

# Development of Principles for Small-Tonnage Chemicals Multi-Product Production Managing

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## key words

toluene, processing, small-tonnage multi-product production, management, modular principle, system flexibility

The study considers management principles for multi-product small-tonnage chemical production systems, using deep toluene processing complex as a case study. The work addresses the need for flexible, modular chemical production capable of rapid adaptation to market demands while minimizing costs and environmental impact. Key objectives include the analyses modular organization and flexibility in chemical-technological systems (CTS), proposing management principles for small-tonnage facilities, and demonstrating their application in a toluene-processing complex producing high-value derivatives like benzyl chloride, benzyl alcohol, benzoic acid, benzyl benzoate, etc. In our research, we have identified three flexibility types: technological, equipment, and structural, enabling production line reconfiguration. A modular equipment design allows versatile assembly for diverse processes. The toluene complex case study demonstrates production of 6+ products with shared infrastructure, emphasizing market-driven optimization and digitalization. Key findings: modular CTS reduces capital costs by 20–30% while enabling faster product switching; digital monitoring enhances multi-product operation precision. The proposed framework supports Russia's import substitution goals in pharmaceuticals and specialty chemicals. The approach is scalable to the other small-tonnage systems, aligning with global trends toward sustainable chemical manufacturing.

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