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

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TECHNOLOGY

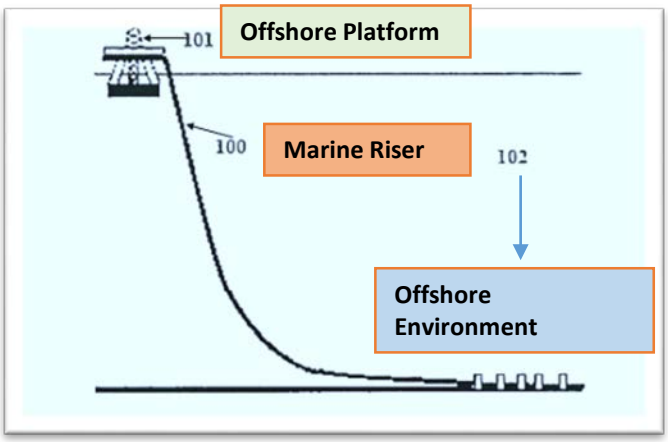

Figure 1 illustrates schematic view of an offshore environment comprising of an offshore platform and a marine riser connected

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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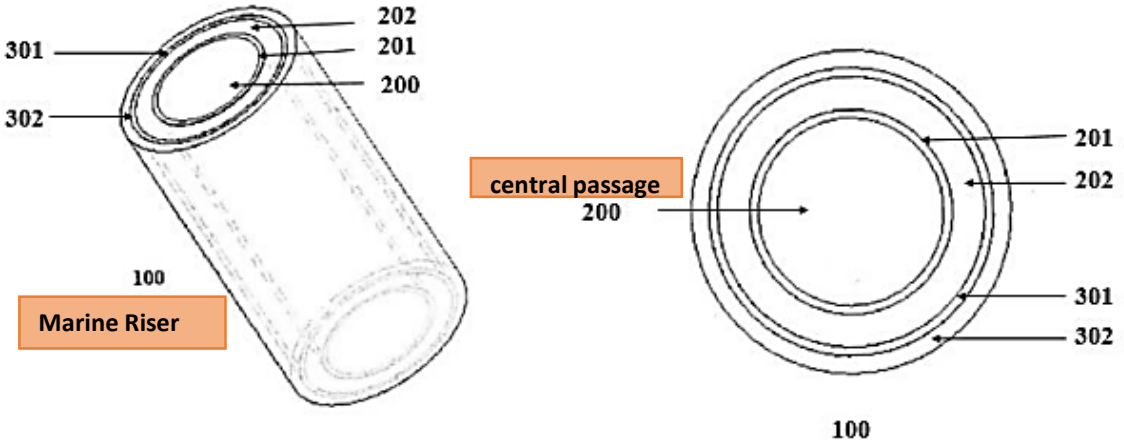

Figure 2 illustrates a marine riser manufactured by Functionally Graded Material-II (FGM-II)

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

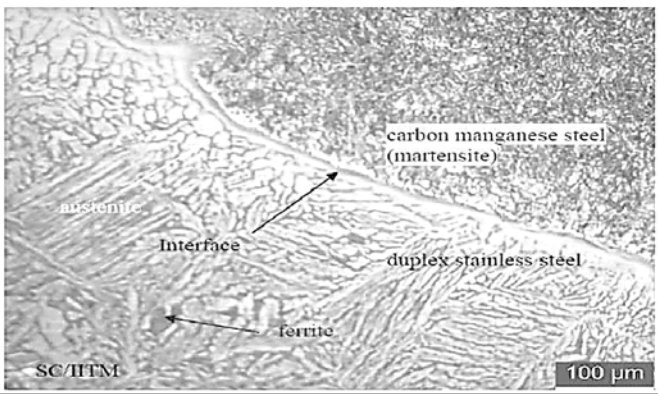

Figure 3 shows the microstructural interface of duplex stainless steel and carbon manganese steel in a marine riser made using FGM at a 100X magnification

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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