Metallic Functionally Graded Materials and Manufacturing Methods thereof

IITM Technology Available for Licensing

Problem Statement

- The problem statement discussed in the present invention is ***how to produce a simplified cost-effective functionally Graded Materials*** without limitations like expensive manufacturing method & other issues like difficulty in determining the component life, & others.
- Hence, there is a need to address the issue & said invention provides the solution efficiently.

Technology Category/ Market

Technology: Metallic functionally graded materials (FGM) & Manufacturing method;
Industry & Application: Defense, Aerospace, rocket heat shields, Marine industry, heat-engine components, Missile Industries, Naval Security/Navy & etc.
Market: The global **ballistic protection** market is projected to grow at a **CAGR** of **5.41%** during the forecast period **(2024-29).**

Technology

- Present patent describes a **high velocity ballistic device** for producing bulk functionally graded materials (FGMs) by impacting projectiles onto a stationery target, the device comprises of

  - **three tubes**
    → a **high-pressure tube** (HPT), a **pump tube** (PT) and a **launch tube** (LT);
  - **a piston**;
- **two diaphragms** separating the **junctions between** the **three tubes** (HPT, PT, and LT);and
- a **means** to **pressurize the high-pressure tube.** (Refer **Fig.2**)
- The **velocity** of the **projectile** is controlled by the **pressure of air** in the **high-pressure tube** & the **diaphragm material** & their total **thickness**.

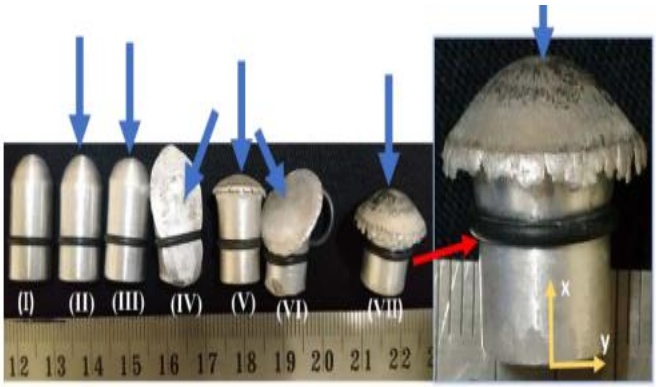

Fig.1 depicts projectiles tested at different impact velocities: (I) untested & un-deformed, the deformation increases from left (II) to right (VII) & the Blue arrow depicts the impact direction.

Table 1: Test conditions for different specimens

Specimen	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
Speed (m/s)	0	100	200	410	500	600	750
Impact angle (in °) (Angle from y axis)	-	90	90	35	90	75	90

Intellectual Property

IITM IDF Ref. 2446;
Patent Application No. 202241071549
PCT Application No. PCT/IN2023/051170

TRL (Technology Readiness Level)

TRL-4, Proof of Concept ready, tested and validated in Laboratory

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Images

Operation

During the pressure inside the high-pressure tube reaches a **critical value**, the first diaphragm between HPT & PT gets ruptured, pushing the piston forward which develops a very high pressure inside the PT that causes the second diaphragm to rupture, the projectile kept in the LT, just after the second diaphragm, gets accelerated & exits the launch tube at a high velocity to impact the stationary placed at a distance.

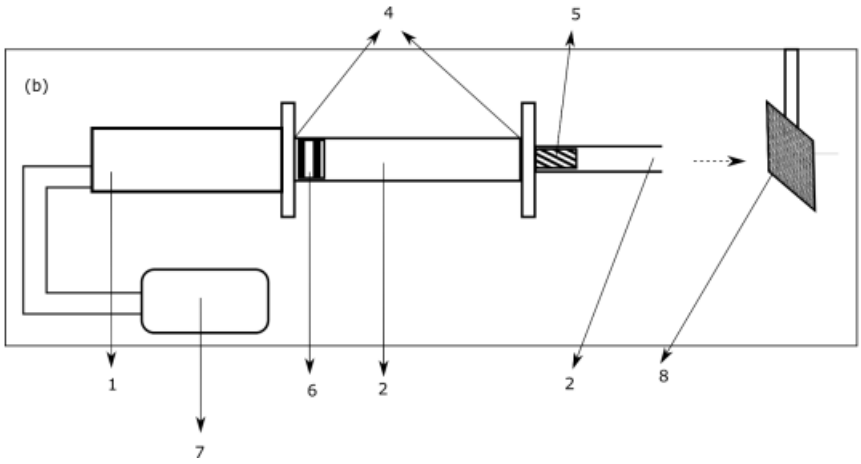

Fig.2 depicts a photographic image of the metal alloy

Key Features / Value Proposition

- Disclose a simple **low-cost method** to produce bulk metallic FGMs using Ballistic Impact.
- The method produces bulk **FGMs** of **varying size & shape** of the FGMs depending on the capacity of the **ballistic setup**
- The **projectiles,** having **hemispherical nose** of desired radius, length, & suitable weight, are made of **metal alloys** & others e.g. **Aluminum** alloys **(Al5052).** (Refer Fig. 3)
- The diaphragm materials can be of any material & further controlling the velocity of the projectile is achieved by changing the thickness of the diaphragms. (Refer Fig. 4)
- The **stationary target** may be any **strong & solid plate**, e.g. an ultra-high molecular-weight polyethylene (**UHMWPE**) plate.
- Applicable in **Security** agency, **Defense/Military**, **Aerospace** and **Missile** industries & etc.
- **Experimental Results:**
- A study of the **grain refinement & hardness variation** was carried out for all the tested projectiles prepared from **Al5052** including test results of different specimen of projectiles. (Refer Fig. 1 & Table 1)

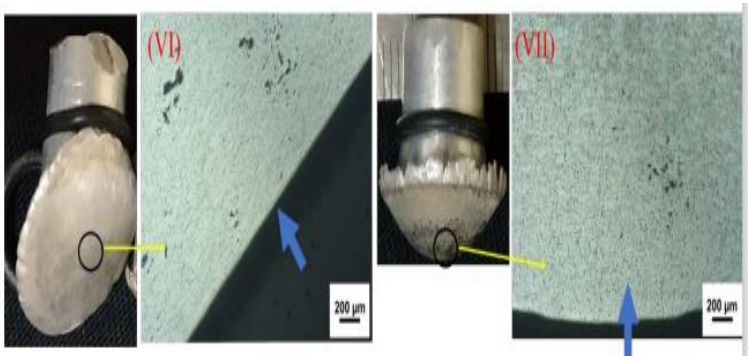

Fig.3 depicts variation in grain refinement in specimens (VI) and (VII) tested at different impact direction and the Blue arrow shows the impact direction

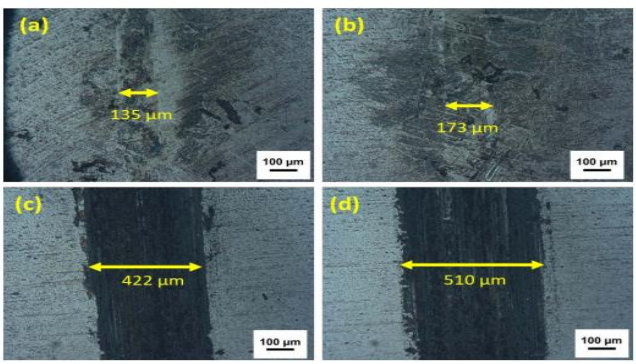

Fig.4 depicts Wear track width measurement at various sliding positions of M2 Steel sample, (a) position 1, (b) position 2, (c) position 3, and (d) position 4

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