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# A REVIEW OF HOT MELT EXTRUSION: PROCESS TECHNOLOGY TO FUTURE PROSPECTION

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## ABSTRACT
Hot Melt Extrusion (HME) technology is a widely used manufacturing technique in plastic as well as drug companies, and it is a simple and effective method for producing a solid dispersion. This method is an environmentally friendly, continuous process that does not require the use of solvents. It saves time and money and can be easily scaled up. Furthermore, HME can be used in conjunction with other innovations to enable greater dissolution and solubility of poorly water-soluble drugs. Numerous research papers on the advancement of HME technology in the pharmaceutical industryhave been written, and HME-based products have been approved by the FDA. This review provides a comprehensive overview of several equipment components, processing requirements, materials used in HME, and various drug delivery systems that have recently used HME. nanotechnology, semi-solids, It provides a thorough examination of several novel opportunities and innovations, including three-dimensional printed dosage forms, abuse-deterrent formulations, co-extrusion, chronotherapeutic drug development, co-crystals, twin-screw granulation, as well asother applications.

**KEYWORDS:** HME Process, Single-Screw Extruder, Twin-Screw Extruder, Future Prospective.

## Hot Melt Extrusion
Hot melt extrusion was established in the 1930s, it was processed at that time. If seen, it rapidly became the most used technology in the plastic, rubber, and fertilizer industry at that time.[1] However, it is reported by experts that the expansion of the application of hot melt extrusion datesback to the early 1970s, also in the pharmaceutical industries, and it is also said that it is most commonly used for manufacturing and manufacturing products. These were used for development as well as in manufacturing.[2] Hot melt extrusion is a type of pharmaceutical process in which active compounds are obtained by obtaining some kind of thermoplastic binder, polymer, or any molecular level mixture, after which many materials with a rotating screw at a temperature abovetheir glass transition temperature.[3] Their main job is to collect and pump them.

## Process of HME
Hot melt extrusion is a process where a material undergoes the deformation of plastic by the application of a single force. To pass it is inserted into a kind of structure so that the material flowsthrough a hole.[4] The material adopts the cross-sectional profile of the die, and if the material has any useful properties, that shape is formed into a final extrusion. The forces required for this process are usually achieved by rotating a moving piston or barrel of a kind. Hot melt extrusion solvent-based processes such as this spray, molecular dispersion, and efficient technology for its production. The first step in selecting the right materials is to determine the plastic's grade first.[5] If the melting point is not suitable for the environment, then you can use commodity-grade plastic. Keep in mind that only plastic should be used in the category which is completely suitable for theapplication. It can also be increased and decreased through extrusion. After that, there is a continuous process in this matter. The extrudate is then cut into pieces according to the predetermined length and then formed into countless parts.[6] The process could be divided into the successive sub-processes.[7]

1. A hopper is used to feed materials into the extruder.
2. Materials conveyed, mixed, vented, and extruded.
3. Putting a pump through the die.
4. Extrudates leaving the die and processing thereafter.

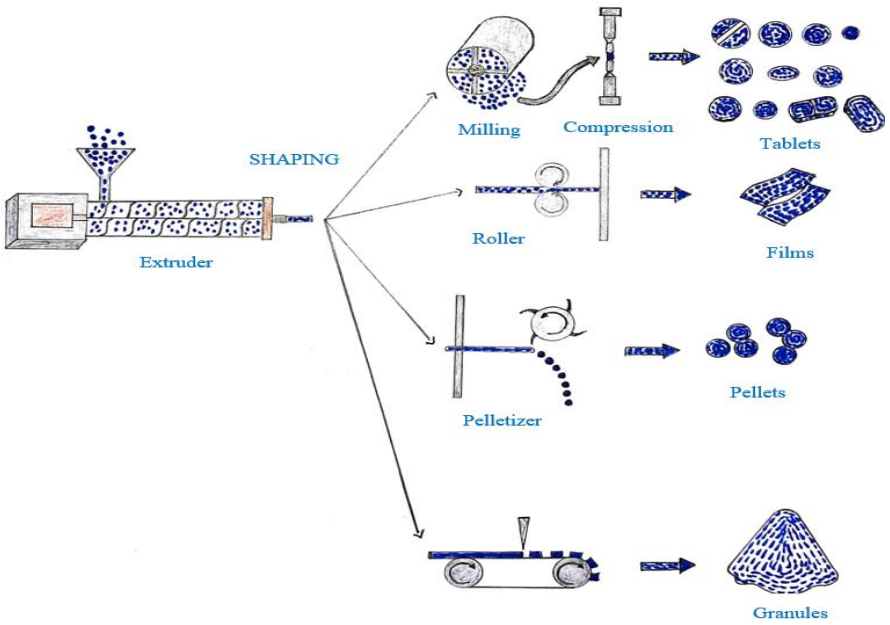


**Fig. 1: HME Process Diagram.**

**Types**

Pharmaceutical Hot Melt Extruders (Screw Extruders) are designed based on a disadvantaged extrusion and their dosage forms formulations are required to meet the current regulatory demands.It can be classified in 3 ways.

1. Single-screw extruder: in the form of a smooth or oval barrel.
2. Twin-screw extruder: as counter-rotating for any kind of intermeshing or non-intermeshing.
3. Multi-screw extruder: for stationary or central rotating.

Despite the complexity of the hot melt extrusion process, it is also essential to be able to rotate thescrew at a given drive speed for the different types of extruders.[8] Whereas in the same operation,the torque and generated shear rate must also be fully compensated for by both the material to be extruded and the type of screw used. The screw used in hot melt extrusion consists of a motor, which acts as a drive unit. A hot melt extrusion barrel is usually manufactured in parts and boltedtogether.[9] The rotating screw of the hot melt extrusion is attached end to end on an end plate.

**Single-screw extruder**

As the name indicate there is only one screw in the extruder, and the main purpose of this is to melt polymers and extrude them into a continuous film.[10] It is also used for feeding, melting, devolatilising, and pumping. All the ingredients are put into the extruder from the hopper thereby transported down using the screw. Most single screw extruders are flood fed.[11]

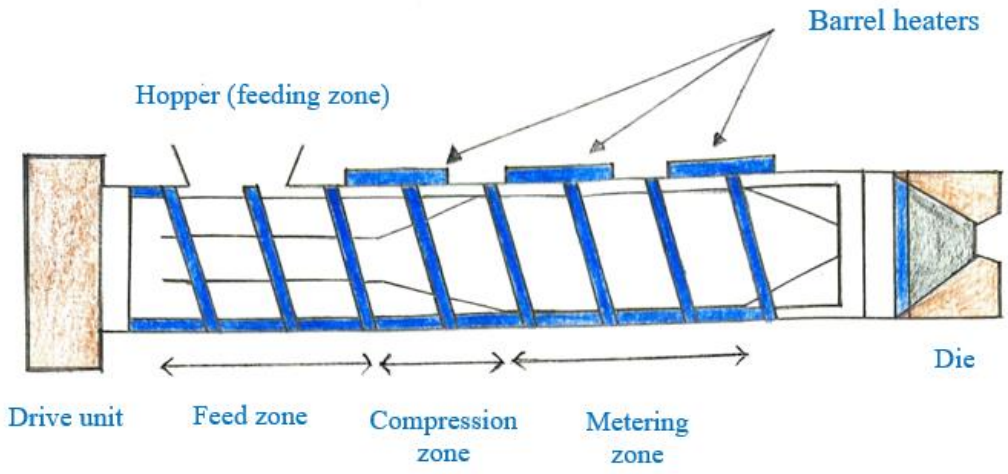


**Fig. 2: Diagram of Single Screw.**

**Twin-screw extruder**

The twin-screw extruder uses two screws arranged parallel in the barrel. It is mainly used for mixing two or more materials together to form a blend.[12] The twin-

screw extruder is again classified into two types (i) fully intermeshing and (ii) non-intermeshing.[13] The main feature of a twin-screw extruder is the enhanced and homogenous mixing of materials during extrusion. Whether it is a single-screw or multi-screw extruder, each has both advantages and disadvantages and some of them are listed below.

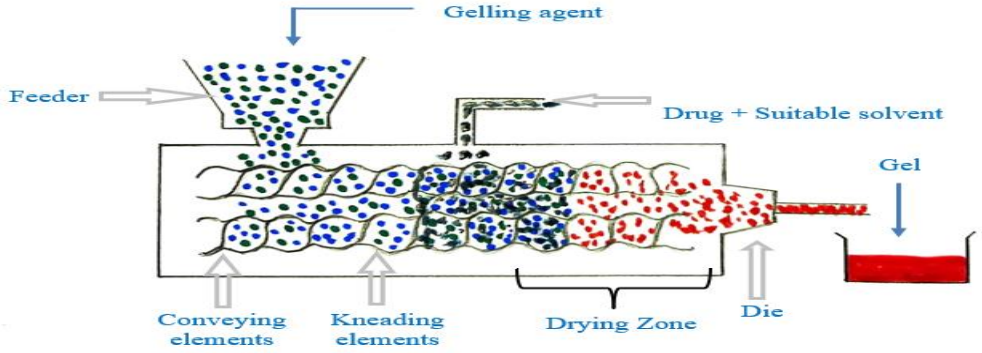


**Fig. 3: Diagram of Twin Screw.**

**Advantages**

Hot melt extrusion is the fastest and most widely used technology in the plastic rubber and compost industries. It is most commonly used in the pharmaceutical industry to manufacture and develop products.[14]

- Used in continuous reproduction.
- Efficient and highly automated.
- Solvent free and water free.
- Optimized for multiple dosage forms as well.
- Insoluble and extremely powerful API.
- Suitable for new institutions and generics as well.

**Disadvantages**

There are many types of damage in this chemical process, it is very important to be careful in the damage caused by it.[15]

- High tendency of overheating.
- Not suitable for heat-sensitive materials.
- It consumes very high energy.
- Shear-sensitive materials cannot be processed by using this method.

**Technology**

The widest range of hot melt extruder equipment is considered to be 18 mm to 80 mm and the same distance it covers.[16] Which fully enables scalability as well as an optimized approach to hot melt extrusion for pharmaceutical applications as well. Simultaneously with the increasing demands of all end-use industries and hot melt extrusion in line acetate type segment in ethylene, its demand is also increasing continuously.[17] In fact, due to it being completely eco-friendly, it will dominate the global markets in the coming years. If seen, this service can be fully contracted without consumer-to-market agreement with the characteristics of hot melt extruders adapted to facilities in the pharmaceutical industries of Europe and North America.

Our comprehensive range of Hot Melt Extruder Equipment ranges from 18mm to 70mm, enabling scalability as well as an optimized approach to hot melt extrusion for pharmaceutical applications.[18] Ab-Vie has proven experience in pursuing challenging projects from pilot to commercial level.[19] With Hot Melt Extruder's expertise in facilities in Europe and North America, customers can contract customized HME services without compromising speed consumer-to-market. Some of the dosage forms developed using HME technology are listed below.

**Table: Formulation developed using HME technology.**

| Dosage form | Drug | Route of administration | Indication | Temperature | Polymerused | Reference |
|---|---|---|---|---|---|---|
| 30 printed tablets | Carvedilol | Oral | Hear failure/ hypertension | $130^0$c | Eudragit epo, kollidonsr, kolliphar tpgs affinisol15lv | [20] |
| Orodispersible films | Aripiprazol | Oral | Antipsychotic | $172^0$c | Polivynilalcohol | [21] |
| Co – crystaltablet | Ibuprofen | Oral | Nsaids | $70 – 90^0$c | Coformer- nicotinamide | [21] |
| Topicol gel | Ketoprofen | Topical | Nsaids | $70 – 97^0$c | Kolliphar –p407 | [22] |
| Nanocomposites | Znso4 | Oral | Dietary micronutrients | $100 – 120^0$c | Soluplus | [23] |
| Co-crystal | Theophylline | Oral | Anti- asthmatic | $140 – 160^0$c | Nicotinamide, hpmc as, kollidon va64, polythlyene oxide, | [24] |
| Films | Topical | Topical | Hiv- infection | $105 – 125^0$c | Polyox n80, hpc, peg -4000 | [25] |
| Pellets | Artemisinin | Oral | Anti - malarial | $20 – 110^0$c | Soluplus | [26] |
| Bioadhesive buccal tablet | Ondanserton hydrochrolide | Oral | Reduce vomiting & nausea | $60^0$c | Hpmc, eslv, oleic acid, polyethylene oxide | [27] |
| Intravaginal ring | Lactic acide, metronidazole | Vaginal | Antibiotic | $80 - 110^0$c | TPU, hydrophilic tpu grades | [28] |

**Trend**

The Global Pharmaceutical Hot Melt Extrusion Market keeps a close watch on key competitors for Metro market trends and their outlook, pricing analysis, and overall overview of market conditions for the forecast period. This is a thorough professional and detailed report focusing on the share of primary and secondary markets, key segments, and also geographic analysis. These were used for development as well as in manufacturing. Hot melt extrusion is a type of pharmaceutical process in which active compounds are obtained by obtaining some kind of thermoplastic binder, polymer, or any molecular-level mixture.[29] In addition, its trends are thoroughly reviewed in the report of key players and their key partner mergers and acquisitions, as well as any trending innovation and business policies. The recent innovation that is included in this technology are,

- abuse dererrant/tamper resistant
- co-extrusion
- 3d printing
- co-crystallization

**Future Prospective**

The Hot Melt Extrusion Market can be classified into 2 segments in total. The first application, second type. The global market can also be classified based on type segment into Polyolefin Hot Melts and Secondly Ethylene Vinyl Acetate.[30] There is also a mixture of polyolefin Hot Melt Tackifier (PHMT) and a type of basic resin among the Different types of fragments that occur. The demand for polyolefin hot melt extrusion is also increasing day by day, and it is also expected that it will be in huge demand in the equipment industry.[31] Its demand is also increasing because its resistance to alcohol, acid-base, and sulfate also plays a very important role in its ability to resist water vapor moisture. It mainly reduces their symptoms.

Besides hot melt extrusion, it is also widely used for materials such as plastic houses bonding, and dryer drum bonding. On the other hand, the growing use of ethylene vinyl acetate segments in any electronics food packaging and manufacturing has predicted a growing demand for it. Simultaneously, with the increasing demands of all end-use industries and hot melt extrusion in line acetate type segment in ethylene, its demand is also increasing continuously.[17] In fact, due to it being completely eco-friendly, it will dominate the global markets in the coming years or even completely and their demand is going to increase significantly in the future. Apart from this, the segment of Hot Melt Extrusion Application elephant is also divided into many other parts like Woodworking, Carton-sealing, Pharmaceutical Industry, etc.[32] Out of these, the packaging applications segment is predicted to have a significant demand in the global market from 2017 to2023.

**Application**

The technology of hot melt extrusion has been used as an application to provide continuous and modified as well as targeted drug delivery.[33] However, the application uses estrogen technology which demonstrates the technology's value as a potential improvement in biological availability, drug delivery, processing, and tools.[34] Hot melt extrusion solvent-based processes such as thisspray, molecular dispersion, and efficient technology for its production. The very first step in selecting the right materials is to find out the grade of the plastic first. If the melting point is not suitable for the environment, then you can use commodity-grade plastic. Keep in mind that only plastic should be used in the category which is completely suitable for the application. It can also be increased and decreased through extrusion.

## CONCLUSION

In the research paper, we studied the hot melt extrusion process, application, trends, advantages, and disadvantages. HME can be used in pharmaceutical dosage forms, including granules, pellets, implants, and tablet companion transdermal systems, which have been reviewed in countless ways. Hot melt extrusion techniques for pharmaceutical applications have shown great interest by scientists and have led to a significant increase in patents and publications.

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**Declaration of interest**

Conflicts of interest are not declared by the authors.

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