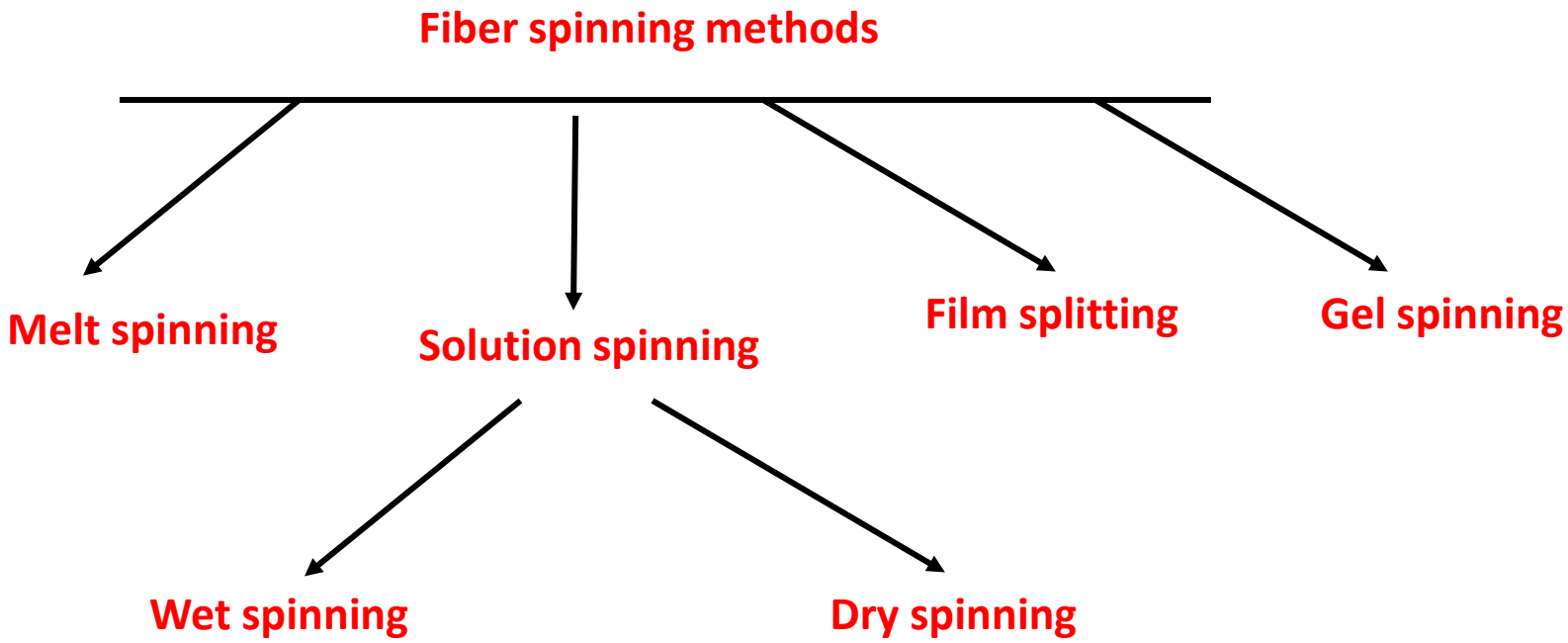

Fiber spinning methods
Melt spinning
Solution spinning
Film splitting
Gel spinning
Wet spinning
Dry spinning

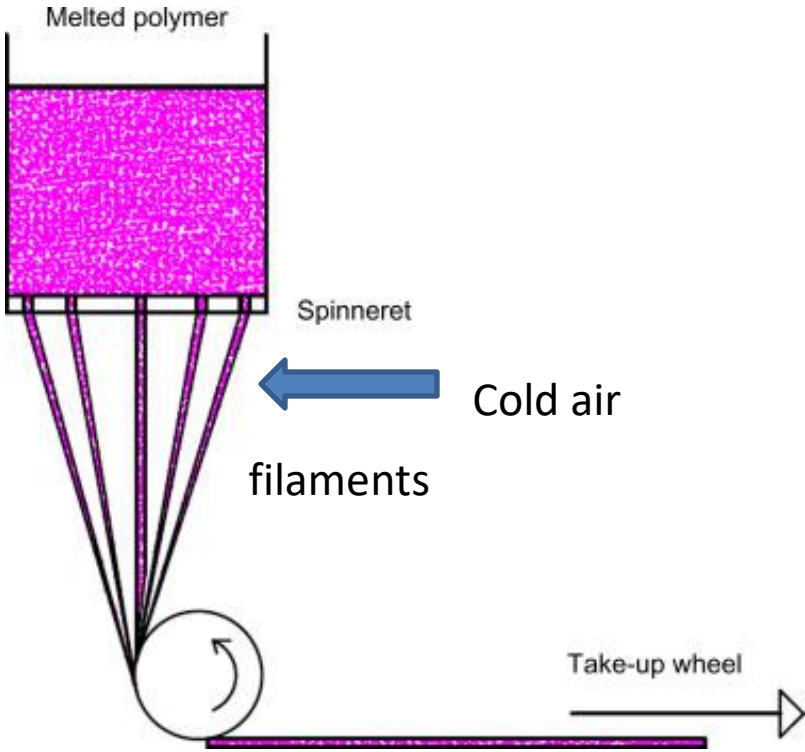
- Fiber spinning is shaping a material in the fiber geometry after the application of suitable processes.
- A stretch-stress process is applied to the synthetic fibers to improve their properties such as increase their crystallinity (orientation), forming linear geometry or etc). **No additive process is applied to the natural fibers except precleaning the source material. (why?)**
- The polymers are transformed into filament structure by passing through a spinneret either in the **melt state** or **solution**.
- If a polymer passes through a spinneret in the melt state its called melt spinning, but if a polymer solution is used, its called **solution spinning.**
- **Melt spinning** is applied to the polymers that can melt without decomposition. **(examples ?)**
- If a polymer has a weak thermal stability and decomposes at Tm, then a solution spinning technique is used during fiber spinning.
- After passing from spinneret, if the solvent is removed from the polymer by the application of hot air/gas /vapor flow>>>>>**dry spinning**
- After passing from the spinneret, the filaments are passed from a bath (coagulation bath) containing a solvent that is highly miscible with the dissolution solvent, and **also has the ability of precipitation** for the polymer. This technique is called **wet spinning.**

- In the **film splitting** technique, the polymer in the form of film is cut into thin lines.Polyolefin fibers are prepared using this technique. (examples?)

- In the **gel spinning**, the polymer that passes through the spinneret is in the form of liquid crystal. Due to the dense interactions between the polymer chains, the tensile strength of the fibers obtained from this method is quite high. Aramide fibers are prepared using this technique.
- (remember synthesis of aromatic polyamides)

Melt spinning

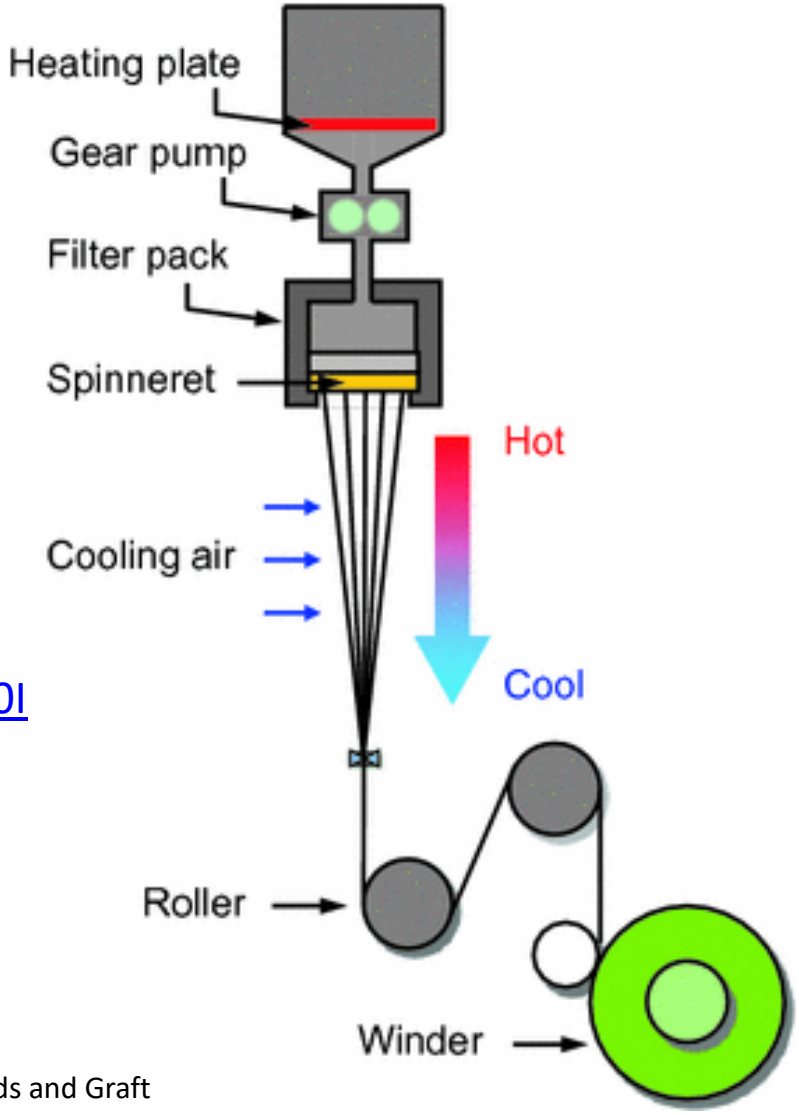
Melt spinning is the most economical process of spinning due to the fact that no solvent is recovered or evaporated just like in solution spinning, and the spinning rate is fairly high. Melt spinning is the preferred method of fabricating polymeric fibers and is used extensively in the textile industry. Melt spinning is used for polymers that can be melted easily. In this process, a viscous melt of polymer is extruded through a spinneret containing a number of holes into a chamber, where a blast of cold air or gas is directed on the surface of fibers emanating from the spinneret. As the air strikes the fibers, the fibers are solidified and collected on a take-up wheel.



https://www.youtube.com/watch?v=cn6K1m7yH0I

Ramazan Asmatulu, Waseem S. Khan, Chapter 1 - Introduction to electrospun nanofibers, Editor(s): Ramazan Asmatulu, Waseem S. Khan, In Micro and Nano Technologies, Synthesis and Applications of Electrospun Nanofibers, Elsevier, 2019, Pages 1-15,

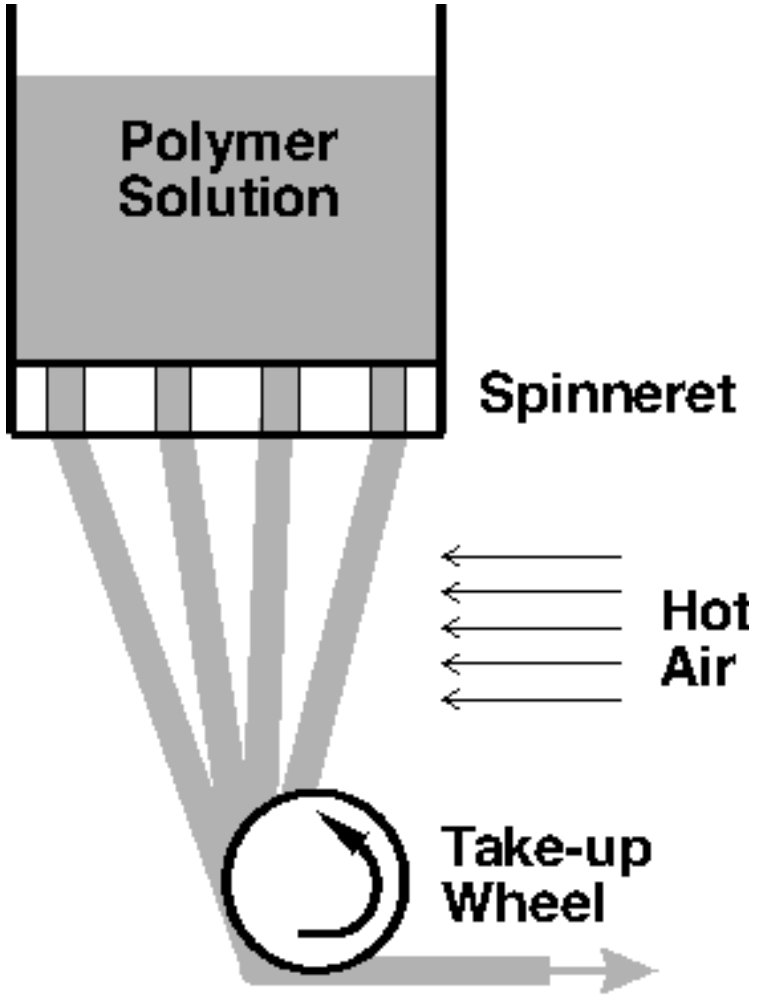
https://www.youtube.com/watch?v=cn6K1m7yH0I



Aranishi Y., Nishio Y. (2017) Cellulosic Fiber Produced by Melt Spinning. In: Blends and Graft Copolymers of Cellulosics. SpringerBriefs in Molecular Science. Springer, Cham

Dry spinning

Dry spinning is used to form polymeric fibers from solution. The polymer is dissolved in a volatile solvent and the solution is pumped through a spinneret (die) with numerous holes (one to thousands). As the fibers exit the spinneret, air is used to evaporate the solvent so that the fibers solidify and can be collected on a take-up wheel. Stretching of the fibers provides for orientation of the polymer chains along the fiber axis. Cellulose acetate (acetone solvent) is an example of a polymer which is dry spun commercially in large volumes. Due to safety and environmental concerns associated with solvent handling this technique is used only for polymers which cannot be melt spun.



Y. Ohzawa, Y. Nagano, and T. Matsuo, *J. Appl. Polym. Sci.*, **13**, pp. 257-283 (1969)

http://www.polymerprocessing.com/operations/dspin/index.html

Wet spinning

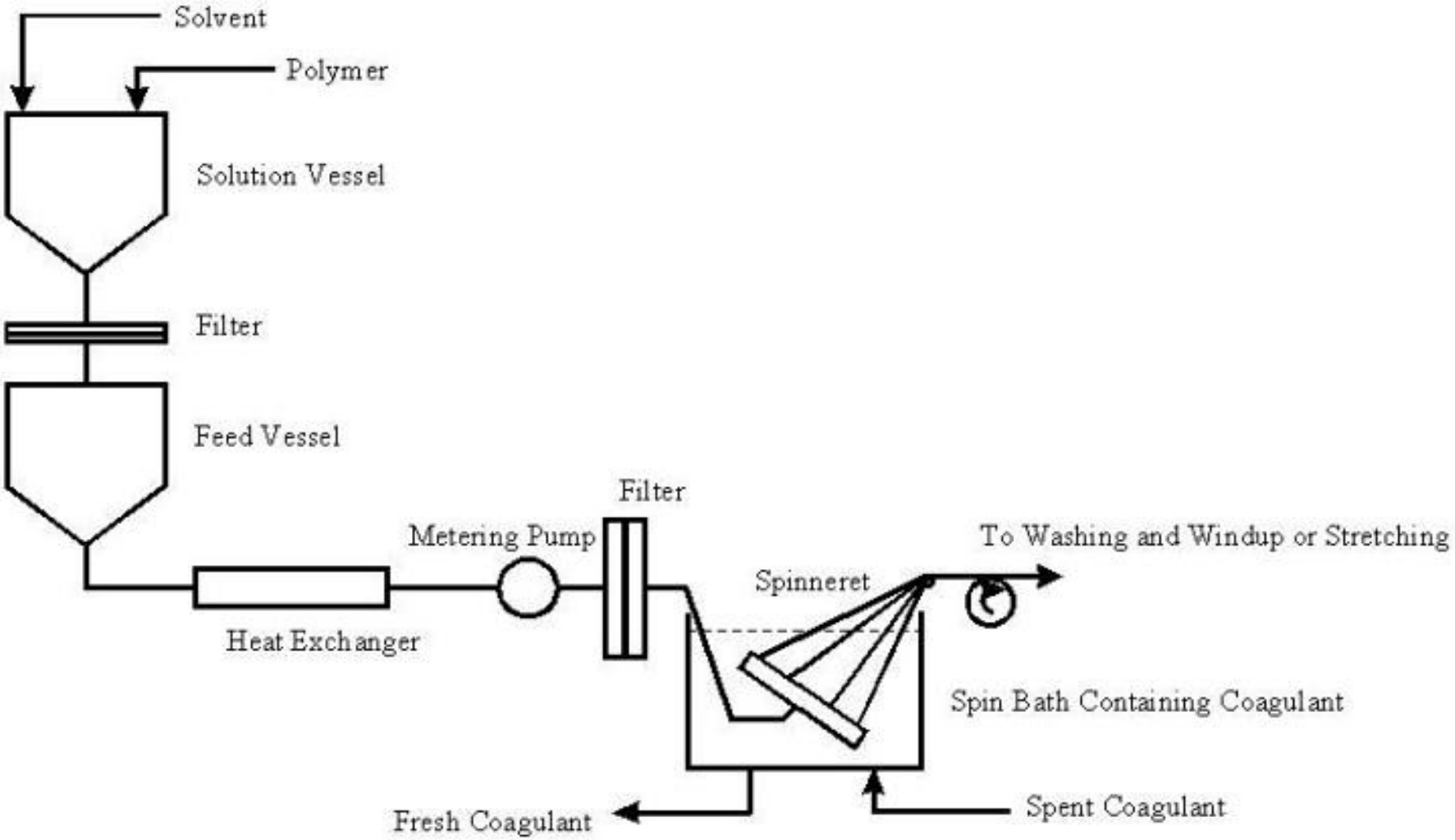
Wet Spinning

Wet spinning is required for polymers that require dissolving in a solvent to be spun. It is named wet spinning because the fibres are extruded directly into a liquid bath. Being extruded into a liquid provides a greater drag force on the Filament than those extruded directly into air, therefore the speeds at which this occurs is reduced from that of melt and dry spinning. Once evaporated these fibres then have to be drawn or stretched in order to orient the polymers to give the fibre its strength.

The fibre solution is extruded into a liquid that will draw out the solvent, leaving behind only the polymer. The rate at which this occurs is crucial, as if it occurs too quickly the bath liquid can create micro-voids in the fibre which will be a weak points.

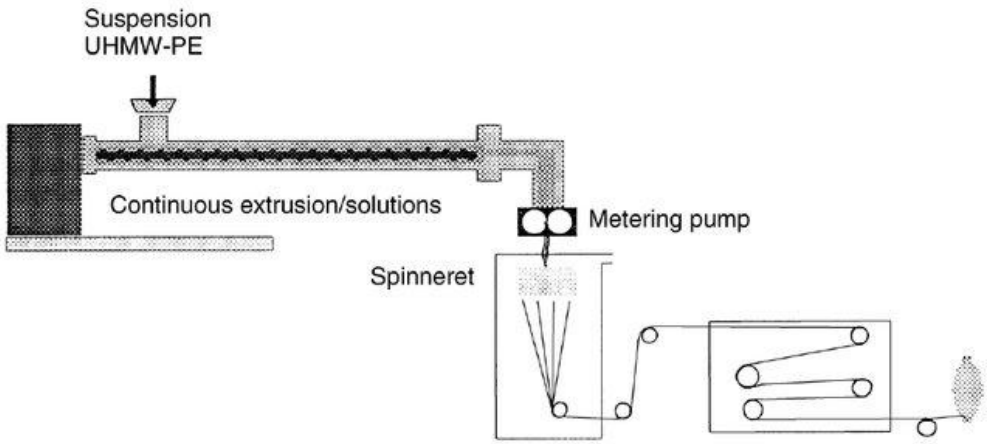
Wet spinning is based on precipitation, where a polymer is drawn through a spinneret into a non-solvent. The prepared spinning dope is extruded into the non-solvent and precipitation or coagulation occurs.

Fibres spun using this process include Acrylic, Rayon, Aramid, and Spandex.



Kroschwitz, Jacqueline I. Encyclopedia of Polymer Science and Engineering. Second Edition, Vol. 6. John Wiley & Sons. New York. 1986 pp. 812-815.

Gel spinning



Gel spinning is usually applied in the processing of high molecular weight or ultra-high molecular weight polymers. The entanglement of long chain polymers is fully stretched by appropriate solvent and temperature. Gel spinning is most widely applied in production of UHMWPE, PVA and PAN, as illustrated
respectively below.

Gel spinning is applied in high strength and high tensile fabrics, including bullet-proof vests, belts, gloves and sportswear. The most popular gel spinning fibre, UHMWPE, can be used to manufacture safety protective equipment, high-tension ropes, fishing nets and sports leisure goods.

Werff, Harm & Heisserer, Ulrich. (2016). High Performance Ballistic Fibres: Ultra-High Molecular Weight Polyethylene (UHMWPE). 10.1016/B978-1-78242-461-1.00003.

(16) (PDF) Gel spinning of synthetic polymer fibres. Available from: https://www.researchgate.net/publication/287527542_Gel_spinning_of_synthetic_polymer_fibres [accessed Nov 20 2019].

Film splitting

As a conclude,

- If a polymer decomposes beyond Tm, melt spinning technique can not be performed.
- In the dry spinning,

during passing the polymer solution from the spinneret, the stretching interaction occurring on the filament surfaces lead to the flowing of the polymers as drops, in spite of filaments from the spinneret.

This problem can be removed with the increment of the solution viscosity, but this is a limited solution because the increment of the polymer viscosity (concentration) could cause congestion and could create a problem during the pumping the solution to the spinneret.

In this case, the wet spinning technique is the most suitable method to obtain a fiber.