INTELLECTUAL PROPERTY INDIA
PATENTS | DESIGNS | TRADE MARKS
GEOGRAPHICAL INDICATIONS

सत्यमेव जयते

क्रम सं/SL No :044172344

पेटेंट कार्यालय,भारत सरकार | The Patent Office, Government Of India

पेटेंट प्रमाण पत्र | Patent Certificate

(पेटेंट नियमावली का नियम 74) | (Rule 74 of The Patents Rules)

पेटेंट सं. / Patent No.	:	490784
आवेदन सं. / Application No.	:	202041007325
फाइल करने की तारीख / Date of Filing	:	20/02/2020
पेटेंटी / Patentee	:	INDIAN INSTITUTE OF TECHNOLOGY MADRAS (IIT MADRAS)
आविष्कारकों का नाम /Name of Inventor(s)	:	1.Srinivasan Chandrasekaran 2.Hari Sreenivasan

प्रमाणित किया जाता है कि पेटेंटी को, उपरोक्त आवेदन में यथाप्रकटित *A MARINE RISER HAVING A FUNCTIONALLY GRADED MATERIAL (FGM) LAYERS AND A METHOD OF MANUFACTURING THEREOF* नामक आविष्कार के लिए, पेटेंट अधिनियम, 1970 के उपबंधों के अनुसार आज तारीख फरवरी 2020 के बीसवें दिन से बीस वर्ष की अवधि के लिए पेटेंट अनुदत्त किया गया है।

It is hereby certified that a patent has been granted to the patentee for an invention entitled *A MARINE RISER HAVING A FUNCTIONALLY GRADED MATERIAL (FGM) LAYERS AND A METHOD OF MANUFACTURING THEREOF* as disclosed in the above mentioned application for the term of 20 years from the 20th day of February 2020 in accordance with the provisions of the Patents Act,1970.

अनुदान की तारीख : 28/12/2023
Date of Grant :

पेटेंट नियंत्रक
Controller of Patents

टिप्पणी - इस पेटेंट के नवीकरण के लिए फीस, यदि इसे बनाए रखा जाना है, फरवरी 2022 के बीसवें दिन को और उसके पश्चात प्रत्येक वर्ष मे उसी दिन देय होगी।

Note. - The fees for renewal of this patent, if it is to be maintained, will fall / has fallen due on 20th day of February 2022 and on the same day in every year thereafter.

IIT MA

Technology Transfer Office
TTO - IPM Cell

Industrial Consultancy & Sponsored Research (IC&SR)

A MARINE RISER HAVING A FUNCTIONALLY GRADED MATERIAL (FGM) LAYERS AND A METHOD OF MANUFACTURING THEREOF

IITM Technology Available for Licensing

PROBLEM STATEMENT

- **Marine risers** are cylindrical conduits used for transporting oil and gas from **offshore reservoirs to platforms or vessels.**
- They **facilitate drilling, well completion**, fuel production, and injection.
- However, they can suffer from **corrosion due to hydrogen sulphide, chlorides**, and carbon dioxide gases in marine environments.
- Marine risers made from **carbon-manganese steel can crack due to extreme loads, causing corrosion and leakage**.
- Composite materials face **delamination, crack formation, premature failure**, design and manufacturing challenges **due to high-pressure, high-temperature conditions, lower D/t ratio**, and special treatments.
- This disclosure aims to **overcome these limitations.**

TECHNOLOGY CATEGORY/ MARKET

Technology: Marine Riser
Category: Energy,Extraction and Mining
Industry: Marine Energy Sector, Offshore Engineering
Application: Oil and gas industrial application
Market: The global market size was estimated to reach a valuation of **USD 3.8 Billion in the year 2022** With a steady **CAGR of 2.2% from 2023 to 2033,** this market is expected to reach **USD 4.1 Billion by 2023 and USD 4.9 Billion by 2033.**

INTELLECTUAL PROPERTY

IITM IDF Ref. 1978
Patent No: IN 490784

TRL (Technology Readiness Level)

TRL-4, Experimentally validated in Lab;

Research Lab

Prof. Srinivasan Chandrasekaran, Hari Sreenivasan, Dept. of Ocean Engineering..

TECHNOLOGY

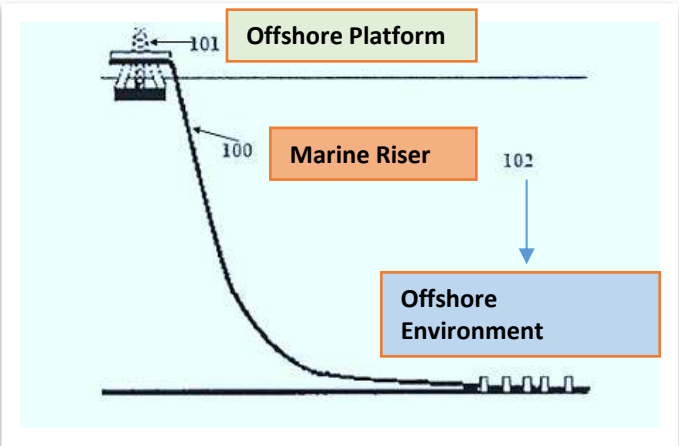

Figure 1 illustrates schematic view of an offshore environment comprising of an offshore platform and a marine riser connected

A **marine riser** having **functionally graded material (FGM)** layers, comprising:

Core layer

- **carbon-manganese steel**, with a core layer that allows fluid flow

First intermediate layer

- **Duplex stainless-steel material**, provided concentrically around the core layer

Second intermediate layer

- **Nickel material**, provided concentrically around the first intermediate layer

Outer layer

- **Titanium material** provided over the second intermediate layer

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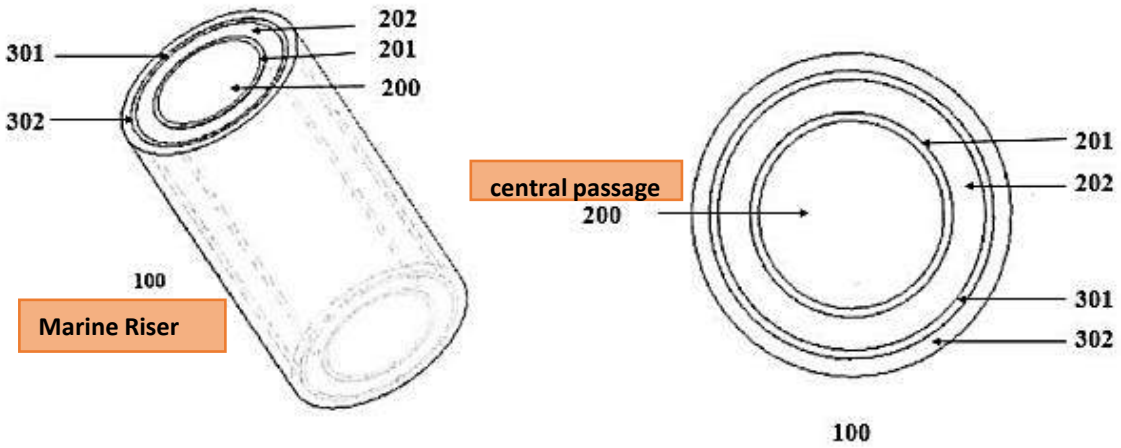

Figure 2 illustrates a marine riser manufactured by Functionally Graded Material-II (FGM-II)

Numerals	Definition
201	Core layer
202	First intermediate layer
301	Second intermediate layer
302	Outer layer

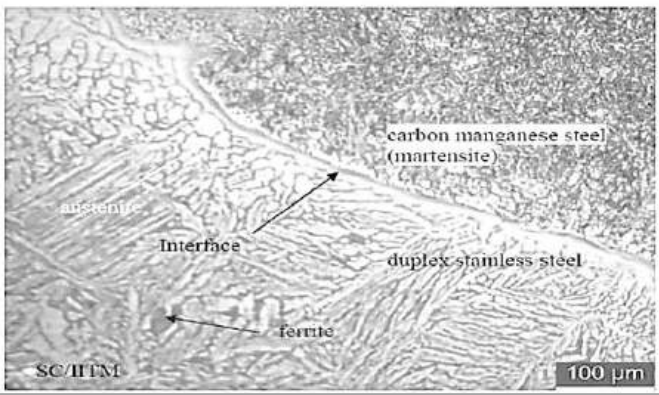

Figure 3 shows the microstructural interface of duplex stainless steel and carbon manganese steel in a marine riser made using FGM at a 100X magnification

Key Features / Value Proposition

- **Core layer** formed of **carbon-manganese steel** material comprises a **martensite** microstructure.
- The **First intermediate layer** formed of **duplex steel material** comprises a **ferrite and austenite** microstructure.
- The **Second intermediate layer** formed of **nickel prevents material interaction** between the duplex stainless-steel material of the first intermediate layer and the titanium material of the outer layer Properties of functionally graded material layers
  - **Yield Strength** of about **513 MPa to 547 Mpa**
  - **Ultimate Tensile Strength** of about **579 MPa to 619 Mpa**
  - **Elongation** of about **11 %**
- **Laying operations** are performed by **Wire Arc Additive Manufacturing (WAAM) technology.**
- **Corrosion**-The outer layer, the first and the second intermediate layers act **as corrosion resistant layers** of the marine riser.
- Exhibit **improved corrosion resistance, mechanical properties and high temperature high pressure resistance** under marine conditions.

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