

# CAPSULE MANUFACTURING TECHNOLOGY

## INNOVATIONS SHAPING THE FUTURE FROM INDUSTRY LEADERS

The pharmaceutical capsule industry stands at the forefront of innovation, continuously evolving with new technologies and trends that drive efficiency, improve product quality, and address the complexities of modern medicine. The past decade has witnessed significant strides in capsule manufacturing technology. Each step has been optimized for efficiency, stability, and compliance with ever-tightening regulations. This article delves into current trends, technological advancements, and prospects in capsule manufacturing. Informed by expert opinions, it draws from interviews with industry professionals spanning the pharmaceutical manufacturing landscape.

### **Manufacturing Technology**

Capsule manufacturing technology has undergone significant transformations driven by the pursuit of enhanced efficiency, precision, and versatility.

Traditional encapsulation methods, such as manual filling and sealing, have gradually given way to automated processes leveraging cutting-edge machinery and robotics. High-speed encapsulation systems with advanced dosing mechanisms and quality control features have emerged as a game-changer.

These cutting-edge machines have revolutionized production workflows, allowing pharmaceutical companies to meet the rapidly escalating demand for medicines while maintaining strict product integrity. With the ability to encapsulate thousands of doses per hour, these systems have increased production speed and reduced manual labor, ultimately saving time and money.

Incorporating quality control features, such as automated weight checks and accuracy monitors, ensures that every dose meets the high standards of the pharmaceutical industry. These high-speed encapsulation systems have transformed pharmaceutical production, enabling companies to meet growing demand and uphold the highest product quality and safety standards.

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## AI in Manufacturing

Integrating automation and AI into capsule production processes represents a transformative leap forward in manufacturing efficiency and productivity. ACG's capsule manufacturing factory in Pithampur, India, was recently incorporated into the World Economic Forum's Global Lighthouse Network. ACG's achievement as the world's first capsule manufacturing facility to join this prestigious network underlines the pivotal role of automation in shaping the future of pharmaceutical production. At the heart of ACG's success lies the adoption of generative AI, a cutting-edge technology that has revolutionized standard operating procedures (SOPs) and workforce training.

**"Our adoption of generative AI was a key reason for ACG's selection."** Says Anil Andrade, Vice President of Global Sales at ACG World. **"The team developed and deployed an AI-driven standard operating procedure (SOP)-interfacing co-pilot. Our in-house data science team drew from 200+ quality, manufacturing, and printing SOPs, maintenance instructions, and case sheets to build a learning model in just two weeks. It was then deployed over 4-6 weeks across multiple channels using the web, mobile, and kiosks to train shop-floor personnel. Using gamification with leader boards, rewards, and recognition, the system has supported a 44% rise in workforce productivity and a 30-40% reduction in mean time to repair, resulting in a 98% reduction in critical defects."**

## Advancements in Soft Gel Technology

Advancements in soft gel technology have propelled the pharmaceutical industry towards more efficient

and sustainable manufacturing practices, catering to both consumer demand and regulatory standards. Soft gel capsules, characterized by their versatility and suitability for large manufacturing batches, have become increasingly popular in recent years. Nutraceuticals have also adopted the use of soft gel capsules. However, challenges such as cross-linking between the capsule shell and the fill and leaking soft gels have prompted innovation in gelatin technology to address these concerns. GELITA, a leading manufacturer of collagen peptides, collagen, and gelatin, has innovated a solution to this pain point.

**"Specific gelatin grades help to avoid cross-linking – no matter how challenging the fill is and even under difficult storage conditions, the stability and shelf life of soft gel capsules can be improved."** Says Jessica Pföhler, spokesperson for GELITA, **"We have been able to develop pharmaceutical-grade soft gel gelatin that helps manufacturers to improve soft gel seams and, thus, avoid leaking soft gels, increasing machine speed, and even reducing the ribbon thickness (less raw material use for production) and not waste raw materials – especially when it comes to expensive fills. All this leads to improved efficiency, lower production costs, and more sustainable handling of raw materials and can be achieved by changing only one parameter in the production process: the right gelatin."**

Furthermore, the demand for enteric soft gel capsules, designed to dissolve in the small intestine instead of the stomach, has surged due to their ability to protect acid-sensitive ingredients and enhance consumer compliance. Traditionally, enteric capsules require a separate coating process, adding complexity and cost to production.

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Furthermore, the demand for enteric soft gel capsules, designed to dissolve in the small intestine instead of the stomach, has surged due to their ability to protect acid-sensitive ingredients and enhance consumer compliance. Traditionally, enteric capsules require a separate coating process, adding complexity and cost to production. However, with the advancements in gelatin technology, GELITA has now enabled the production of truly enteric soft gels in a single step, streamlining manufacturing processes and making enteric technology accessible to all soft gel manufacturers. Advancements in soft gel technology, driven by innovative gelatin solutions, are reshaping capsule manufacturing by enhancing stability, efficiency, and sustainability. By addressing key challenges such as cross-linking, leaking, and enteric delivery, these advancements empower manufacturers to deliver safe, compliant, and high-quality products to consumers.

## Trends Shaping Capsule Manufacturing

Consumer demand for personalized healthcare solutions has spurred a trend toward customized capsule formulations tailored to individual patient needs. From dosage adjustments to incorporating specific active ingredients, manufacturers increasingly embrace flexibility in capsule design and composition. This trend enhances patient adherence and therapeutic outcomes and fosters brand loyalty and differentiation in a competitive market landscape.

## Personalized Healthcare

The expanding trend towards personalized healthcare is paralleled by the rapid evolution of nutraceutical technology, exemplified by innovations such as Sidebyside dietary supplements.

Sidebyside products represent a groundbreaking advancement in oral dose capsules. Using a three-piece capsule design, Sidebyside capsules feature a unique cup-shaped divider membrane separating wet and dry ingredients or incompatible actives within the same product.

This innovative design allows for simultaneous but separate housing of ingredients, ensuring optimal efficacy and compatibility. With both chambers dissolving simultaneously upon ingestion, Sidebyside supplements facilitate the coordinated release of ingredients, leading to enhanced nutrient absorption, particularly in the presence of oils.

ACG's future Sidebyside roll-out program includes features such as delayed release, catering to the growing market demand for products that provide targeted benefits at different stages of digestion. This innovative approach not only underscores the shift towards personalized healthcare solutions but also highlights the potential of nutraceutical technology to address individualized health needs effectively.

## Environmentally Sustainable Practices

In response to growing environmental concerns, the pharmaceutical industry is prioritizing sustainable manufacturing practices across the entire production lifecycle, including capsule manufacturing. From eco-friendly materials sourcing to energy-efficient manufacturing processes, companies are exploring innovative solutions to minimize their carbon footprint and reduce waste generation. Biodegradable capsule materials, reusable packaging, and closed-loop manufacturing systems are among the sustainable initiatives gaining traction in the industry.

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Pharmaceutical manufacturing companies are increasingly embracing environmentally sustainable practices across various facets of their operations, as evidenced by initiatives from GELITA and ACG. GELITA's innovative enteric solution for soft gels represents a more sustainable alternative to traditional enteric capsules, offering enhanced environmental benefits. Additionally, GELITA's development of EASYSEAL gelatin contributes to sustainability by minimizing waste in soft gel manufacturing processes through the prevention of leaks and reduction of raw material usage.

ACG's commitment to sustainability is evident in their adoption of HPMC capsules, which replace animal-derived resources with cellulose, aligning with global efforts to reduce dependence on animal products. Furthermore, ACG's focus on recyclable and compostable packaging materials underscores their dedication to environmental stewardship throughout the product lifecycle. Investments in renewable energy sources, such as solar farms, and the implementation of Zero Liquid Discharge facilities further demonstrate the industry's commitment to minimizing environmental impact. Recognitions like the Green Dot award highlight pharmaceutical manufacturing companies' leadership in environmental sustainability, setting a precedent for responsible and ethical practices in the industry.

## Conclusion

The pharmaceutical capsule industry is experiencing a transformative shift driven by innovation, sustainability, and personalized healthcare solutions. Over the past decade, advancements in manufacturing technology, including automation and AI integration, have revolutionized capsule production processes, enhancing efficiency, precision, and versatility.

Moreover, the trend towards personalized healthcare has prompted the development of customized capsule formulations tailored to individual patient needs, fostering patient adherence and therapeutic outcomes. Innovations such as Sidebyside dietary supplements exemplify this trend, offering groundbreaking solutions for simultaneous but separate housing of ingredients within a single capsule. Additionally, pharmaceutical companies prioritize environmental sustainability across the entire production lifecycle, with initiatives ranging from sourcing ecofriendly materials to energy-efficient manufacturing processes. Collaborative efforts from industry leaders like GELITA and ACG underscore the industry's commitment to responsible and ethical practices, setting a precedent for a more sustainable and patient-centric future in capsule manufacturing. As the pharmaceutical landscape continues to evolve, these innovations and sustainability efforts will play a pivotal role in shaping the future of capsule manufacturing, ensuring safer, more effective, and environmentally conscious pharmaceutical products for patients worldwide.

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