Basalt Fiber: Newer Fiber for FRP Composites

Shiza Parmar
Lecturer / Research Scholar at GTU, Textile Technology Department, R.C.T.I., Sola, Ahmedabad 380060

Dr. Hireni Mankodi
Associate Professor, Department of Textile, The M.S.University of Baroda, Kalabhavan, Vadodara 390001

Abstract – Basalt is a common extrusive volcanic rock formed by decompression, melting of Earth's mantle. It has extensive occurrence all over the world. Basalt fiber have properties such as good range of thermal performance, high tensile strength, good electromagnetic properties, inert nature; and resistance to acid, radiation, UV light, vibration and impact loading. This paper discuss about their manufacturing processes. Finally it is concluding that this is low cost material and possible to manufacture in India also because large availability of basalt rock (nearly 5, 00,000 sq. km). This paper deals with the manufacturing of basalt fibres, their properties and the applications.

Index Terms – Basalt Fiber, Fiber Reinforced Composites, Eco friendly fiber, Inorganic fiber.

1. INTRODUCTION

Basalt originates from volcanic magma and flood volcanoes, a veryhot fluid or semifluid material under the earth's crust, solidified in the open air. Basalt is a common term used for a variety of volcanic rocks,which are gray,dark in colour,formed from the molten lava after solidification [1- 4]. Basalt rock-beds with a thickness of as high as200 m have been found in the East Asian countries [5].

2. FIBERS FORM BASALT ROCK

All the related works that have been done by other researchers that are related to the current research problem should be summarized in this section. Times New Roman font with size 10 must be used in this section. Sub topic should be written as given below:

- History
- Fiber Forming Process
- Properties of Basalt fiber

2.1. History

A French scientist in the US field the first patent revealing the technique of producing basalt fiber in the year 1923 and subsequently the research was started in the United States of Soviet Russia (USSR). The development of basalt continues fibers (BCF) technology was conducted in the USSR; it had a status of closed scientific programs. Therefore, there were no contacts with scientists and engineers from abroad. The main development efforts are given by USSR for defense and aerospace applications.

The first samples of BCF were received at scientific research institute in Ukraine of USSR in 1956-61: but the initial industrial equipment was very expensive and large energy consuming. After dismantling of USSR in 1990's this research or technique made available to others. The recent efforts are taken for this technology to lower the cost and commercial use [5].

2.2. Fiber Forming Process

All In many ways, basalt fiber technology is similar to glass fiber technology, except only one material, basalt rock. Basalt continues filaments are made from the basalt rocks in a single step process melting and extrusion process. Technological process of manufacturing basalt filament consists of melt preparation, fiber drawing (extrusion), fiber formation, application of lubricants and finally winding. Basalt fibers are currently manufactured by heating the basalt and extruding molten liquid through a die in the shape of fibers, as shown in plant layout figure. Crushed rock material are charged into bath type melting furnace by a dozing charger, which is heated using air gas mixture or electrically.

Crushed rocks are converted into melt under temperature 12850C to 14500C in the furnace bath. Molten basalt flows from furnace to feeder through feeder channel and feeder window communicate to recuperate.

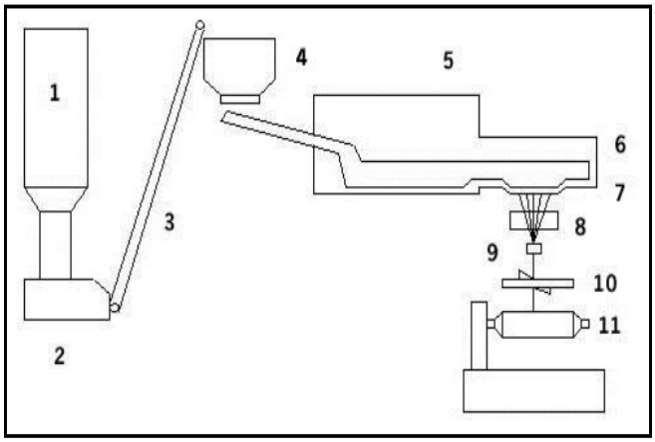

Figure 1 Plant layout of Basalt fiber formation [6]

The feeder has a window with a flange connected o slot type bushing and is heated by furnace waste gases or by electrically. The melt flows through platinum-rhodium bushing with 200 holes which is heated electrically. The fibers are drawn from melt under hydrostatic pressure and subsequently cooled to get hardened filaments. A sizing liquid with components to impart strand integrity, lubricity and resin compatibility is applied, and then filaments are collected together to form 'strand' and forwarded to take up devices to wound on forming tube.

1 Batch silos: raw material supply
2 Weighing, dosing and mixing
3 Pneumatic transport
4 Batch box : charging
5 Melting Furnace
6 Feeder
7 Bushings, (continuous filament formation)
8 Sizing application
9 Draw plate feeder; Strand formation
10 Lubricator
11 Automated winder

By varying the drawing speed of the fiber and temperature of the melt, fibers of wide size range could be produced. For example, a drawing speed of 12m/s and nozzle temperature of 13250C a fiber of 7 micron were produced while at 4m/s and 12850C a fiber of 17 micron was produced [6].

2.3. Properties of Basalt fibers

Basalt fibers have different properties as follows

Thermal Resistance

Basalt fiber has excellent thermal properties to that of glass fibers. It can easily withstand the temperature of 12000C to13000C for hours continuously, without any physical change, which is similar to S2 glass fibers and carbon fibers. Unstressed basalt fibers and fabrics can maintain their integrity even up to 1250 C, which makes them superior compared to glass and carbon fiber.

Mechanical Strength

Basalt fiber has tensile strength 3000-4840 M Pa, which is higher than E-glass fiber. It has higher stiffness and strength than E-glass fiber. Basalt fiber has slightly higher specific gravity, 2.6 – 2.8 g/cc, than other fibers.

Chemical Resistance

Basalt fibers have very good resistance against alkaline environment, with the capability to withstand pH up to 13-14. It also has good acid and salt resistance.

Chemical	%
SiO_2	52.8
Al_2O_3	17.5
Fe_2O_3	10.3
MgO	4.63
CaO	8.59
Na_2O	3.34
K_2O	1.46
TiO_2	1.38
P_2O_5	0.28
MnO	0.16
Cr_2O_3	0.06

Chemical composition of Basalt Rock[5]

Property	Value
Density, g/cc	1.95 - 2.75
Tensile Strength, Mpa	1200 - 4840
Compressive Strength, Mpa	420
Bending Strength, Mpa	800
Elastic Modulus, Gpa	89
Elongation at Break, %	3.15
Moisture at 65% RH, %	< 0.1
Max Application Temperature, °C	982
Sustained Operating Temperature, °C	820
Min Operating Temperature, °C	-260
Melting Point, °C	1450
Thermal Conductivity, W/m K	0.031 - 0.038
Glow Loss, %	1.9 - 2.0
Sound Absorption Coefficient	0.9 - 0.99
Loss Angle Tangent Frequency, MHz	0.005
Specific Volume Resistance, Ωm	1×10^{12}
Relative Dielectric Permeability, MHz	2.2

Physical properties of Basalt Fiber [5]

Corrosion and Fungi Resistance

Basalt fiber has better corrosion resistance. It does not undergo any toxic reaction with water and air or gases also. Moisture regain and moisture content of basalt fibers exist in the range of less than 1%. Basalt materials have strong resistance against the action of fungi and micro-organisms.

Abrasion Property

Basalt material is extremely hard and has hardness values between 5 to 9 on Mohr's scale, which results in better abrasion property. Even continuous abrasion of the basalt fiber-woven fabrics over the propeller type abraders do not result in the splitting of fiber by fracture and results only in breaking of individual fibers from woven structure which eliminates possibility of causing hazards.

Ecological Friendliness

Basalt fibers have natural raw material, which is basalt rock it does not cause any damage to the health. Basalt fiber has no biological hazards and solves waste disposal problems. It does not clog incinerator as glass. Hence, it is incinerator friendly [6].

3. POSSIBILITY OF IMPLEMENTATION IN INDIA

Current sources of basalt fiber production are mainly in Eastern Europe, viz., Russia, Ukraine, Germany, Belgium, United Kingdom and United states of America where technology immersed. Also these sources expanded and now in Israel and China. Various plans for more production have been announced but these plans haven't all materialized.

These fiber manufacturing should be closed to suitable basalt quarries and inexpensive energy. Basalt is also available in southern part of India. This technology has possible to implement in India. Basalt rock covers (Deccan Trap) an area of about 5,00,000 Sq. Km which is large part of the Maharashtra, Kutch, Gujarat, Madhya Pradesh, Goa, Karnataka, Andhra Pradesh etc [6].

4. CONCLUSION

Basalt can be used in manufacturing and made into fine, superfine ultrafine fibers. Basalt is an alternative raw material for fiber forming because of its relatively homogeneous chemical structure, its large scale availability throughout the world, its freedom from impurities and of course, its ability to form fibers in the molten state.

Basalt Rock fibers have no toxic reaction with air or water, are non-combustible. When in contact with other chemicals they produce no chemical reactions that may damage health or the environment. So it is ecological friendly material. Hence it is possible to make a fiber reinforced matrix with basalt fiber.

REFERENCES

[1] Jean Marie Nolf. 'Basalt Fibres - Fire Blocking Textiles'. Technical UsageTextile, no 49(3rd qrt), 2003,pp 38 - 42.
[2] K Vladimir and L Vladimir. 'Fibres from Stone'. International Textile Bulletin,no 5, 2003, pp 48 - 52.
[3] L A Taylor, A Patchen, R G Mayne and D H Taylor. 'The Most Reduced Rock from the Moon, Appllo 14 Basalt 14053 : Its Unique Features and their Origin'. The American Minerologist 89 (11 / 12), 2004, pp 1617.
[4] P R Renne. 'Flood Basalts - Bigger and Badder'. Science, no 296(5574), 2002 pp 1812-13.
[5] D Saravanan,' Spinning the Rocks - Basalt Fibres', IE(I) Journal-TX, Vol 86, February 2006, pp 39-45.
[6] Vishal Kumbhar,' An Overview: Basalt Rock Fibers - New Construction Material', Acta Engineering International, 2014, 2(1), pp 11- 18.

Authors

Shiza Parmar is a lecturer in Textile Technology Department at RCTI Ahmedabad amd Phd Scholar at GTU. After graduating from M S University with Master degree in Textile Engineering, she has worked in textile industry for 7 years. Then she joined academic and from last 6 yerars she is working as a lecturer.

Dr. Hireni Mankodi is working as Associate Professor in Textile Engineering department at M S University Baroda. She has 25 years of experience. Her area of interest are textile composite, medical textile, Garment technology and manmade technology. She has also published several papers in reputed national and international journals and conferences. She is also Phd guide at GTU and M S University.