

A review paper on “Vanta-black Color”, “Reinforced Polymer Based Materials/ Radar Absorbing Materials” & “Thermal Infrared Reflective Metal Oxide Sol-Gel Coating” used in “Stealth Vehicle.”

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Abstract

Every country is doing a lot of research and development work on security and defense. A country like India shares their border with different countries from three sides need a lot of protection on border. Countries are making new armors and weapons with latest technologies so that their border can be protected. With the help of stealth technology, we make any object similar to surrounding environment in term of color (vanta black) and shape. If we use this technology in army jeep and tanks, then enemy will not be able to find out the position of our jeep and tanks on border. Stealth vehicle will be very useful from defense point of view on border. To make the vehicle stealth, we will give a new design to the vehicle, do thermal infrared reflective coating on engine and used super alloy to make the body of the vehicle. By applying thermal infrared reflective coating on vehicle, the vehicle will not emit heat and any heat sensor will not be able to detect the position of the vehicle. Thermal infrared reflective coating will act as heat insulator and will not allow heat to escape from the engine and vehicle body. We will use advanced cooling system to keep the engine temperature under control. The enemy army uses a heat sensor device to detect the vehicle's position and when the vehicle does not emit heat, the sensor device will become useless. We see the use of thermal barrier coating in aerospace industry where thermal barrier coating applied on engine turbines. Thermal barrier coating concept is similar as Thermal infrared reflective coating. Thermal infrared reflective coatings have anti corrosive properties as well as with stand on high temperature up to 1100°C. Thermal expansion that occurs in the turbine blade due to high temperature does not degrade the thermal infrared reflective coating. The outer surface of Aircraft is also an example of high quality thermal infrared reflective coating. The most commonly used thermal infrared reflective coating material is Ferromagnetic Oxide which has extremely high resistance against thermal shock up to 1100°C. Ferro-magnetic Oxide increases the durability of thermal infrared reflective coating and it is a rare earth element. Metal Oxide is generally applied on the material as thermal infrared reflective coating by the process of chemical deposition method and physical vapor deposition (diffusion coating methods).

Keywords: Stealth vehicle, Radar Absorbing Material, Thermal Infrared Reflective Metal Oxide Sol-Gel Coating, Vantablack, Heat Conduction.

I. INTRODUCTION

Countries like US and China have already included stealth bomber planes in their air force, an example of which is the Aurora bomber plane. The Aurora bomber plane flies at supersonic speed, due to which the radar and sensors of enemy countries cannot detect its position. Due to these feature of Aurora bomber plane, it is called a stealth plane. But now countries like America are doing a lot of research on the lane of stealth technology even in infantry fighting ground vehicles. Basically stealth does not mean disappearance but if a ground vehicle's position cannot be detected by radar or sensor then that vehicle is called stealth vehicle. It is similar to how a chameleon adapts its color to the surrounding environment and becomes difficult to see. To make the ground vehicle stealth, we give a special type of design to the vehicle so that it mixes with the surrounding environment, as well as the color of the paint is taken as the color of the surrounding things. For example, the ground vehicle used by the army in desert areas is of the color of wheat or beige, so that it mixes with the color of the surrounding sand. In the same way, the color of army jeep is kept green in dense forests so that it mixes with the surrounding trees and it is not easy to identify. But we know how much technology has evolved in today's time and mixing the color and design of the vehicle with the nearby things is not enough to steal the vehicle. In today's time there are many Gatling guns, rockets and missiles that have motion sensors and heat sensors, with the help of which they target their enemies. The snake hunts only hot blooded animals because some heat keeps coming out of the body of all hot blooded animals, which the snake feels with the help of its tongue, the snake's tongue has the ability to sense heat. Sensors also detect the position of the vehicle in the same way by sensing the heat released from the vehicle's engine and then the missile easily targets the vehicle with the help of the information received from these sensors. If we make such arrangements that the heat emitted from the engine of the vehicle does not escape so that the vehicle does not emit heat, then no heat sensor will be able to detect the position of the vehicle. But if the engine heat is not released, then the engine may be damaged, for which we will have to use the engine cooling system of very good technology, which does not allow the engine heat to escape and also keep it under control [1]. In order not to emit engine heat, we will do thermal infrared reflective coating on the outer surface of the vehicle body; thermal infrared reflecting coating can be easily applied on the surface of complex shape. In order not to emit engine heat, we will do thermal infrared reflective coating on the outer surface of the vehicle body; thermal infrared reflective coating can be easily applied on the surface of complex shape. We can use Radar Absorbing Material as a material to make vehicle body because these RAM do not allow radiation reflection easily. This is a bit similar to the way that by applying a certain kind of paint on the bomber aircraft and stealth ship, the heat of the engine does not come out to a great extent. The function of thermal infrared reflective coating is to block heat radiation as the name suggests. Metal Oxide which is mainly used for thermal infrared reflective coating and this material does not degrade even at 1100°C. We will use Diffusion coating and Overlay coating techniques to apply it to the surface of the engine and vehicle. By using thermal infrared reflective coating, we can protect the vehicle from the infrared sensor but to avoid the vehicle from the grip of the motion sensor, we will use a color named Vantablack on the outer surface of the vehicle whose total hemispherical reflectance below 1.5% in visible spectrum [2]. In this research paper, we will look at different techniques of

thermal infrared reflective coating, try to understand the properties of the material used in it, study the crystal structure of thermal infrared reflective coating closely. We will study in detail on VantaBlack paint to know its properties and methods of apply on the surface of vehicle bodies. Apart from this, we will know about some special types of Radar Absorbing Material, how RAM brought a new revolution in the manufacturing industry and which RAMs are used today in making advanced machines [3].

II. FEATURE REQUIRE IN STEALTH VEHICLE

A. *Acoustics*

Acoustic stealth technology plays a major role for submarines and ground vehicles. We know that if a vehicle is making a sound then its position can be determined quickly, so if we want the vehicle not to produce sound then it has to be made acoustic proof. Animals like bats, blue whales move from one place to another with the help of acoustic technology, these creatures produce sound from their mouth or any part of the body, so that they know their location and the location of their partner [4]. The submarine is coated with rubber material so that the location of the submarine is not known to the enemy army. Slow turning propellers are used in stealth aircraft to minimize noise from the aircraft. In the same way, to make a stealth vehicle, we have to work the sound of that vehicle's engine, as well as use rubber material between the body parts of the vehicle which can absorb the vibration and do not allow the sound to be produced.

B. *Visibility*

If we want an aircraft to be minimum visible, then by increasing its speed to supersonic speed (Aurora Bomber), we can stealth that aircraft, but the speed of the vehicle is not so much that it cannot be stealth by increasing its speed. The simplest technology of visual camouflage is used dark color (Black/Grey) on the outer surface of vehicle. Most stealth fighter plane use matte paint and Black/Grey colors, and operate only at night [5]. We will use Vantablack color on the outer body of the vehicle to make the vehicle stealth.

C. *Infrared*

To achieve infrared stealth, the exhaust gas is cooled to the temperatures where the maximum wavelengths of its radiation are absorbed by atmospheric CO₂ and water vapor, greatly minimize the infrared detectability of the exhaust emission [6]. The temperature of the exhaust gas can be worked out with the help of exhaust gas recirculation; heat of the exhaust gas can also be minimizing efficiently by installing a turbocharger in the vehicle. We can also reduce the exhaust temperature is to circulate coolant fluids such as fuel inside the exhaust pipe [7]. Thermal infrared reflective material coating on the outer surface of vehicle is good option to achieve infrared stealth.

D. *Reducing Radio Frequency Emission*

Radio Frequency Emission is a major concern to manufacture a stealth aircraft/vehicle. We should reduce infrared and acoustic emissions which emits by any tactical aircraft or vehicle. A stealth vehicle also must avoid radiating any other detectable energy, such as from onboard radars, communications systems, or radio frequency leakage from electronics enclosures [8]. We can use passive infrared and low light level television sensor systems to reduce radio frequency emission from vehicle.

E. Speed

If we want to stealth any aircraft or vehicle, then the speed of that aircraft or vehicle also play a major role. Supersonic speed technology is used in all stealth aircraft. Achieving supersonic speed is not easy in the case of vehicle but keeping the vehicle light can maximize the speed of the vehicle, so that the vehicle can easily change its position and the radar could not detect the vehicle position.

F. Tactic

GPS technology should be used in the vehicle, with the help of GPS, the vehicle can travel on a safe route so that the vehicle does not come under the radar range of the enemy. Mobile radar system also known as AWACS can be used in the vehicle, this technology helps the vehicle to avoid the radar of the enemy and makes the vehicle stealth.

III.ROLE OF COLOR IN MAKING VEHICLE STEALTH

We can see how different colors are used in army jeeps to make a vehicle stealth, such as the vehicles which are used in the desert are made of desert yellow color and the vehicles which are used in the forest is given green color. By doing this, the vehicle gets camouflage in its surrounding situation and its position is not known to the enemy. Apart from taking these colors, if we do new experiments and use Vantablack color on the upper surface of the vehicle, then we will be able to steal the vehicles in a better way, especially when the light is not sufficient. Its total hemispherical reflectance is 1.5% in the visible spectrum, making this color object not visible. The original Vantablack coating is applied to the outer surface of the vehicle body using a chemical vapor deposition method, this method firstly used in the United Kingdom and it is believed to be the world's darkest coating layer that absorbs up to 99% of visible light [9]. Vantablack coating is also unique because light falls on it from any angle, this coating retain uniform light absorption from almost all viewing angles. Chemical Vapor Deposition & spray coating methods are most suitable method for Vantablack coating on the outer surface of the vehicle [10]. Vantablack also has greater thermal stability up to 1100⁰C as well as greater resistance to mechanical vibration [11]. Early development was carried out at the National Physical Laboratory in the UK; the term "Vanta" was coined some time later [12]. As one of the darkest color, Vantablack has following more application, such as preventing stray light from entering telescopes, and increase the performance of infrared cameras both on night and in underwater [13]. Infrared camera helps researchers to take pictures in the forest or under the sea at night.



Fig no.01- Vantablack colour Firefox tank



Fig no.2- Comparison between gold colour and Vantablack colour

IV. ROLE OF BODY IN STEALTH VEHICLE

The designing of the vehicle should be such that the cross section area is minimum the technique of stealth an aircraft by minimizing the cross section area is being used in the designing of aircraft since the 1930s. The B-2 bomber in 1980s, which is a United States bomber plane, is rarely caught by the radar due to its shape; it is comparatively small in shape and size and has less cross section area. It is now known that it had a extremely stealthy shape apart from the vertical element of the tail. To make the ship stealth, the design of the ship minimizes the vertical surface in the body of the ship, thereby reducing retro reflective right angles and preventing the cat's eye effect that leads to ship stealth. We can also make vehicle stealth by using the same technology as the stealth technology we use in ships and aircraft. The Swedish Army, the British Army and the United States Army make their infantry ground vehicles too small in size to make them stealth, the Humvee which is a ground vehicle of the United States military is a great example [14]. If we look in the case of aircraft, then we will get the names of many stealth aircraft such as F-22 Raptor, F-117 Nighthawk and Sukhoi Su-57, but the name of ground stealth vehicle is negligible which is used in the infantry army of any country.



Fig. no. 03:- ATV Stealth Vehicle



Fig. no. 04 -: Stealth Car



Fig. no. 05-: Stealth Bomber Plane



Fig. no. 06-: Stealth Navy Ship

V. REINFORCED POLYMER BASED MATERIALS/RADAR ABSORBING MATERIAL USED IN STEALTH VEHICLE

If we make the outer body of the vehicle with the help of radar absorbing materials, then it helps a lot in making the vehicle stealth. We also call radar-absorbing material as radiation absorbing material and in short it is called RAM. RAM is made and designed in such a way that it absorbs radio frequency radiation so that no radar can detect the vehicle position. The more effective the RAM, the minimum resulting level of reflected Radio Frequency Radiation. Radar-absorbent materials are used in stealth technology to minimize the reflection of radiation from the surface of the aircraft or vehicle and stop the radar detection. There are five different types of RAM used in stealth vehicle manufacturing; these are Iron Ball paint absorber, Foam absorber, Jaumann absorber, Split-ring resonator absorber, Carbon nano tubes absorber. RAM cannot perfectly absorb radar at any frequency, but composition of different Radar Absorption Materials increase the work efficiency of RAM [15]. A common misunderstanding is that RAM makes an object invisible to

radar. A radar-absorbent material can significantly minimize an object's radar cross-section up to some limit radar frequencies, but it does not give 100% result in "stealth" on any frequency [16].



Fig. no. 07-: Carbon Nano Tubes Materials

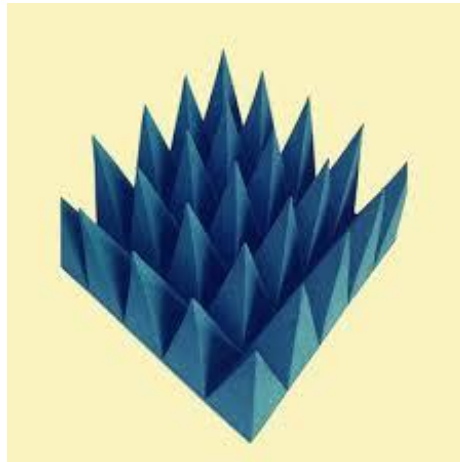


Fig. no. 08-: Foam Radar Absorbing Material

VI.THERMAL INFRARED REFLECTIVE METAL OXIDE SOL-GEL COATING USED IN STEALTH VEHICLE

Infrared wavelength can be used to identify and locate a number of objects in our day-to-day life. For military point of view, thermal imaging can be used to detect aircraft & ground vehicles in dark areas. This imaging science is made possible by the technology of thermal infrared radiation object emit in free space. To promoting stealth aerospace and ground vehicle, a selection of coatings can be added on the outer surface of the vehicle. Coating material is Metal Oxide Sol-Gel used for this purpose. These coatings material interact with infrared light to reflect or absorb the photons of light toward the surface of vehicles. The selection of thermal reflective material is critical to success of good reflectivity from a specific material. Thermally reflective materials are used for their capability to withstand in certain amount of laser energy at specified times. In past research work, reflection and absorption for specified radiation wavelength (approx 700nm) has been demonstrated by various materials on the micro and nanometer scale. Thermal Infrared Reflective behavior of any materials is mainly based on low emissivity. A low-emissivity coating

can reflect 95% of thermal radiation from its surface. A wide range of uses such as telecommunication system chip, window pane sensor for greenhouses and junction layers for solar cell have been made by these materials. Research has shown that the composition of metal oxide sol-gel with ferromagnetic materials can increase the infrared reflectivity. Three different design patterns have been used for this type of coating; namely single layer of metal, sandwich structure and multilayer design. Thermal Infrared Reflective coatings are used in outer surface of buildings and automobile glass windows for heat protection in gulf countries.

VII.CONCLUSION

Stealth technology is a boon in warfare by which lost wars can also be won. The basic concept of stealth is to blend into the environment around you in such a way that no one will notice your presence. In the last 40 years, a lot of work has been done on aircraft detection and tracking technology, due to which traveling with an aircraft or vehicle in the enemy's border has become fatal [17,18]. Stealth technology does not make an aircraft, ship or ground vehicle invisible, but helps it to camouflage in the surrounding environment, due to which the exact location of the object cannot be easily detected [19]. To make the vehicle stealth, we work on the acoustics, visibility, speed and tactics of the vehicle, so that we can make a vehicle camouflage in its environment to a great extent. For the process of making the vehicle stealth, we apply such paint on the top surface of the vehicle which has minimum reflectance. A lot of research has to be done on radiation absorbing material because its different composition gives different results; stealth technology depends a lot on the composition of RAMs [20]. Vehicle body design requires a lot of attention and stealth technology can be greatly improved with the help of thermal infrared reflective coating [21]. In the process of making a vehicle stealth, there are 3 things that are very important to pay special attention and these are -: The design of the stealth vehicle greatly affects the stability of the vehicle because stealth vehicle has poor aerodynamic properties, manufacturing the stealth vehicle is very time consuming and costly and stealth vehicle manufacturing process requires a lot of research work [22].

We know that a lot of research was done in every country to make the aircraft stealth and we also got the results in the form of F-22 Raptor, F-117 Nighthawk and Sukhoi Su-57. But neither attention is being paid nor is much research being done on ground vehicle stealth technology. This paper helped us to understand different techniques to make ground vehicle stealth; so that we will be able to make our infantry army strong and able to get the minimum loss of our army.

VIII.REFERENCE

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