

Invention Details

Names that represent invention

Bulletproof metal armor plate and production process

Fields of Science Related to Invention

5 mechanical engineering, materials science, and processes related to bulletproof materials.

Background of related art or science

The insurgency caused by various conflicts such as bombings, assassinations of civilians and peacekeeping officers, including the shooting of officers while driving on duty or patrolling precarious routes, risking many officers to get injured and killed because of such incidents. The vehicle used for duty may prevent the officer from getting shot, it is necessary to use a competent vehicle with high and excellent protection. There is a lot of demand for bulletproof vehicles to ensure the safety of officers, but the number of vehicles is not enough to meet the demand due to the excessive cost of procurement. In particular, the APC 4X4 REVA MK III wheeled armored vehicle imported from South Africa. The price is about 11 million baht per car. It weighs 7.8 tons, 10 measures 6.0 meters in length, 2.48 meters in width, 2.4 meters in height, 63 millimeters thick bulletproof glass, can carry 10 people, 4-wheel drive, operating range 500 kilometers, maximum speed 100 kilometers per hour. This model uses ARMox Shield armor in combination with Sweden's Weldom Shield. It is considered one of the most effective armor plates in the world. It is also 7.62x51 bulletproof (M-60).

20 The Department of Army Transport, the agency that owns the frame of small regular trucks with armor invented and transformed the bulletproof tactical vehicle or armored pickup truck into a 4-door Double Cab pickup, reinforced turbo diesel engine with a thickness of 1.0 to 1.3 centimeters around the roof and the area under the car with bulletproof glass around the car. In simple maintenance for metal armor plates for small regular trucks. It is caused by the stacking of several types of metal sheets of different thicknesses. When combined into a normal structure, a 25 small, armored truck results in heavy weight and increases the load on the vehicle's suspension or suspension system. This results in decreased performance.

Bulletproof metal armor plates for cars made of metal material. which has passed the NIJ bullet protection test at each level. NIJ standards are standards related to testing methods for 30 evaluating the ability or effectiveness of bullet protection of body armor set by the National

Institute of Justice., United States. This is a test according to NIJ standards at level 3 of bulletproof metal armor for cars fired by a 7.62x51 mm. NATO FMJ 148 Gr bullet at an angle of 0 degrees, a firing distance of 15 meters, with a bulletproof metal armor plate of at least the size. 12 × 12 inches (305×305 millimeters), number of test shots: 3 plates, each plate fired 5 times with a radius of 5 centimeters apart at all four corners and in the middle. with an average speed of 847 meters per second. The result is that there must be no penetration regardless of the distance of the shot mark, then it considered that “this armor can be used in normal or higher threat situations.”

P.K. Ray et al. have designed HSLA-100 steel to achieve a yield strength of more than 700 MPa and an impact strength of more than 81 Joules, at -84 degrees Celsius. However, this is because it is a steel with extremely low carbon content (less than 0.6% wt.), so other alloying components were added to increase shock absorbing properties. However, this feature causes limitations in its practical use. This is because it is a property that occurs only in environments with specified temperatures.

R.Q. Chi and colleagues studied and designed the use of a two-layer armor which It consists of a hard front surface and an energy-absorbing base layer, resulting in a lightweight design compared to single-layer metal armor that provides the same level of ballistic protection. Several researchers have developed empirical and numerical analysis models. To predict the remaining velocity of the bullet and the ballistic limit velocity (BLV) after impact with the armor. However, special materials and a combination of the two materials are required. Therefore there is a complicated production process.

Pradipta KumarJena et al have studied the selection of appropriate materials, crucial to reduce the weight of armor, and have conducted research on high-strength steel, aluminum alloys and titanium alloys. It is used as armor. The steel plates were subjected to annealing at 300 degrees Celsius for 2, 24 and 48 hours. A slight variation in strength and hardness was observed with increasing time, while it was found that the toughness and strength values of Charpy's bumps subsided. Bullet performance is evaluated by the 7.62 mm and 12.7 mm armor piercing bullets that were hit at an impact angle of 0 degrees. The results show Slight differences in bullet performance when hit with a 7.62 mm armor-piercing round, and the effectiveness of the armor plate decreased when hit with a 12.7 mm armor-piercing round. This form of alloy produces satisfactory results but due to the metal alloying steps involved, Therefore causing high production costs.

A. Banerjee et al. attempted to numerically investigate the collision of a bullet with a normal steel plate of medium thickness by a pointed bullet traveling at high velocity. The material and damage model were determined using the form of Johnson-Cook model to simulate material behavior and damage under constant force impact conditions. By simulating with the program Altair-Hyper-Works The pattern of penetration was obtained from predictions of maximum ballistic velocity and was found to be consistent with actual experimental data. It is a finite model using armor plates measuring 200x200x50 millimeters, divided into 10 elements along the width of 8 nodes hexagonal bricks, and has a fixed direction and range of bullets. The results showed complete penetration into the armor plate without the bullet being destroyed. It was found that by using a high-speed camera, it was possible to see the penetration of the armor plate without the bullet being destroyed as well. Measurements of the velocities occurring at each step were compared using the finite element method and experiments found that the values were consistent with both methods.

M. WasifAlia et al investigated numerical calculations of ballistic protection provided by combinations of armor plates. A 7.62 mm armor-piercing bullet was used during the experiment to determine the ballistic response of the aluminum plate and the combination of steel plate and aluminum plate. Armor-piercing rounds can penetrate aluminum armor plates. While the inclusion of steel plate armor can stop bullets from penetrating armor. And a finite element modeling method was developed to determine the penetration pattern of the armor plate. A brittle fracture caused by the bending of the bullet core due to an asymmetrical impact is expected, and the resulting fragments of the projectile cannot penetrate the base plate and collapse marks are created. on the surface of the armor plate from the impact of bullet fragments. Numerical models can only predict hole growth and bullet penetration when the base plate is directly affected by a bullet.

United States patent US 6698311 has a multi-layered armor design divided into the following sections: The front plate serves to absorb the impact of a high-velocity projectile. Made from extremely strong ceramic or metal materials. Later, the middle sheet, which acts as a force absorber, is a foam material with a high porous content of approximately 80 percent, with properties that support the deformation of the front sheet when it receives an impact and the last sheet made from titanium, aluminum, steel or composite ceramics with polymer-based materials serves to support the force and is a plate that joins all the sheets together to support the deformation that occurs. This form of armor has three layers of material, resulting in a complex fabrication

process. In addition, the innermost material that serves to support the force is a special material made from a combination of various types of steel, which is difficult to produce and has a high production cost.

US Patent US 5364679 includes a design that protects against high-velocity bullets coming from a rifle. It was designed from a combination of many components. The outer component consists of a layer of flexible material. And inside is an armor plate that is a material that has impact resistance and has a circular material made from glass (Soda lime glass) arranged in two layers next to each other between flexible layers by systematically arranging them next to each other so that there are no gaps. It has the shape of a square and a hexagon connected to each other.

Due to the complexity of the bead layer pattern and production details, this form of armor is expensive and difficult to mass produce.

From past research and patents for making bulletproof metal armor plates for automobiles. Currently used materials have many limitations, including specific materials and combinations of many materials, creating complexity in the production process, causing difficulties. Determining the appropriate heating rate and duration in the hardening process depends on many variables, such as the steel composition. The original structure of the steel, residual stress in the material, shape, and size of the workpiece to be hardened and in general, the heat that the steel receives on the surface and in the middle will not be the same at first. This is because it takes a certain amount of time for the heat to transfer through the steel surface to reach the middle. As a result, when giving high heat to the steel, the temperature difference between the middle and the center will be large. This may result in twisting or bending of the material and cause it to crack easily. This is due to the complexity of the said process. This makes the material more expensive as well. Therefore, Energis 42 Company Limited sees the importance and need to research and develop bulletproof metal armor plates for cars that can provide higher protection against bullets. Therefore, it is an important issue in designing and researching this into an innovation that can be extended to commercialization.

Nature and purpose of the invention

The aim of the this invention is to create a more effective bulletproof metal armor plate with the least weight of armor steel by a simple method of heat treatment of the metal plate to obtain armor plates that can protect against bullets according to the National Institute of Justice, NIJ standard test at level 3 of bulletproof metal armor plates for cars fired by 7.62x51 mm. NATO FMJ 148 Gr bullets at an angle of 0 degree, shooting distance of 15 meters.

Brief description of the drawing

Figure 1 Diagram of method for heat treatment of bulletproof metal armor plates.

Full disclosure of the invention

Bulletproof metal armor plate made of steel material in the shape of a flat sheet and is a single steel sheet with a thickness between 5 mm and 6 mm. all over, which produced by hot rolling using large rollers or presses. When finished producing, it will be in the form of a sheet. It has an alloy structure with high strength, high toughness, good hardening properties and can deeply harden less tendency brittleness excellent machining performance under specific temperature and good appearance after machining also has good welding performance and most importantly, it has excellent shock absorption efficiency. The overall mechanical properties are the ability to resist tensile forces greater than or equal to 100 kgf/mm², yield strength greater than or equal to 85 kgf/mm², elongation greater than or equal to 12%, cross section reduction rate greater than or equal to 45%, impact value greater than or equal to 6 J/cm², hardness ranges from 285 to 352 Vickers Hardness Test and has the following chemical composition.

Carbon (C) has a proportion between 0.38% to 0.43% and is an important alloying element of steel. which affects many mechanical properties. Improves hardness and resistance to tensile stress. Increase hardening ability but it has the effect of reducing the toughness and elongation properties of steel. In addition, carbon will combine with other alloying elements such as chromium, molybdenum, tungsten, and form carbide, which will improve properties in various applications, such as hardenability, toughness. Resistant to abrasion and maintaining hardness at high temperatures.

Silicon (Si) has a proportion between 0.15% to 0.35%. It is usually in amounts of 0.2 to 0.3% because in the steel smelting process, silicon is used to expel oxygen gas. As for silicon,

which is an alloying element, it plays a role in helping carbon combine to form graphite. Therefore, in some steels with a high carbon content and approximately 1% silicon, there will be a structure after hardening that consists of scattered graphite. This helps make it slippery when used to make molds. Reduce the problem of metal sticking while forming. This element is not to be used alone
5 but used in combination with molybdenum or vanadium. It gives satisfactory results in terms of reducing oxidation at high temperatures, which makes it easier to harden and helps maintain good hardness while tempering.

Manganese (Mn) has a proportion between 0.06% to 0.90%. It is a commonly founded element in steel. This is because in the steel production process manganese is added as a gas
10 remover and combines with sulfur (S) with a maximum proportion not exceeding 0.00020%. Manganese is classified as an alloying element in steel only if the amount is higher than 0.6%. Manganese has its role in increasing the hardenability of steel. The steel mixed with manganese alone has the disadvantage of becoming brittle after tempering in the temperature range of 400 degree Celsius to 600 degrees Celsius. Therefore, manganese is often mixed with chromium (Cr)
15 and molybdenum (Mo), which increases the ability to harden is greater than that of manganese alone.

Chromium (Cr) has a proportion between 0.90% to 1.20%. It is an alloying element that is added for many properties, such as increasing hardenability, increasing abrasion resistance properties, increasing toughness, etc. Chromium can combine with carbon to form many forms of
20 carbide, which if it is used at high temperatures and these carbides melts completely. The grain will expand a lot. Therefore, the use of steel alloyed with chromium alone Must avoid using at high temperatures and leaving it soaked for a long time or it can be prevented by adding vanadium to slow down the grain expansion.

Molybdenum (Mo) has a proportion of between 0.15% to 0.30%. Its advantages include a
25 stable composition and low levels of harmful elements, high iron purity, a small carbon separation layer and few surface defects. It has a low cold crack rate and a maximum tensile strength of 850 to 1,000 megapascal. This material has an exceptionally good balance between strength, toughness, and wear resistance. The chromium content of the alloy provides good hardness permeability, and the molybdenum element provides average hardness and high strength for
30 hardening effect. It also makes it possible to maintain the hardness of martensite up to a temperature of 500 degree Celsius. However, the disadvantage of molybdenum is that iron forms

a lot of oxide at temperatures of 1 000 degree Celsius to 1 100 degree Celsius and tends to cause loss of carbon easily on the steel surface. Therefore, silicon is often added to improve this defect.

Nickel (Ni) has a proportion between 0.01% and not more than 0.25%. It increases the impact resistance of steel. Therefore, it is used in steel that will be surface hardened by mixing it with chromium. This makes the steel highly resistant to corrosion. Not easy to rust and has heat-resistant properties.

Phosphorus (P) has a proportion between 0.01% and not more than 0.0030%, destroying the properties of steel. Often accidentally mixed into the steel. It should be as little as possible. These substances are often called impurities. High grade steel must contain no more than 0.03 % to 0.05 % phosphorus.

Sulfur (S) causes red shortness in steel, making it brittle and easily broken. In general, the amount of sulfur in steel is therefore limited to no more than 0.025% or 0.03 %, except for Free Machining steel where sulfur is added up to 0.30 % to create small sulfides distributed throughout the steel. This causes scraps in the unwanted parts to fall off easily, which makes it easy to trim them with machine tools.

As shown in Figure 1, a diagram of the heat treatment method for bulletproof metal armor plates. The process begin by preparing bulletproof metal armor plates to the desired size using water jet cutting technology, which uses high-pressure water to cut apart metal and other materials to cut into narrow angles conveniently and quickly and with high precision. Then it goes through a heat treatment process to change the properties of the metal to suit the conditions in which it will be used. Start by placing the steel sheet in an electric oven, for steel sheets with a thickness of 6 mm, the best temperature is set in range of 725 to 827 degrees Celsius, for sheet steel with a thickness of 5 mm, the best temperature is set at 925 to 1235 degrees Celsius, using a heating ratio that increases by range of 5 to 10 degrees Celsius per minute until the temperature reaches the setting range throughout the sheet. This method causes the temperature of both the furnace and the workpiece to heat up at a similar rate in such a way that the temperature difference between the surface and the center of the steel plate is minimal. When the temperature reaches the setting range, the temperature must be maintained for 10 to 15 minutes. After that, the steel plate with a temperature in the setting range is immersed in water at a water temperature of 25 to 38 degrees Celsius, with the water temperature maintained throughout the process for a period of 0.5 to 3.7 seconds and remove the steel plate from the water for 0.5 to 3.7 seconds, then repeat the immersion

process until the temperature of the steel sheet was reduced to range of 90 to 105 degrees Celsius, then allowed to cool in air at a temperature of 30 degrees Celsius, and then the cooled steel sheets were put into the annealing process with a temperature in range of 500 to 600 degrees Celsius for 30 to 60 minutes, then let it cool in an electric furnace to temperature of 30 degrees Celsius to
5 reduce stress in the metal and change the properties of the metal to be consistent Including reducing gas mixed in the metal to a lesser extent, because contaminated gas may result in low ductility of the metal.

The hardness value of bulletproof metal armor plates after hardening has an average hardness in the range of 590 to 720 kilograms per square millimeter. In terms of the hardness of
10 the outer steel surface on all sides of the armor plate It has a hardness value in the range of 650 to 720 kilograms force per square millimeter and the central part of the steel inside has a hardness value in the range of 586 to 662 kilograms force per square millimeter.

The best methods for crafting

The best method of invention is the method described in the details of the complete
15 disclosure of the invention.

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Claims

1. Bulletproof metal armor plate with a thickness of 6 mm all over, made of steel material in the shape of a flat sheet and is a single steel sheet. The overall mechanical properties according to Vickers Hardness Test format as follows:
 - 5 Hardness ranges from 285 to 352 kgf/mm²
The ability to resist tensile forces greater than or equal to 100 kgf/mm²
Yield strength greater than or equal to 85 kgf/mm²
Elongation greater than or equal to 12%
Cross section reduction rate greater than or equal to 45%
 - 10 Impact value greater than or equal to 6 J/cm²
and has the following chemical composition:
Carbon (C) in range of 0.38% to 0.43% by weight.
Silicon (Si) in range of 0.15% to 0.35% by weight.
Manganese (Mn) in range of 0.60% to 0.85% by weight.
15 Chromium (Cr) in range of 0.90% to 1.20% by weight.
Molybdenum (Mo) in range of 0.15% to 0.30% by weight.
Nickel (Ni) in range of 0.01% to 0.25% by weight.
Phosphorus (P) in range of 0.01% to 0.030% by weight.
Sulfur (S) in range of 0.01% to 0.030% by weight.
 - 20 Then hardened using the heat treatment process type 1 starts by placing the steel sheet in an electric oven set in range of 725 to 827 degrees Celsius, using a heating ratio that increases by range of 5 to 10 degrees Celsius per minute until the temperature reaches the range of 725 to 827 degrees Celsius throughout the sheet. When the temperature of bulletproof metal armor plates for automobiles reaches the range of 725 to 827 degrees
25 Celsius, the temperature must be maintained at the range of 725 to 827 degrees Celsius for 10 to 15 minutes. Then using the water quenching process which begins by taking a steel plate that has been heated with an electric furnace to a temperature in range of 725 to 827 degrees Celsius, then immersed in water at a water temperature in range of 25 to 38 degrees Celsius, for a period of 0.5 to 3.7 seconds and remove the steel plate from the
30 water for 0.5 to 3.7 seconds, then repeat the immersion process until the temperature of the steel sheet was reduced to the range of 90 to 105 degrees Celsius, with the water

temperature maintained throughout the process. Then allowed to cool to a temperature of 30 degrees Celsius. Then begins the annealing process by using bulletproof metal armor plates that has undergone a hardening process with water quenching to heat in an electric oven until the bulletproof metal armor plate for cars reaches a temperature in range of 500 to 600 degrees Celsius and maintain a constant temperature for 30 to 60 minutes, then stop heating and let the temperature decrease in the electric furnace until the temperature of bulletproof metal armor plate for automobiles is 30 degrees Celsius. Therefore, it is a bulletproof metal armor plate with a thickness of 6 millimeters.

2. Bulletproof metal armor plate according to claim 1 with a thickness of 5 mm all over, made of steel material in the shape of a flat sheet and is a single steel sheet. Then hardened using the heat treatment process type 2 starts by placing the steel sheet in an electric oven set in range of 925 to 1,235 degrees Celsius, using a heating ratio that increases by range of 5 to 10 degrees Celsius per minute until the temperature reaches the range of 725 to 827 degrees Celsius throughout the sheet. When the temperature of bulletproof metal armor plates for automobiles reaches the range of 925 to 1,235 degrees Celsius, the temperature must be maintained at the range of 925 to 1,235 degrees Celsius for 10 to 15 minutes. Then using the water quenching process which begins by taking a steel plate that has been heated with an electric furnace to a temperature in range of 725 to 827 degrees Celsius, then immersed in water at a water temperature in range of 25 to 38 degrees Celsius, for a period of 0.5 to 3.7 seconds and remove the steel plate from the water for 0.5 to 3.7 seconds, then repeat the immersion process until the temperature of the steel sheet was reduced to the range of 90 to 105 degrees Celsius, with the water temperature maintained throughout the process. Then allowed to cool to a temperature of 30 degrees Celsius. Then begins the annealing process by using bulletproof metal armor plates that has undergone a hardening process with water quenching to heat in an electric oven until the bulletproof metal armor plate for cars reaches a temperature in range of 500 to 600 degrees Celsius and maintain a constant temperature for 30 to 60 minutes, then stop heating and let the temperature decrease in the electric furnace until the temperature of bulletproof metal armor plate for automobiles is 30 degrees Celsius. Therefore, it is a bulletproof metal armor plate with a thickness of 5 millimeters.

3. Bulletproof metal armor plate according to claim 1 to 2 either of them, when taken through the heat treatment process type 1 or heat treatment process type 2, Therefore it became a bulletproof metal armor plate which have chemical composition as follows:

Carbon (C) in range of 0.100% to 0.105% by weight.

5 Silicon (Si) in range of 0.230% to 0.235% by weight.

Manganese (Mn) in range of 0.712% to 0.720% by weight.

Chromium (Cr) in range of 1.00% to 1.05% by weight.

Molybdenum (Mo) in range of 0.175% to 0.180% by weight.

Nickel (Ni) in range of 0.0001% to 0.0149% by weight.

10 Phosphorus (P) in range of 0.0001% to 0.0087% by weight.

Sulfur (S) in range of 0.001% to 0.020% by weight.

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