

Nonwoven Fabric Manufacturing and Applications: A Comprehensive Review

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Abstract

Nonwoven fabrics are engineered textile materials produced by bonding or interlocking fibers through mechanical, thermal, or chemical processes, eliminating the need for traditional weaving or knitting. This paper reviews the manufacturing techniques, properties, and diverse applications of nonwoven fabrics, highlighting recent advancements and sustainability trends. The study also explores the role of fiber composition and processing parameters in tailoring nonwoven fabrics for specific end-uses.

1. Introduction

Nonwoven fabrics have revolutionized the textile industry by offering cost-effective, versatile, and sustainable alternatives to woven and knitted fabrics. Unlike traditional textiles, nonwovens are formed directly from fibers or filaments without converting them into yarn, resulting in simplified production and reduced costs. Their unique properties make them suitable for applications ranging from hygiene products to industrial filters and geotextiles.

2. Manufacturing Processes

Nonwoven fabrics are produced using several techniques, each imparting distinct characteristics:

Mechanical Bonding

Needle Punching: Fibers are mechanically entangled using barbed needles to create durable fabrics. Commonly used for geotextiles and automotive insulation.

Thermal Bonding

Fibers are bonded using heat and pressure, often applied in spunbond processes for lightweight, strong fabrics.

Chemical Bonding

Adhesives or binders are used to bond fibers, suitable for disposable products like wipes and hygiene items.

Hydroentanglement (Spunlace)

High-pressure water jets entangle fibers, producing soft, cloth-like fabrics for medical gowns and wipes.

Advanced Techniques

Spunbond Process

Steps:

- **Polymer Extrusion:** Polymer granules (e.g., polypropylene) are melted and extruded through spinnerets.
- **Filament Formation:** Continuous filaments are drawn and cooled.

- Web Formation: Filaments are laid randomly on a conveyor belt to form a web.
- Bonding: Heat and pressure bond the fibers together.

Properties:

- High tensile strength.
- Good dimensional stability.
- Breathable and lightweight.

Applications:

- Medical gowns
- Surgical masks
- Geotextiles
- Packaging

Meltblown Process

Steps:

- Polymer Melting: Polymer is melted and extruded through fine nozzles.
- Fiber Formation: High-velocity hot air attenuates the polymer into microfibers.
- Web Formation: Fibers are collected on a moving belt.
- Bonding: Fibers self-bond due to residual heat.

Properties:

- Extremely fine fibers (1–5 microns).
- Excellent filtration efficiency.
- Soft and lightweight.

Applications:

- Face mask filters (N95)
- Air and liquid filtration media
- Oil absorbents

3. Properties of Nonwoven Fabrics

Category	Description
Mechanical	High tensile strength, durability
Functional	Thermal insulation, air permeability, water absorbency
Customizable	Tailored by fiber type, bonding method, and processing parameters

4. Applications

Medical & Hygiene

Industrial

Agriculture

Automotive

Fashion & Apparel

5. Sustainability and Future Trends

The industry is shifting towards eco-friendly solutions: use of natural fibers, biodegradable nonwovens, and integration of smart fabrics for advanced applications.

6. Conclusion

Nonwoven fabrics represent a dynamic and rapidly evolving segment of the textile industry. Their adaptability, cost-effectiveness, and sustainability potential make them indispensable across diverse applications. Future research should focus on enhancing performance, recyclability, and exploring novel fiber sources.

Bonding Methods Comparison Chart

Method	Process Description	Properties	Applications
Mechanical (Needle Punching)	Fibers entangled using barbed needles	Durable, strong	Geotextiles, automotive insulation
Thermal	Heat and pressure bond fibers	Lightweight, strong	Spunbond fabrics, hygiene products
Chemical	Adhesives or binders applied	Soft, flexible	Wipes, disposable items
Hydroentanglement	High-pressure water jets entangle fibers	Soft, cloth-like	Medical gowns, wipes

Real-World Examples for Bonding Methods

Mechanical (Needle Punching)

Used in geotextiles for road construction and automotive insulation mats.

Thermal Bonding

Applied in production of spunbond fabrics for surgical masks and disposable gowns.

Chemical Bonding

Common in wet wipes and disposable hygiene products.

Hydroentanglement (Spunlace)

Used for medical gowns, baby wipes, and facial wipes.

Spunbond

Manufacturing of protective clothing, crop covers, and packaging materials.

Meltblown

Critical for N95 respirator filters and high-efficiency air filtration media.

In India, the most commonly used nonwoven manufacturing process is needle punching (mechanical bonding). This technique is widely adopted for industrial textile applications such as geotextiles, automotive insulation, filtration media, and acoustic panels because it produces durable, medium-to-heavy weight fabrics (300–3000 gsm) at a relatively low cost.

Other processes like spunbond and meltblown are also significant, especially for medical and hygiene products (e.g., surgical masks, gowns, diapers), but needle punching dominates in industrial sectors due to its strength and versatility.

Global Trends

- **Dominant Processes:**
 - **Spunlaid (Spunbond + Meltblown):** Accounts for **~48% of global production**, widely used in hygiene, medical, and filtration sectors.
 - **Needlepunch:** Significant for **geotextiles and industrial applications**, but less dominant than spunlaid globally.
- **Market Size:**
 - Global market was **USD 52.56 billion in 2023**, projected to reach **USD 75.74 billion by 2030** (CAGR ~4.9%).
- **Key Drivers:**
 - Hygiene and healthcare demand, sustainability initiatives, and technological advancements (smart textiles, biodegradable fibers).
 - Asia-Pacific leads with **43% global share**, with China as the largest producer.

Key Differences

Aspect	India	Global
Leading Process	Needle Punching (industrial)	Spunlaid (spunbond + meltblown)
Growth Driver	Hygiene & automotive	Hygiene & sustainability
Market Size	\$4.75B (2024) → \$7.38B (2035)	\$52.56B (2023) → \$75.74B (2030)
Tech Adoption	Moderate, cost-focused	Advanced, eco-friendly & smart

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