent composites, and be widely used in armament & defense industry such as aerospace, rocket, missile, fighter plane, nuke, warship, tank and so on. It can improve the upgrade of the armament, reinforce the war power; it can alternative carbon fiber in some field to reduce the cost and can be used both war industry and civil industry. So taking the application research & development in defense industry has significant strategic and realistic meaning.

The Russia gave the order to develop continuous basalt fiber firstly. From 60s' after 30 years' struggle, the Russia government successfully developed this CBF before its disintegration. CBF firstly was applied in defense industry. One of the famous fact was the Russia spacecraft "union-19" which successfully completed connected with the American spacecraft "APOLLO" applied this CBF in its structural material. The Russia disintegration objectively influenced the basalt fiber development and prompt, because of this CBF has a Series of excellent performances which are different from the carbon fiber, Aramid fiber and UHMWPE fiber and has the cost effectiveness, these make it be popular in defense & war industry in American and Europe union. The American government even purchased its national CBF plant, now this plant locates in south American, Alabama. The productions completely be used in defense industry, the abstract application was secreted to outside. Obviously, in recent years, the American government

discovered many new values in CBF research & application.

3.1 The high-temperature resistance property made it be widely used in fire protection, environment protection and war industry.

It stays the first stage in fire suits, because of its individual performance, CBF has much advantages in fire suits field. The advantages of this CBF are inorganic fiber, non-inflammation, high-temperature resistance (-269°C-650°C), high strength, efficient innocuous dust filtration, excellent heat-insulation, no melting or dropping, no shrinkage. And the disadvantages are heavier than Aramid fiber, the less comfortable than Aramid fiber when wears. If CBF weaves with other fiber can be made fire-resistance material, which has the obvious advantages whey applied the in armament industry.

The UHMWPE is the best choice in making the soft ballistic materials, because of its low heat resistance, the melting point is only 144°C-152°C, the strength and elastic modulus begin to reduce as the increasing temperature, the weak creeping, over 70°C the performance abruptly reduced so there will be ballistic threading melting condition when make use of it for the ballistic material. Many of the ballistic experts turn their attention to this high-temperature resistance CBF, the related comparative research & application are undertaking. From that we can foresight that CBF has the wide application value & promising development future in tank, radome, ballistic automobile , ballistic blanket, ballistic boxes tunnel door of the military engineering and so on.

Form the above comparative performances, the CBF high-temperature application is lower than alumina fiber, carbon fiber but higher than any other organic fiber. And its super low temperature is the best. As the cost effective CBF is the cheapest. The overseas often regards the American Kavlar, Nomex, Teflon as the best choice for fire-resistance material. Which will be carbonized or decomposed at 370°C though it has the excellent high-temperature resistance and chemical-resistance property. CBF is at its first stage in fire suits, its unique property made it has the promising application future. The advantages of this CBF are inorganic fiber, non-inflammation, high-temperature resistance (-269°C-650°C), high strength, efficient innocuous dust filtration, excellent heat-insulation, no melting or dropping, no shrinkage. And the disadvantages are heavier than Aramid fiber, the less comfortable than Aramid fiber when wears.

Obviously, the fine CBF (the diameter is about 7μm) which has the excellent cost effective & high-temperature resistance maybe can alternative Kavlar, Nomex, Teflon as the fire protection material, and which is the alternative of the other high performance.

At present, the main filter materials are natural fiber, synthetic fiber, inorganic fiber and metal fiber. Cause of the further requirement for the high-temperature resistance and introducer Nomex, Procon, Torcon, Basfil, P84 and so on. Now, all the filter material can't solve the problem of filtering high-temperature resistancemedium, but the basalt fiber can be long used at -269°C-650°C and its high-temperature resistance can't be compared with the other fibers. The Canada Albarrie, which specialized the environmental protection industrial dust filter

material for 30 years used the CBF filter needled felt base cloth for 10 years. At present, it pays much attention to our national filtering environmental protection market and wants to have its own share. This successful application case and market movement should attract our attention for the environmental protection field.

Depending on its high-temperature resistance, CBF is the novel material in high-temperature filtering material (including dust-proof bag, automobile muffles filter core) fire fighting suit heat insulation material, fire-proof curtain, cold fighting suit, ballistic suits, heat-proof suits, military tent, heat-insulation & sound-insulation hood for tank motor, the inner decoration of the nuke, rocket throat and so on. Many colleagues American, Canada, Japan, Korea gave high praise of its heat-temperature resistance and its application field are increasingly expanded

3.2 The CBF will bring a revolution for building material.

Since 70s' definitely, China architecture & technology academe developed the GRC research and put forward the "double insurances" technological policies. That is (alkali-resistance Glass fiber reinforced low alkali sulfate concrete) though gained some success during 10 years, the GRC industry can't solve the duration resistance problem, the unsolved problems are as following:

(1) reducing the ZrO_2 content in the alkali resistance glass fiber ;(2) the unstable cement quality in low alkali aluminates ; (3) using the alkali Glass fiber to instead of the alkali-resistance Glass ciber (4) using the general Portland cement to instead of the low-alkali sulfate cement The other hand, some of the GRC plants' mechanize level

Is low, almost are manual operation and the rough technological rules which lead to the poor quality. Obviously, our GRC industry has a long way to go. As the basalt fiber mass production, the technology of basalt fiber reinforced silicate cement attracted much attention from all the fields, especially, those chemical building firms which has applied polypropylene fiber reinforced cement & concrete actively adopt basalt fiber reinforced silicate cement and concrete. And many of the

Firstly, the application in the concrete reinforcement. Now the main concrete reinforcement materials are carbon fiber, glass fiber, counterpoint Aramid, steel fiber and basalt fiber. The purpose of the reinforcement is to improve the tensile strength and the 防渗抗裂。From the strength, CBF has the absolutely advantage which is better than the above mentioned fiber. From the alkali resistance, CBF is lower than counterpoint Aramid, but better than glass fiber and steel fiber. From the compatible with the concrete, CBF and concrete has the basic contents, approximate density, so the CBF compatibility and dispersibility are much better than the other reinforced material. It can solve the duration when are used as reinforced railway cement crosstie, especially, be used in the changeable climate such as QingZang plateau. If you are interested in it, please read the article "the CBF application in the construction and foundation engineering which was published in the magazine "industrial architecture"

Secondly, the application in repair and strengthening of infrastructure

The carbon fiber weaves is a high-tech and high-cost product when used in infrastructure repair and strengthening field. At present, the main repair and strengthening material are carbon fiber and Aramid fiber because of its high strength and elastic modulus. Concerning the strength, the strength of the basalt fiber is not weaker than carbon fiber but higher than Aramid fiber though the elastic modulus is not good as carbon fiber. As the affinity to the resin, this basalt fiber is much better than carbon fiber and Aramid fiber, which intensively improve the repair effect and prolong the work life. Especially, in the bridge, the cubic winding reinforcement, this basalt fiber is not different from the carbon fiber. This significant discovery is come from the DUNAN university civil engineering academe comparatively between basalt fiber and carbon fiber at the same condition. From the cost comparative, basalt fiber is much less the carbon fiber and Aramid fiber. So basalt fiber has an advantage in a competition and it is the best substitute of the carbon fiber in reinforcement, earthquake-resistance, repairing fields. It can be widely applied in the repair and strength of the girder, pole, plate, wall and also can be used as reinforcement in bridge, tunnel, dam and so on. Especially, the earthquake -resistance. In the reinforcement fields, the differences between cohesive steel and carbon fiber as following: electric insulation, high-temperature resistance, freezing-melting resistance, the high affinity with the concrete and resin. Acid and alkali resistance, environment resistance, deformation consistent after pressing, but after reinforcement the carbon fiber is fragile after reinforcement. Take the architecture reinforcement and repair as example, carbon fiber and Aramid fiber at present are the main high performance fibers for reinforcement and repair. The preliminary findings showed that compare to the carbon fiber and aramid fiber, basalt fiber is much better than the other kinds fibers in tensile resistance, cutting resistance, antibounce strength, heat vibration stability and has the cost effectiveness. It has the promising application future in structural anti-earthquake reinforcement & repair such as bridge, tunnel, housing.

Moreover, The preliminary findings showed that the composites reinforcing steel bar of the CBFPR is a new kind building material which can alternative carbon fiber & Aramid fiber in building field. This new material can be applied to alternative steel bar in the worse environmental concrete to solve the steel bar rust problem and improve the duration of the concrete.

Thirdly, the application in the road-works fields.

It has become a research direction which applies the fabric Geogrid in the road reinforcement. The fabric Geogrid is a new Geogrid synthetic material, which has themany excellent performances: reasonable structure, good quality, high heat & cold resistance, high strength, high modulus, low expansion coefficient, stable physical property. The main purpose of the fabric Geogrid is fatigue-crack resistance , high-temperature resistance track, low-temperature resistance shrinkage, releasing reflection breakage. So this fabric Geogrid is widely used in expressway, the floor of bridge, manipulate expressway and airport pavement etc. now the Geogrid material main are glass fiber and plastic fiber. Basalt fiber priors to

those two fibers. The main advantages of basalt fiber are high tensile strength, excellent elongation, no long creep, good heat stability, be well compatible with asphalt, stable chemistry, low-temperature resistance.

3.3 The widely application of the CBF reinforced resin base

The CBF outstanding technique property as following: low volume, low heat conductivity, low water absorption, the chemical stability to corrosion material, reducing structural weight easily forming new structural material. Making these properties we can apply them in war industry and civil fields. Basalt fiber reinforced resin base composites is the body material of making tank armored car and can decrease the total weight. If it is used in making rocket material, especially gun barrel heat-shield can impressive enhance the hit rate and firing precision. It also can be widely used in gun bullet, fusee, bullet box, Large - caliber scatter-gun stack, the thin sheets of the tank armored vehicle, automotive motor hood, damping device. In the vessels industry, basalt fiber was applied in vessel hoods, passenger compartment thermal insulating & sound insulation material and superstructure. basalt fiber laminate which can be made railway carriage, not only can reduce the carriage weight but it is a excellent heat-resistance. It is reported that the American government through Ford and General automobile are drafting the industrial standards of adopting basalt fiber to instead of carbon fiber. German has had more than two years experiences ob basalt fiber research. Our automobile industry should pay much attention to this new material development trend. The pipe (diameter:5~2000mm, inner pressure: 0~400Pa) which is winded with basalt fiber oxide resin can be applied for transporting oil, gas, cold-heat water, chemical corrosion liquid, balk cargo, cable, high & low pressure gas tanks etc. take the gas pipe as the example, it is unnecessary for paying the money for the electronic-chemical treatment when bassalt fiber was applied in the gas pipe. And it can last 80 years. Obviously, it must bring a revolutionary in the pipe industry. Because of the short supply of the carbon fiber, the severely sufferer can be say are the makers of the sports leisure products. For that, its application in the sports field must attract much attention. Firstly, the basalt fiber's golden brown is the best choice for the sports products surface decoration. Secondly, it can reduce the cost when applied with the carbon fiber, which can release the short supply of the carbon fiber. Thirdly, basalt fiber is a new product for making the sports products.

3.4 CBF can be applied as the special material in the heat-vibration condition

For example, the basalt fiber 648 oxide-resin which can be used for the fighter-gun, the outside of the inlet of the composite structure. This fighter-gun underside is gun-doorway, which has the heavy vibration wallop, so it has the higher requirement for the flexibility. The basalt fiber breakage elongation is much higher than carbon fiber and has the excellent heat-vibration stability. In the mechanotronics field, basalt fiber polymer base composites are the excellent insulation material which can be made for instrument and meter, motor and many electronic accessories (such as gear wheel, bearing, packing material)

The excellences are can lighten its weight, improve its reliability and prolong its work life. Moreover, CBF has the excellent heat-temperature resistance and

mechanism performance. It can replace the expensive Aramid fiber and carbon fiber for the high-temperature mat, vessels insulation, friction base cloth for vehicles arrester.

3.5 The excellent electric insulation performance

CBF has the excellent electric insulation property. Its volume resistivity is higher a order of Magnitude than E glass fiber. This basalt fiber contents the conductivity oxide less than 20%. Conductivity oxide fiber hasn't be made for insulation material, after the special sizing treatment, its dielectric loss tangent is lower 50% than glass fiber and can be produced new heat resistance electronic-insulation material. Making use of its property, low-water absorption and high-temperature performance, it can be made metal-clad plate of the high-quality multilayer printed circuit board. With the speeding up of the telegraphy communications and large-scale computer information processing technology, there are higher requirement for high frequency work base. There are minor dielectric constant, dielectric dissipation factor, the small change for temperature and frequency. The glass temperature of the base board, heat resistance (over 270°C), reliability, even thickness, heat expansion, low water absorption.

In recent years, there is much higher requirement for the high-performance printed circuit board. Basalt fiber has the excellent heat-temperature and electric-insulation. The basalt fiber heat-temperature, insulation papers is the best choice for the electric insulation.

Furthermore, the basalt fiber has the radicalization-proof performance. It has the wide application in the power station construction, war industry, civil fields etc.

After all, along with the further research & development, mass production, cost reducing, its application must be expanded, and will become the novel technology industries.

And it will change the situation of the world advanced composites.