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Investigation on Stealth Strategies in Coir Fiber Reinforced Polymer Composites

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Abstract

Stealth aircraft are aircraft that use stealth technology to interfere with radar detection as well as means other than conventional aircraft by employing a combination of features to reduce visibility in the infrared, visual, audio, and radio frequency (RF) spectrum. This philosophy also takes into account the heat, sound, and other emissions of the aircraft as these can also be used to locate it. Stealth is accomplished by using a complex design philosophy to reduce the ability of an opponent's sensors to detect, track, or attack the stealth aircraft. This paper provides a new platform towards the stealth technology with considerably less cost materials. The major contribution of the work is to introduce natural fiber composites in stealth technology. The coir fiber reinforced polymer composites are fabricated using Hand-Layup method. The fabricated composites and aluminum plates were tested for its absorption characteristics using the microwave generator setup by placing the laminate at different angles and at different distances from the transmitter terminal. The reflection loss is also calculated to compare the absorption rate for the natural fiber composites and aluminium plates.

Keywords: ICAM, convection, mountainous area.

Introduction

The stealth technology is most noteworthy in modern military applications since it can stay away from being detected by radars and other tracking systems. For that reason, many researches concerning the applications of stealth technology to weapon systems such as aircrafts, missiles, and warships are performed all over the world[1]. Stealth technology also termed LO technology (low observable) is a sub-discipline of military tactics and passive electronic countermeasures which cover a range of techniques used with personnel, aircraft, ships, submarines, and missiles, to create them a lesser amount of visibility to radar, infrared, sonar detection methods. There are various different stealth technologies as follows visual stealth, infrared stealth, acoustics stealth and radar stealth[2].

Stealth technology allows an aircraft to be partially invisible to Radar or any other means of detection which never allows the aircraft to be fully invisible on radar. The goal of stealth technology is to make an airplane invisible to the enemy radar by reducing the detection range. Most of the stealth aircraft uses RADAR absorbing Surface (RAS) to reduce its RADAR signature. Radar-absorbent material, or RAM, is a class of materials used in stealth technology to disguise a vehicle or structure from radar detection. A material's absorbency at a given frequency of radar wave depends upon its composition. RAM cannot perfectly absorb radar at any frequency, but by changing the composition does have greater absorbency at some frequencies than others. Radar absorbent materials (RAM), are used especially on the edges of metal surfaces. While the material and thickness of RAM coatings vary, the nature of the absorption is the same, it absorb radiated energy from a ground or air based radar station into the coating and converts it to heat rather than reflect it back[3,4].

The fiber-reinforced composite materials have been extended to commercial products as well as aerospace applications due to their excellent mechanical and electrical properties[5]. Using these characteristics of composite materials, researchers have studied the radar absorbing technique is called ‘Stealth’ technology[6,7]. Using of natural fiber adds advantages such as low weight, easy availability and economical. Since aluminium and its alloys are used in manufacturing skin of an aircraft, which is a fully reflecting body, RAM should be coated to absorb RADAR signals. Activated carbon which is a good absorber of electromagnetic waves is coated first with the help of epoxy resin as an adhesive. Epoxy resin when mixed/added with proper materials its microwave absorbing properties gets increased. Then to replace the artificial synthetic fiber natural fiber (COIR) is chosen which is capable of absorbing microwaves at certain frequency range[8]. In this paper the natural fiber reinforced polymer composites were fabricated using the Coir fibers and Epoxy resin. The transmission loss of the coir fiber composites were found by conducting various tests using the microwave absorption test equipment and it is compared with the aluminum.

Mechanized Methodology

Coir (Coconut fiber), Epoxy resin and hardener and activated carbon are the raw materials which are used in the fabrication process. The hand lay-up technique is used to fabricate the Coir

Fiber Reinforced Polymers composites. The coir fibers were extracted from the husk of the coconut. Coir fibers are typically 0.01mm to 0.02mm in diameter and 100 to 300mm long. Epoxy LY 556 resin, chemically belonging to the 'epoxide' family is used as the matrix material. Its common name is Bisphenol A Diglycidyl Ether. The low temperature curing epoxy resin (Araldite LY 556) and corresponding hardener (HY951) are mixed in a ratio of 10:1 by weight as recommended. The epoxy resin and the hardener are supplied by Ciba Geigy India Ltd. The composite consisting of 30% of fiber and 70% of epoxy resin. The mix is stirred manually to disperse the fibers in the matrix. The cast of each composite is cured under a load of about 60 kg for 24 hours before it is removed from the mould. Then this cast is post cured in the air for another 24 hours after removing out of the mould. Specimens of suitable dimension are engraved using a diamond cutter for testing.

Expeimental Setup: In order to verify the effectiveness of the microwave absorption strategies of the fabricated coir fiber-epoxy resin composites, the experimental setup shown in the figure.1 is designed and built. The experimental setup consists of three main apparatus: i. Transmitter end, ii. Receiver end and iii. Display unit. The transmitter is used to generate the microwave in the specified frequency. The transmitter end consists of klystron power supply, klystron mount, Isolator, variable attenuator and frequency meter. The klystron power supply is used to generate the beam voltage. These beam voltages are then converted into microwaves by the klystron mount. These are the unattenuated microwave beams which are passed through the isolator.

Then the unattenuated beam is attenuated using the variable attenuator, whose frequency is varied using the frequency meter. Then the beams are sent through the transmitting horn antenna. These transmitted beams are received using the receiving horn antenna. The receiver antenna can be rotated to various angles by the rotating table. The laminate is placed between the transmitter and the receiver antenna. The receiver antenna in turn is connected to the Digital Storage Oscilloscope through the output channel. The various output of the receiver antenna is displayed in DSO as a waveform with the values including Vpp, Vmin, Frequency, Period, and Duty Cycle.

Reflection Loss and Output Gain: Reflection loss is a measure of the reflected energy from a transmitted signal. It is commonly expressed in positive dB's. The reflection losses of the coir composite and Aluminium plate is measured by using the formula as follows:

$$RL(dB) = 10\ Log_{10}\, P_i/P_r \qquad (1)$$

Where, RL (dB) is the reflection loss in dB, P_i is the incident power and P_r is the reflected power. The output power gain is calculated to measure the voltage dropped. The power gain is measured using the following equation:

$$Output\ power\ gain = 20log\ (V_o/V_{in}) \qquad (2)$$

Where, V_0 = Output voltage (in Volts), V_i = Input voltage (in Volts).

Results and Discussion

The reflection loss for the aluminium plate and fabricated coir fiber composite materials were investigated by conducting the absorption test using the experimental setup shown in the figure.1. The experiments were conducted by placing the specimens at 100mm, 200mm and 300mm from the transmitter end within the frequency range of 8GHz to 12GHz. The aluminum /coir fiber laminate plate is placed at 45º at various distances from the transmitter and the receiver section is rotated with respect to the transmitter. The frequency of the incoming waves is altered using the frequency meter. When the aluminium plate is placed at 45º and the receiver is rotated about 30º the reflection losses is minimum at all frequencies.

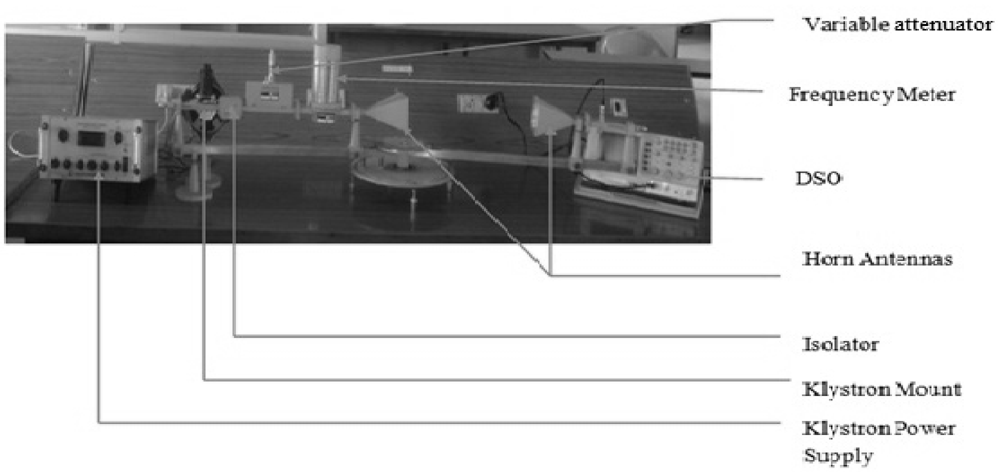

Figure-1
Experimental Setup

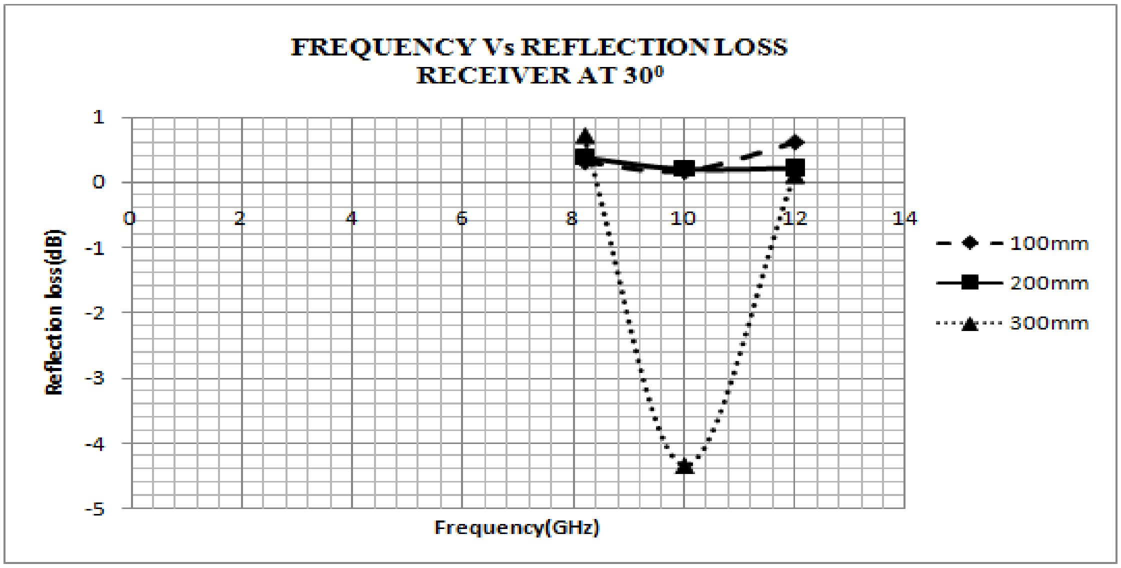

Figure-2
Reflection loss when the receiver is 30º

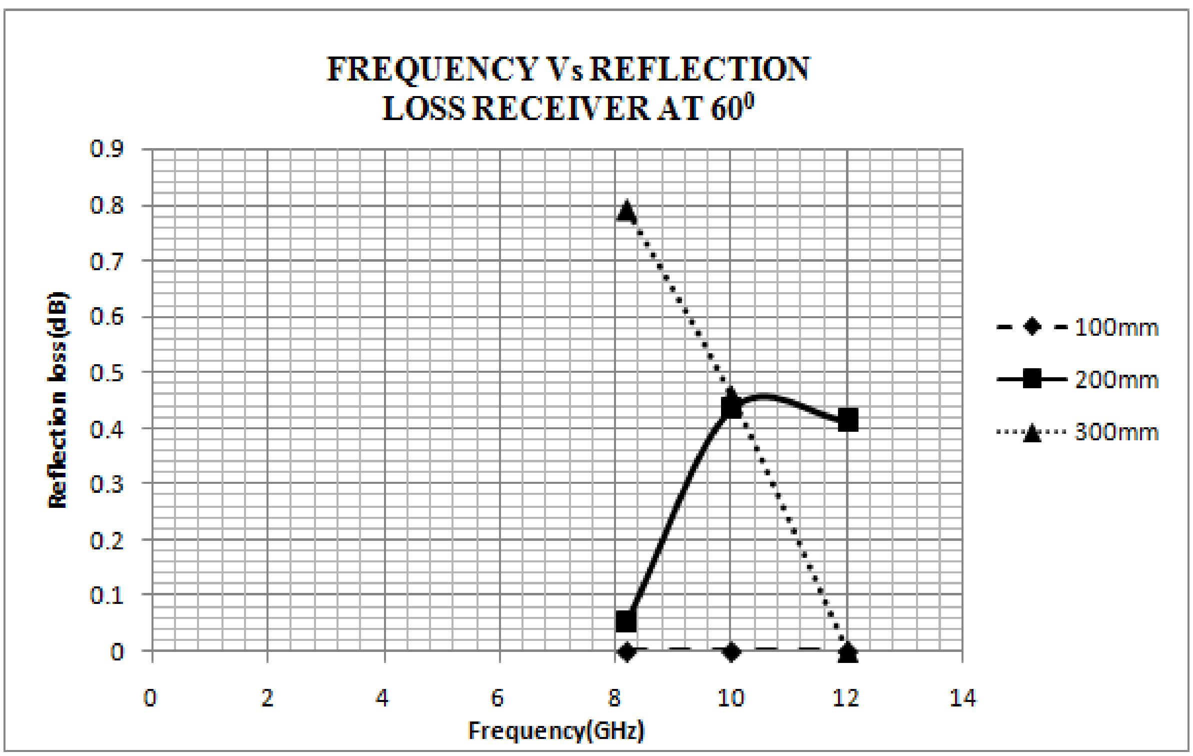

Figure-3
Reflection loss when the receiver is 60º

The reflection loss of the aluminium plate is analytically calculated using the equation 1 and 2. The reflection loss of the aluminium placed at 45º and the received end is at 30º is illustrated in the figure 2. When the aluminium plate is placed at 45º and receiver at 60º the aluminium plate gives a maximum reflection loss of about 0.8 dB. From the both graphs it can be predicted that the aluminium reflects the received waves with minimum losses, which can be detected easily by the enemy radar.

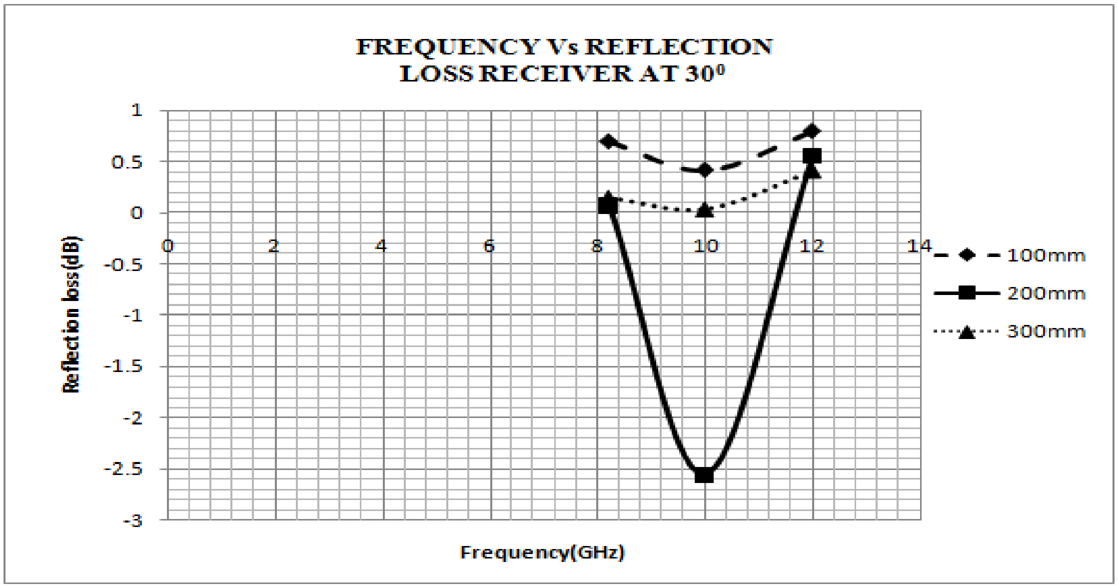

Figure-4
Reflection loss when receiver placed at 30^0

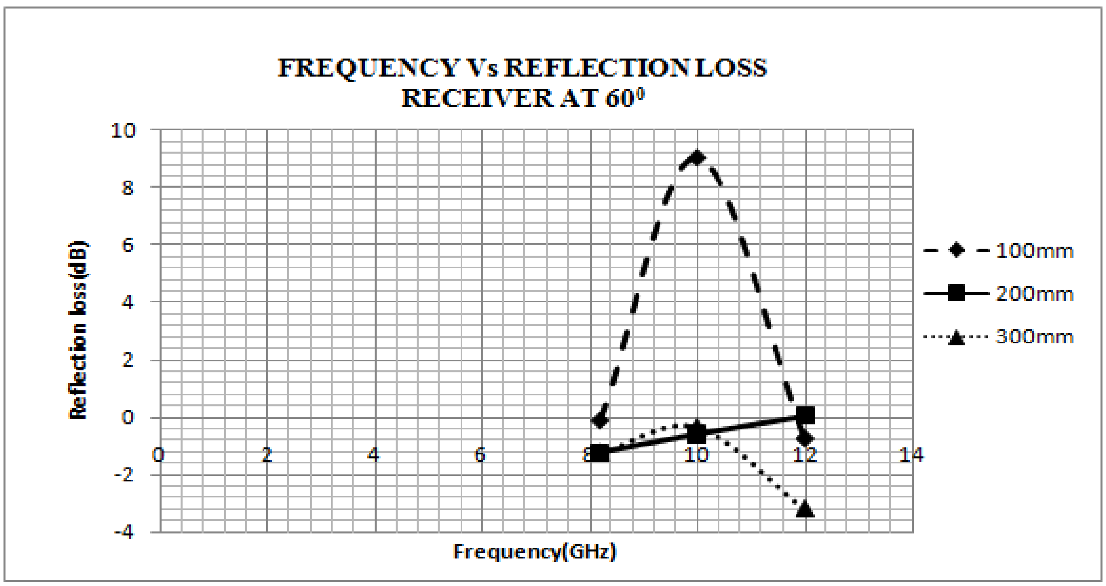

Figure-5
Reflection loss when receiver placed at 60^0

For the same orientation the specimen is changed to the coir fiber laminate, figures 4 and 5 shows the characteristic curves of this specimen with various configurations. When the coir laminate is placed at 45º and the receiver is rotated about 30º the waves are reflected with maximum refection from 0.9 to 2.5 dB which is more than that of the aluminum plate. When the coir laminate is placed at 45º and the receiver is rotated about 60º the wave's incident on the laminate is reflected with maximum losses of about 9 dB, which reduces the delectability of the laminate The reflection loss shows of coir fiber are effectively to absorb radar waves in frequency band of 8-12GHz. The prepared sample obtained the largest absorbing peak value of 450 dB at 12 GHz. From the above results it can be concluded that the natural fiber composites can be used as the radar absorption material in stealth applications.

Conclusion

From this research a new stealth technology is analyzed by less cost which might be better than present available stealth technologies. On considering the present stealth technology, using Natural fiber composite as RAM adds economical advantages and weight reduction .The Coir composite material is easily available one and it also increases the strength to weight ratio of an aircraft structure. From the experimental results it is shown that the reflection loss for the coir fiber laminate is higher than that of the conventional Aluminum that is upto 9dB. At higher distances due to absorption of microwaves by coir fiber composite the signal received by receiver varies in aspects such as frequency, amplitude which makes very difficult to determine the presence of aircraft. From the experimental analysis coir fiber has higher absorbing tendency than the Aluminum.

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