

(177)

Evaluation of Material Flow for Sustainable Wafer Production by Highlighting Inefficiencies

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Abstract

Rapid industrial growth in the global wafer manufacturing sector has intensified solid waste generation and resource inefficiency, particularly in developing economies such as Sri Lanka, where expansion often outpaces the establishment of robust environmental controls. This study employed process flow mapping, quantitative material balance analysis, and targeted on-site waste auditing across key production stages mixing, baking, creaming, cutting, and packing to systematically identify process inefficiencies and waste hotspots. Findings revealed a total waste generation of approximately 890 kg per day, with the baking and cutting phases contributing over 55% of the total, mainly through plain sheet discards, cutter trims, and oven lumps. These wastes originated from suboptimal thermal management, mechanical misalignment, and insufficient operator oversight, indicating systemic weaknesses in process control and maintenance practices. The absence of Standard Operating Procedures (SOPs) further exacerbated inefficiencies, leading to poor equipment calibration, irregular maintenance, and inadequate process monitoring, resulting in mechanical failures such as oven overheating, sensor malfunctions, and conveyor misalignment. Such operational lapses not only increase material and energy losses but also hinder productivity and sustainability performance. The study recommends strategic interventions including advanced equipment calibration, proactive preventive maintenance, intensive workforce training, and the establishment of comprehensive SOPs to standardize operations. Implementation of these measures supports the achievement of Sustainable Development Goals (SDGs) 9 and 12, promoting industry innovation, resource efficiency, and responsible production practices aligned with waste reduction and circular economy practices as emphasized in the waste management policy in Sri Lanka.

Keywords: *Wafer manufacturing, Waste flow analysis, Process inefficiency, Workforce training, Standard operational procedures*