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Documentation on Glass Bottle Manufacturing Instead of Using Plastic Bottles

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Abstract: Provide a short summary (5–8 sentences) of the glass bottle manufacturing its global impact, scientific findings, and importance of continued research and preparedness. In reallife there is so many complications using plastic bottles and also so many health diseases in different ages of peoples avoid this things using glass bottles more advantages instead of plastic bottles.

Keywords: *Glass Bottle Manufacturing, Silica sand, Soda Ash, Limestone, Cullet (Recycled Glass), Blow- and-Blow Process, Press-and-Blow Process, Quality Control, Defects (Cracks, Bubbles, Thickness Variation) Graphs and Table of Columns Analysis Part.*

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I. INTRODUCTION

Overview of SARS-CoV-2 and the disease it causes. Glass bottle manufacturing is one of the oldest and most significant processes in the packaging industry, with applications ranging from beverages and food to pharmaceuticals and cosmetics. The process involves the fusion of raw materials such as silica sand, soda ash, limestone, and cullet (recycled glass) at extremely high temperatures to form molten glass, which is then shaped into bottles through molding techniques like blow- and-blow or press-and-blow.

Due to their non-reactive nature, durability, and aesthetic appeal, glass bottles have remained a preferred packaging material despite competition from plastics and metals. A major advantage of glass is its 100% recyclability without loss of quality, making it highly sustainable and environmentally friendly. Modern manufacturing plants employ automation, robotics, and advanced inspection systems to ensure high precision and low defect rates, as defects such as cracks, bubbles, or irregular thickness can affect product quality and safety. With increasing demand for eco-friendly packaging, glass bottle manufacturing continues to evolve by focusing on lightweight designs, energy efficiency, and closed-loop recycling systems, thus playing a vital role in sustainable development. COVID-19 spreads mainly through Raw Material Impurities – Presence of unwanted particles (like stones, metals, or poorly mixed cullet) can create bubbles or inclusions.

Incorrect Furnace Conditions – Wrong melting temperature or uneven heat distribution leads to incomplete melting, streaks, or weak spots. Molding Issues – Poor mold design, damaged molds, or wrong lubrication can cause cracks, uneven thickness, seams, or shape defects. Improper Cooling (Annealing) – If bottles are cooled too quickly or unevenly in the annealing lehr, they develop internal stresses, making them brittle and prone to cracks. Machine Malfunctions – Defects can occur due to misaligned feeders, faulty blow heads, or wrong timing in the blow-and-blow / press-and- blow process.

Contamination or Handling Errors – Dust, oil, or mechanical mishandling during transfer and packaging may cause scratches, cracks, or breakage.

- *Proper Documentation of Glass Bottle is Crucial for:*

Glass bottle manufacturing is an important industrial process widely used in beverages, food, pharmaceuticals, and cosmetics because of glass's durability, chemical inertness, and recyclability. The main raw materials used are silica sand, soda ash, limestone, and cullet (recycled glass), of which cullet plays a vital role in reducing energy consumption and improving melting efficiency. These materials are first weighed and mixed in the batch house and then melted in furnaces at very high temperatures of about 1500–1600 °C. Once molten, the glass is conditioned to achieve the right viscosity and then shaped into bottles by two main methods: the blow-and-blow process, used for narrow-neck containers, and the press-and-blow process, used for wide-mouth jars. After forming, the bottles pass

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through an annealing lehr, where they are cooled slowly and uniformly to remove internal stresses and prevent cracks. Quality inspection is a crucial stage, where automated systems check for common defects such as blisters, seams, cracks, or uneven thickness. Defective bottles are recycled back into the furnace as cullet, ensuring minimal waste. The main causes of defects include impure raw materials, uneven heating, poor mold design, or improper cooling. Quality control tests ensure that bottles can withstand internal pressure, thermal shock, and handling stress. Glass bottles remain highly valued because they are 100% recyclable without loss of purity, hygienic, and provide a premium appearance. With advancements in automation, robotics, and lightweight designs, modern plants have significantly reduced defect rates and improved efficiency. Thus, glass bottle manufacturing not only supports safe and aesthetic packaging but also contributes strongly to sustainability and the circular economy.

➢ *Mathematical Data & Assumptions*

- A plant produces about 1,000,000–1,200,000 bottles per day.
- The average defect rate in modern plants is assumed at 1–2%, while advanced plants may reduce it to 0.5% or less.
- Each defective bottle is recycled as cullet, but still causes a scrap loss (extra cost of energy and reprocessing).
- Raw materials (silica sand, soda ash, limestone, cullet) are assumed to be of consistent quality.
- Furnaces operate at 1500–1600 °C with stable energy supply and proper maintenance.
- Production uses blow-and-blow for narrow- neck and press-and-blow for wide-mouth bottles.
- Automated inspection systems are assumed to detect and reject all defective bottles.
- Cooling in the annealing lehr is assumed to be uniform to avoid thermal stress.
- Market demand is sufficient to consume the daily production volume.

II. RESULTS

- A plant producing 1,200,000 bottles/day with a 1.2% defect rate yields about 14,400 defective bottles and 1,185,600 good bottles.
- After quality improvements reducing defects to 0.6%, defectives drop to 7,200/day and good bottles increase to 1,192,800/day.
- The daily scrap loss reduces from ₹57,600 to
- ₹28,800, saving nearly ₹28,800 per day.
- This improvement translates to about ₹8.64
- lakh savings per month (30 days).
- The results confirm that better quality control and automation reduce defects, improve output, and lower production costs.

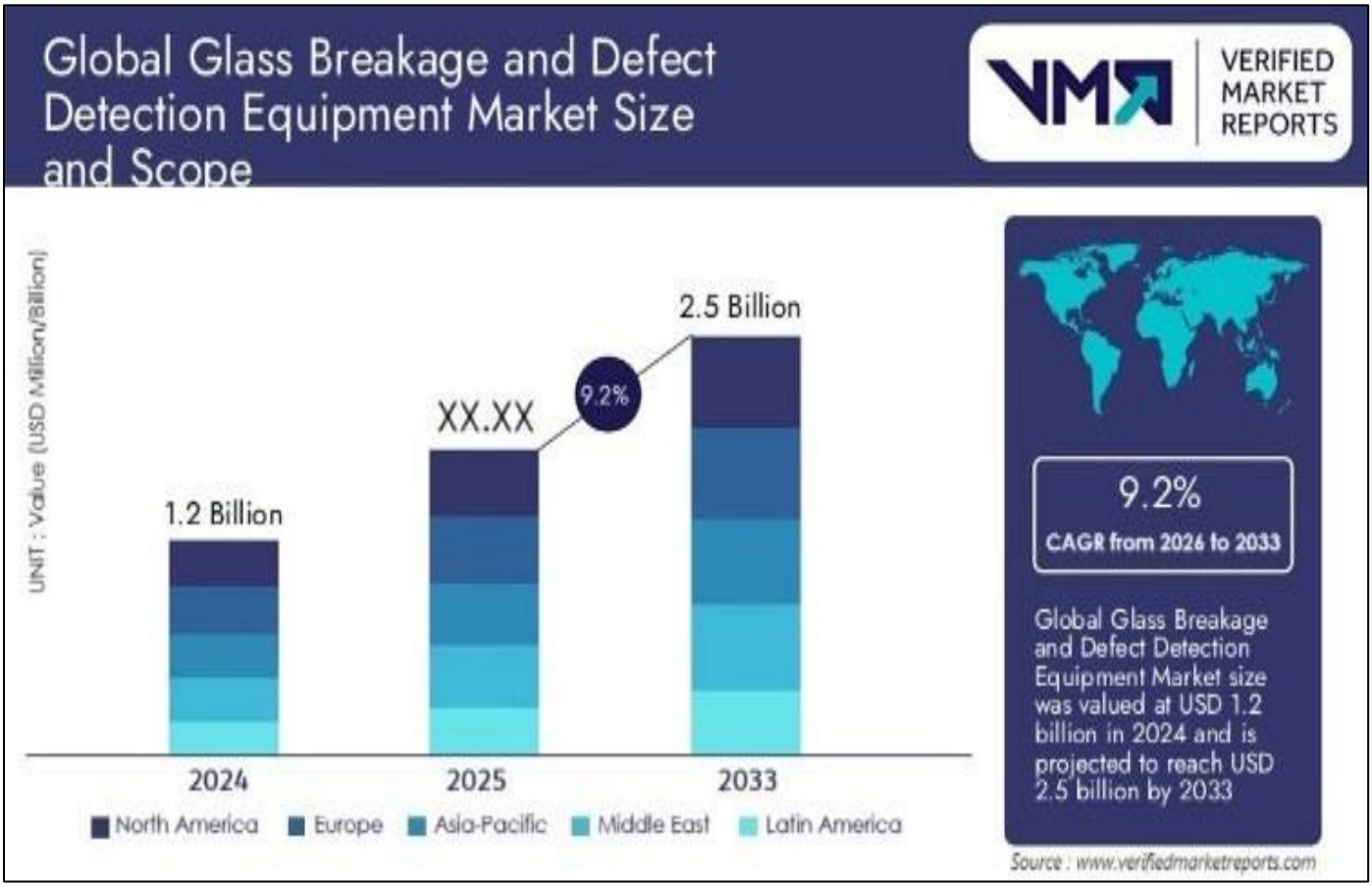

Fig 1 Global Glass Breakage and Defect Detection Equipment Market Size and Scope

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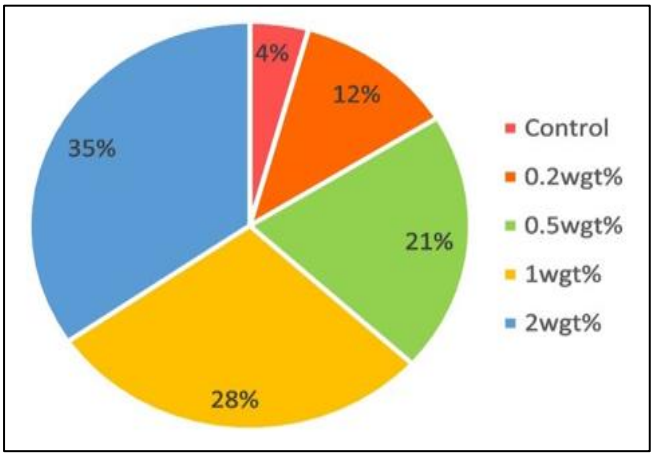

Pie Chart 1 Proportion of Vaccinated VS Unvaccinated Population (India-Specific).

III. DISCUSSION

The analysis of glass bottle manufacturing highlights the balance between efficiency, quality, and sustainability. Results show that even a small reduction in defect percentage can lead to significant cost savings and higher usable output. For example, reducing the defect rate from 1.2% to 0.6% in a plant producing 1.2 million bottles per day saves nearly 8.64 lakh rupees monthly. This underlines the importance of strict quality control, proper furnace operation, and efficient annealing. Automation and AI-based inspection systems play a crucial role in lowering defect rates. Additionally, recycling cullet not only reduces production costs but also makes the process more sustainable, supporting the circular economy. Thus, continuous improvement in process control and quality assurance is essential for maintaining competitiveness in the global packaging industry.

ACKNOWLEDGMENT

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