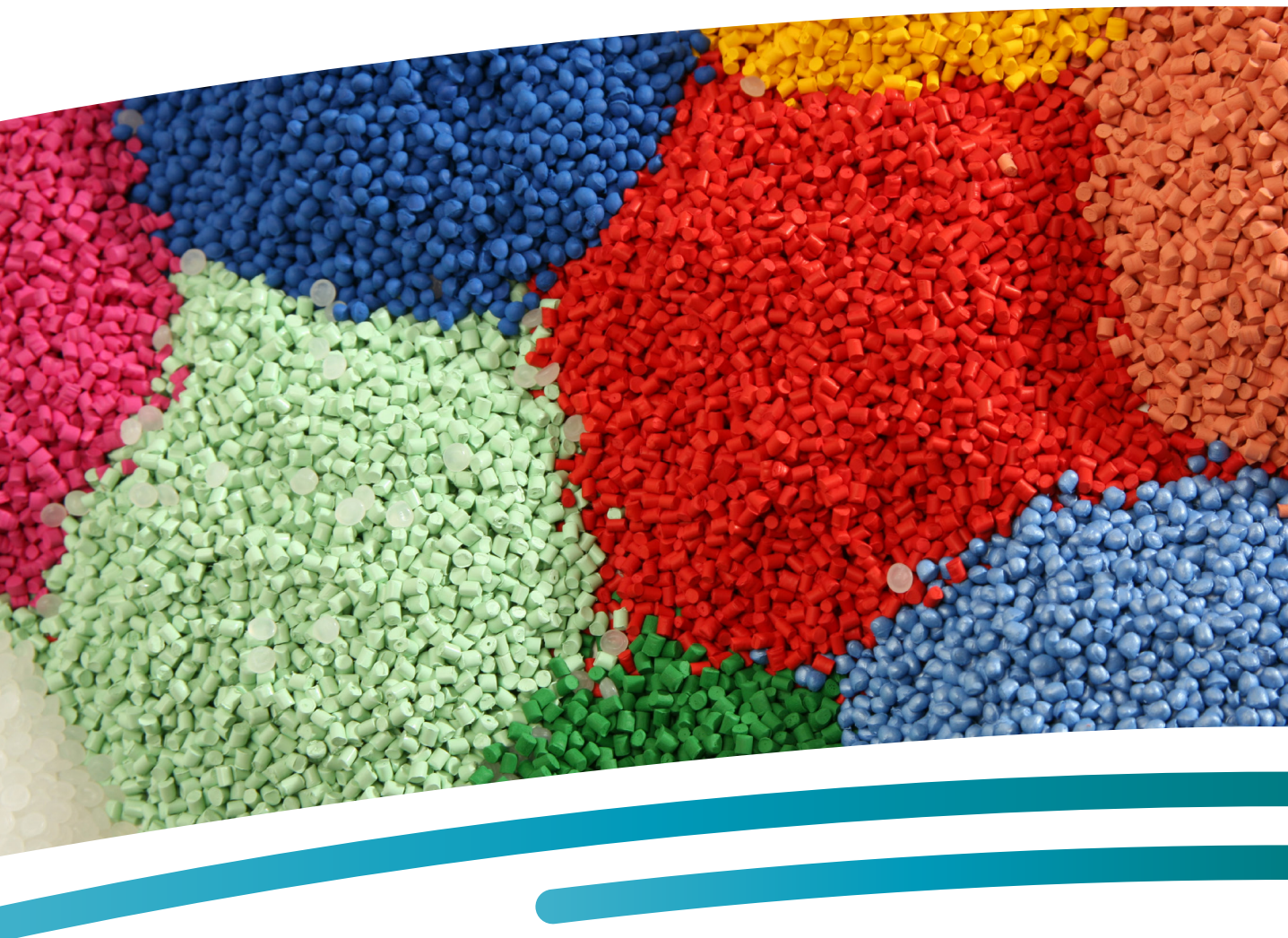




EMBASSY OF DENMARK
Hanoi



Danish Energy Agency



TECHNICAL GUIDELINE FOR THE PLASTIC INDUSTRY

Hanoi, 2022

TECHNICAL GUIDELINE FOR THE PLASTIC INDUSTRY

Developed in collaboration with:

Agency for Innovation, Green Transition and Industry Promotion,
Ministry of Industry and Trade of Vietnam

Danish Energy Agency

Viegand Maagøe

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CONTACT

Agency for Innovation, Green Transition and Industry Promotion,
Ministry of Industry and Trade

Address: 54 Hai Ba Trung street, Cua Nam ward, Hanoi

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LIST OF ACRONYMS

BM _i	: Blow moulding
E _i	: Extrusion
G _i	: General Solution
PE	: Polyetylen
PVC:	: Polyvinylchloride
PP:	: Polypropylene
PET:	: Polyethylene terephthalate
TIM _i	: Thermoplastic injection

1 Vietnam plastic industry

1.1 Introduction

The Vietnamese plastic industry has been established in 1950 with a few packaging plastics enterprises such as Hanoi Plastic Packaging and Exporting Company, Rang Dong Plastic Joint Stock Company, and Tan Tien Plastic Packaging Joint Stock Company. To present, the number of companies operating in the plastics industry has increased significantly.

According to the GSO, the number of plastic companies in Vietnam increased considerably from 1150 companies in 2013 to over 6000 companies in 2019. Most of these enterprises are located in the South, mainly in Ho Chi Minh City, Binh Duong, Dong Nai, and Long An, only a few are located in the North and Central. The plastic industry attracts more than 250,000 employees in 2021 according to the Plastic Association's data. The plastic industry's revenue, as of October 2021, was estimated at US\$22.466 billion, an increase of 28.9% compares to the same period in 2020. Export turnover was estimated at US\$3,974 billion, accounting for 14.6% of the revenue.

Vietnam's raw plastic materials depend mainly on imported sources. High revenue growth is due to the strong impact of the increase in the price of imported plastic materials for production, the growth rate ranges from 11.2% to 22%, depending on the type of material, compared to the same period of 2020. Plastic enterprises, whose main consumption market is the domestic market, are losing money due to a series of expenses arising from the social distances, together with the demand of the market, which has not shown any signs of recovery.

- **Plastic packaging:**

Growth potential depends on end-product industries such as food and beverage. The production index of intermediate packaging products (for the next production process) in 2020 increased by 5.3% over the same period in 2019. Driving the growth of the plastic packaging industry, especially packaging. Flexible packaging and food PET packaging is the development of supporting industries for the consumer goods industry such as packaged food, canned drinks, bottled, etc.

- **Household plastic/engineering plastic:**

High consumption but under great competitive pressure from foreign competitors. The production index of products for the population's consumption increased by 10.9%. According to statistics, because the percentage of consumers using Vietnamese products is increasing, the consumption of Plastic products is

increasing. Currently, in the system of Vietnamese supermarkets plastic products, 85% - 90% are plastic products with Vietnamese brands.

However, low technology leads to unequal products in terms of quality as well as limited financial potential, household plastic enterprises are currently facing competitive pressure from foreign competitors, typically a brand of household plastic products Lock&Lock, Typerware. High-end products of foreign enterprises with good quality have better profit margins than average Vietnamese products.

Countries in Southeast Asia focus on engineering plastic products, while Vietnamese enterprises mainly make household and packaging plastics because of their limited potential (financial & high-quality human resources) and This product line has a good sales force in the domestic market. Weak technology makes it difficult for Vietnamese enterprises to produce plastic products with high technical content as well as high added value, such as products in the group of building materials and engineering plastics.

Engineering plastic companies in Vietnam mainly produce products for foreign-invested manufacturing enterprises in the fields of manufacturing motorcycles, electrical and electronic equipment... from Korea and Japan such as Honda, Yamaha, Canon, Samsung...

- **Construction plastic:**

Real estate and construction slowed down due to the lag in infrastructure projects under public projects and very low growth in the residential housing segment. The production index of products that are means of production in 2019 increased by 5.9%.

The market share of the construction plastic segment accounts for only 1% of the total plastic industry but grows quite quickly, to 15-20%/year. Currently, the whole country has approximately 200 enterprises operating in two areas: plastic pipes for construction and plastic construction materials. Expectations along with the slow recovery of major economies and Vietnam being the only bright spot in economic growth in 2020 in Southeast Asia will create a driving force for the construction plastic industry to grow with The average real growth rate is about 6%/year in the period 2021 - 2024.

2 Technical best practices

The following table show list of best practices for each technology is as follows:

I	Blow molding
BM1	Recycle high pressure compressed air
BM2	Install insulation for the extrusion shaft of the bottle blowing machine
BM3	Install inverter for the blowing machine
II	Extrusion
E1	Install inverter for the sheet extruder
E2	Replace the heating system for the extruder
E3	Install insulation for the extrusion shaft of the extruder
E4	Insulate the extruder with fixed film
III	Thermoplastic injection
TIM1	Replace the cooling system for the cylinder barrel of the plastic injection machine
TIM2	Install insulation for the cylinder barrel of the plastic injection machine
TIM3	Install an inverter to control the speed of the hydraulic oil pump motor
TIM4	Use Servo motor and Server Driver set, combined with the hydraulic system
TIM5	Use all-electric plastic injection machines using Servo motors when investing in new plastic injection machines
TIM6	Replace the heating system of the injection machine
IV	General equipment
G1	Preheat plastic granules in the mixer
G2	Set the humidity sensor control for the drying tank

G3	Replace the drying system with the granulator
G4	Replace the expansion valve for the chiller
G5	Install equipment to control the temperature

2.1 Blow molding

In packaging plastics, blow molding is a technology that is commonly used. The major energy requirement for this process is the electricity to drive the extruder screw motor, which uses up about 40% of the total energy. A significant amount of energy is used to drive cooling fan motors and a small amount is used for the cooling equipment. Cold coils and cooling baths require a huge amount of water, and this water is often recirculated. Steam and other exhaust gases are released into the atmosphere from the tank's vents, the fuel hopper section, and the mold area.

Opting for all-electric machines is the most energy-efficient option because they hinder the energy losses at the electrohydraulic interface. Process control will improve machinery efficiency, and provide more precise pipe thicknesses and lengths, which can lead to improved material and energy efficiency.

The extrusion machine uses only a small amount of externally applied heat, most of which is generated by the mechanical process. This technology requires even distribution of the molten substance around the mold but producing a uniform film gauge thickness is very complicated.

In Vietnam, the extruder used in this process mostly has one small-diameter screw. If the PVC, and PV are used as the raw material, whether to use water or air for the cooling system depends on the input material, e.g., water for PVC, PV, and air for PE.

BM1: Recycle the high pressure compressed air of the blow molding machine

Solution	Recycle high-pressure compressed air at the end of the blow cycle by installing a recycling system.
Status	A compressed air system provides the high-pressure and low-pressure compressed air for the injection blow molding processes. High-pressure compressed air is not recycled after the blowing process, thereby causing energy waste. This high-pressure compressed air can be reused for low-pressure compressed air segments or returned to the air compressors to produce compressed air before blowing or may be used for other

	loads. After a blow cycle is completed, one by-pass valve will open to recover compressed air for the low-pressure compressed air system, at the final stage of recovery, excess compressed air pressure and excess low pressure will be discarded.
Economic benefit	Reduce material and energy costs and has a payback period of one year.
Energy savings	Can recycle 40-50% of the high-pressure compressed air (at low pressure), which is equivalent to an energy savings potential of about 20% of the consumed electricity of the compressed air system.

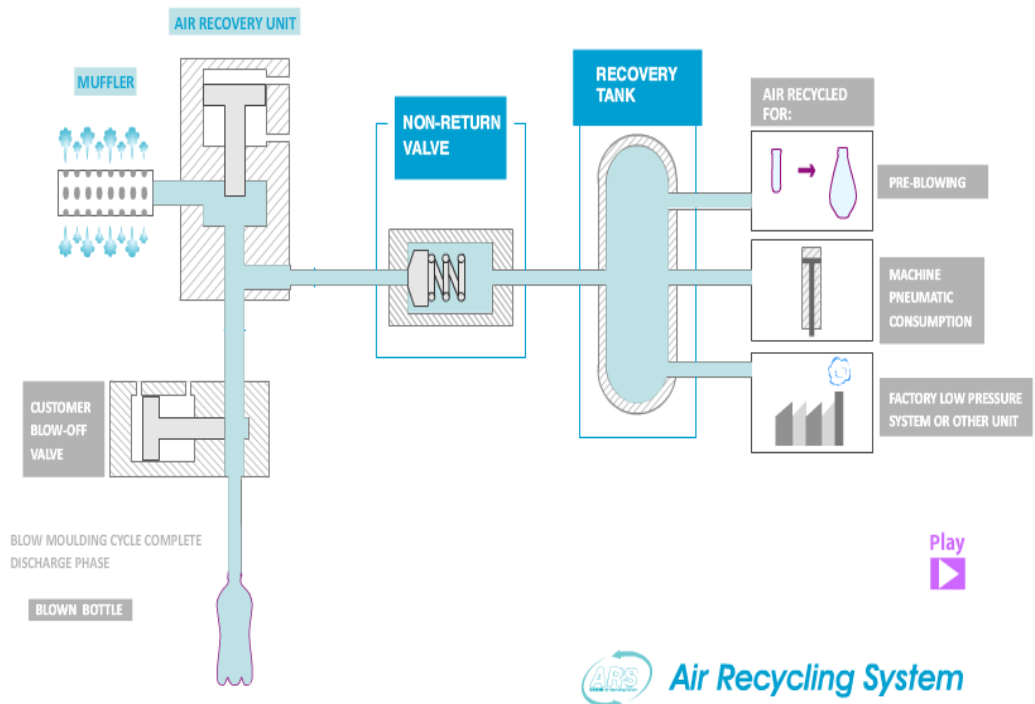


Figure 1: Air recycling system

BM2: Install insulation for the extrusion shaft of the bottle blowing machine

Solution	Insulation for the heating chamber of the semi-automatic bottle blowing machine.
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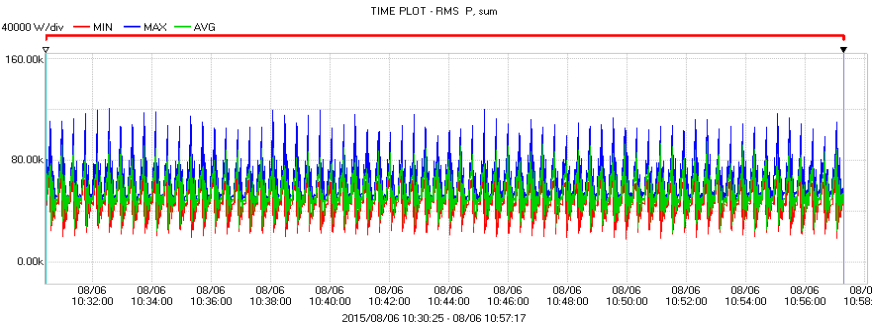
Status	Semi-automatic bottle blowing molding uses a heating chamber with lights, creating a temperature of about 200°C to heat the billet to 90-100°C before blowing. The chamber's shell is made of steel with a diameter of 800mm, and 400mm high, the shell's surface temperature of about 70°C can cause heat loss. Therefore, it is necessary to conduct insulation for the heating chamber.
Economic benefit	The economic benefit depends on the amount of heat and energy saved.
Energy savings	Depends on the amount of heat loss reduced.



Figure 2: Insulate the heating chambers of the blow molding

BM3: Install inverter for the blowing machine

Solution	Install inverter for bottle blowing machine
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Status	 Electric motors are very inefficient when in idling or under load mode. Conventional electric motors usually use 60% to 80% of rated power, sometimes they even run at 50% load. Therefore, it is possible to install an inverter to save energy when the machine is running under load. The inverter is essentially a frequency converter that feeds the motor, leading to a change in rotational speed in accordance with the load.
Economic benefit	Payback period of about 2-3 years based on the amount of energy saved.
Tiết kiệm năng lượng	Reduce over 61,440 kWh/year for the 650 EXHS pressing machine (total capacity is 120 kW, of which the capacity of the main engine is 75 kW and the Heater is 45 kW).

2.2 Extrusion

Extrusion technology is usually used in construction plastics production. Extrusion is the final forming process and an intermediate step for other processing techniques, including injection molding, blow molding, and film blowing. The outputs are tubes, pipes, aluminum sheets, other products, etc.

The main energy used for this process is electricity to drive the extruder-screw motor. Part of the electricity is used to drive puller motors and saws. In other cases, the cut-off equipment may be operated by compressed air. Among the plastic construction products, aluminum composite panel production usually has the highest specific energy consumption. Significant amounts of water may be used to cool the lineal and recirculated.

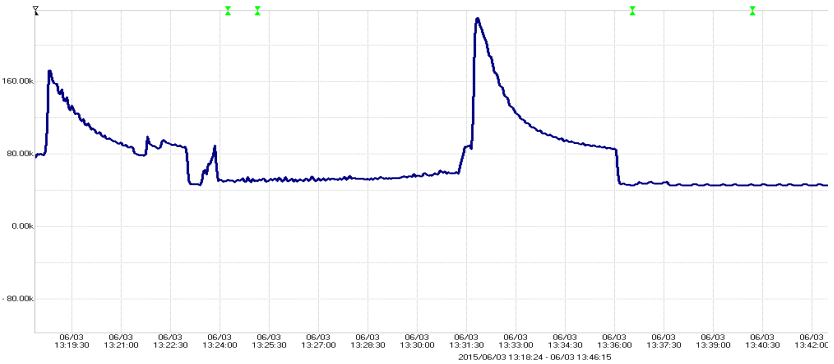
Thermoplastic raw material, typically in pellet form, is fed from a hopper into a barrel

that stores rotating screws. A small laboratory extruder may have a screw diameter of 10 mm, while a screw for a large volume extruder may have a diameter exceeding 300 mm. The screw is usually driven by an electric motor that has variable speed which can be combined with the single or multi-speed gearbox.

The plasticized material is pressed through the mold to form the desired shape. After passing through the die, the partially solidified extrusion can be further formed with a caliper or a vacuum press to achieve the final desired design and to maintain the required tolerances. Then the extruder is cooled by water or by air. Once the material has hardened enough to resist handling damage, a pull system is used to maintain constant tension on the extruder. In addition to the puller, a movable sawing or shearing mechanism is used to cut the product into desired lengths for further transport or processing.

Many custom operations use different sizes of multi-extruders. However, considerable productivity, quality, and energy efficiency can be achieved by using a machine that is suitable for a particular job. For particular material and flux, it is important to select the appropriate screw diameter, length-to-diameter ratio, and operating conditions. The tube extrusion process includes a vacuum section to ensure the uniform circular shape of the product.

E1. Install inverter for the sheet extruder

Solution	Install an inverter for the sheet extruders
Status and technical plan	 The operation of the sheet extruder is based on: Thickness, style, design, ... of the products. However, the amount of power consumed by the extruder motor does not change much in all cases. Therefore, it is possible to install an inverter to control the extruder motor so that the motor runs close to the load demand to save energy.

Economic benefit	Economic benefits are related to machine performance, power consumption, etc. The payback period for this investment is estimated at 18 months.
Energy savings	Usually about 20-30% of the power consumption of the extruder motor.

E2. Replace the heating system for the extruder

Solution	Replace resistance heating with induction heating system (induction heating system has more advantages, and saves energy)
Status and technical plan	Currently using a resistance heating system, heat is transferred by contact with the resistive surface, so only part of the contact surface is heated, thus causing energy loss. Very low thermal efficiency, about 50%; 20% loss due to self-heating resistor before heat transfer; 30% loss during heat transfer. Therefore, it is possible to replace the resistance heating system with an electromagnetic heating system, which shortens the heating time and precisely controls the temperature.
Economic benefit	The payback period for this investment is estimated at 13 months.
Energy savings	Save about 6.3% of the total energy consumption of the machine.



Figure 2: Heating system

E3. Install insulation for the extrusion shaft of the extruder

Solution	Fiberglass and aerogel sheet extruder insulation tank
Status and technical plan	Some extruders have uninsulated extrusion shafts, a surface temperature of 85°C to 180°C, resulting in large heat loss. Therefore, it is necessary to insulate the extrusion shaft of the plate extruder with fiberglass and aerogel.
Economic benefit	The payback period for this solution is estimated at 12 months with an investment level as low as 15 million dong.
Energy savings	Potential to save 0.2% power consumption of extruder.

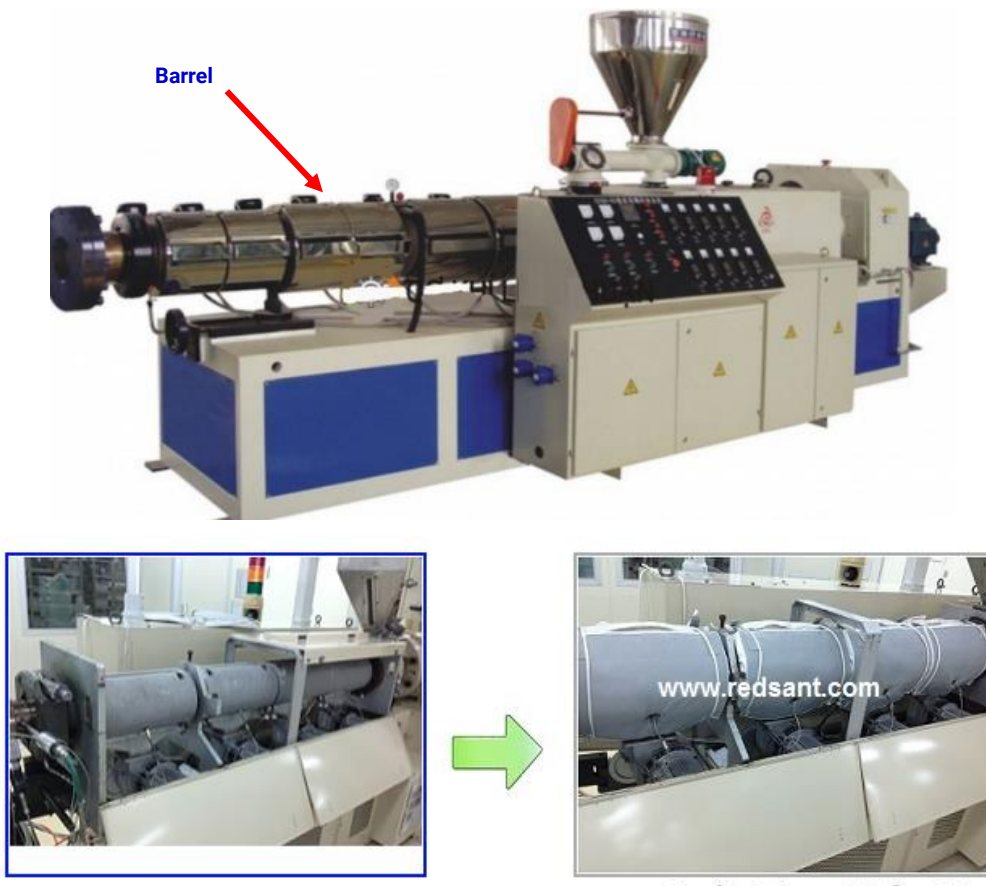


Figure 3: Extruder barrel (Before and After)

2.3 Thermoplastic injection molding technology

Thermoplastic injection molding is a versatile process used to produce a wide variety of end products. With proper tool design and material selection, injection molded parts can provide a broad range of physical properties, decorative features, and resistance to chemical attack as well as aging. When required, metal inserts may be used in injection molded parts to provide additional strength.

The energy used for this process is mainly electricity, used for the hydraulic system. Most of the energy is used for plasticizing materials, injection, and mold transport.

Motor and hydraulic oil pumps are the biggest energy-consuming parts of the injection molding process. Most hydraulic oil pumps are fixed flow pumps.

Injection molding machines are generally classified according to the clamping tonnage - the force required to resist the pressure caused by the material being introduced into the mold during the injection process. Pressure is usually high, at 20,000–30,000 psi. As a result, clamping capacities typically range from 20 tons for small machines to 6,000 tons or more for larger ones.

Cycles vary according to the materials used, the thickness of the parts, and the tool technology. Thin-walled barrels typically have cycles of several seconds. Large parts with heavy cross-sections will take several minutes to solidify before being removed from the mold.

Plastic enterprises in Vietnam commonly use hydraulic injection molding machines. Some enterprises produce plastic products that are not part of the plastic industry according to VSIC2007, such as plastic tables and chairs, plastic toys, plastic utensils, etc. These products are also produced with the injection molding process.

TIM1: Replace cooling system for injection molding cylinder

Solution	Use a fan cooling system instead of water cooling for injection molding barrel
Status and technical plan	When the temperature of the plastic is too hot, the injection molding barrels will be cooled by cold water from the chiller. Although cooling is required, the amount of heat released will be large, and cooling too quickly will make it difficult to properly control the temperature, leading to overheating. Hence, the heating system for the barrel will have to spend more energy to heat the plastic.

Economic benefit	The economic benefit depends on the amount of energy saved.
Energy savings	Save about 70% of the total heat of the injection molding barrel, which is equivalent to 11.9% of the total system.

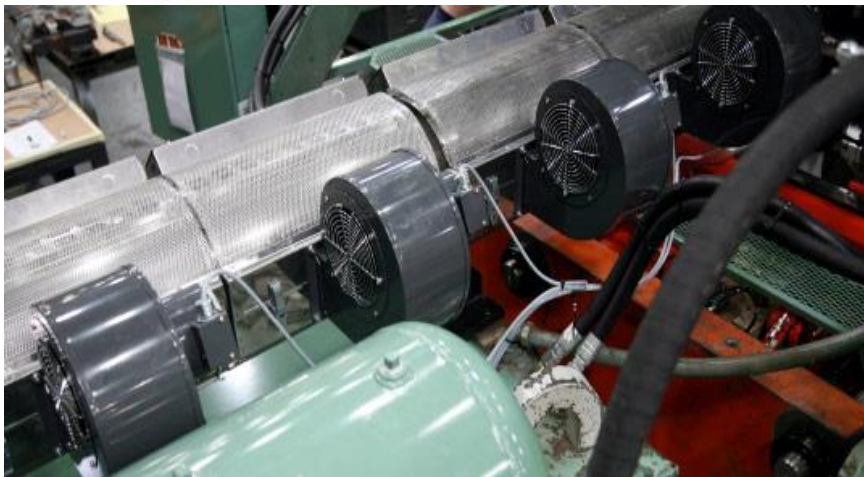
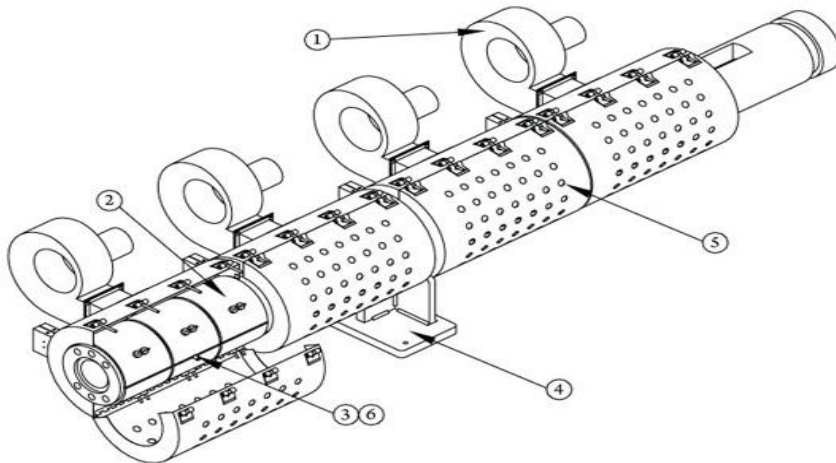


Figure 4: Replace the cooling system for the injection molding barrel

TIM2: Install insulation for the cylinder barrel of the plastic injection machine

Solution	Install insulation for the cylinder barrel of the plastic injection machine
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Status and technical plan	In some companies, injection mold barrels are not insulated. The temperature recorded in the injection mold barrel is 1500C – 2200C. This leads to huge heat loss and waste of energy (moreover, it leads to an increase in ambient temperature, which directly affects workers and, reduces labor efficiency). Therefore, it is necessary to cover the insulation with an inner layer of cotton insulation about 50 mm thick and the outside can be covered with aluminum sheets to protect the insulation.
Economic benefit	The payback period ranges from 2 to 3 years.
Energy savings	The saving potential is 2.55% of the power consumption of the plastic injection machine.



Figure 5: Insulate the injection molding barrel

TIM3: Install an inverter to control the speed of the hydraulic oil pump motor

Solution	Install inverter for hydraulic oil pump motor of injection molding machine
Status and technical plan	The motors and hydraulic oil pumps are the biggest energy consumers of the injection molding process, and the hydraulics are the driving forces of the machine. Most hydraulic oil pumps are fixed flow pumps. The cooling demand and standby flow are lowest while the fixed flow pump still serves the maximum flow, the excess oil is returned to the oil tank. - Wastes energy and increases the temperature of hydraulic oil due to friction with pipes, filters, valves, ... - Needs a lot of energy to cool Therefore, it is necessary to install an inverter to control the hydraulic oil pump motor for plastic injection machines. The inverter adjusts the rotational speed of the hydraulic oil pump based on the pressure and flow signals. As a result, the flow and pressure of the oil pump can be adjusted, resulting in a change in the pump speed. When there are high pressure and flow requirements, the motor rotates at full speed, while the motor can slow down or stop. As a result, the performance of the motor is improved and energy is saved
Economic benefit	The benefit comes from the hydraulic system and depends on the capacity of the oil pump. The payback period ranges from 2-to 3 years.
Energy savings	Potential saving is 20-30% of the total process.

TIM4: Use Servo motor and Server Driver set, combined with the hydraulic system

Solution	The old asynchronous motors connected to the hydraulic pump will be replaced by a servo motor, a controller will control the servo motor.
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Status and technical plan	Differences between inverter solution and servo motor solution are as follows: - When using the inverter with the old engine, the hydraulic pump still provides a larger flow of hydraulic oil than is needed to make different products and this excess flow is returned to the hydraulic oil tank, thus resulting in energy losses; - For the solution using a servo motor, the control from the controller will be performed much more precisely, thus will not create unnecessary oil flow. - With closed-cycle control technology, based on the signals of pressure and flow, etc., returning from the sensors, the controller will adjust the motor and oil pump speed so that the amount of oil used is accurate to each cycle, thus reducing power consumption.
Economic benefit	The benefits come from the hydraulic system and depend on the load, power ratio, and hours available for operation. The payback period ranges from 2-to 3 years.
Energy savings	Potential energy savings up to 30-45% of the presser's power consumption.

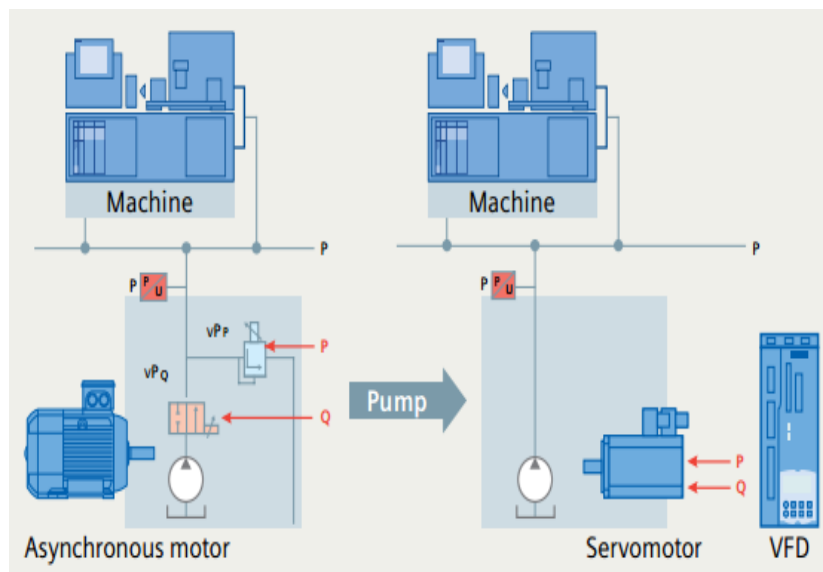


Figure 6: Install servo motor and servo driver combined with the hydraulic system
(Before and after)

TIM5: Use all-electric plastic injection machines using Servo motors when investing in new plastic injection machines

Solution	Using all-electric plastic injection machines using Servo motors when investing in new plastic injection machines
Status and technical plan	When investing in new or replacing old plastic injection machines using hydraulic oil pump motors with low efficiency, enterprises should use all-electric plastic injection machines using Servo motors. Instead of being controlled by a hydraulic system, the injection molding process only use a high-performance servo motor and high-speed digital control to control the whole operation cycle. Each servo motor controls the spraying, pinching, screw rotating, screw scrolling and pushing the products out, etc. The outcome is a faster, cleaner, more repeatable, and higher-performance injection molding process.
Economic benefit	The benefits come from the hydraulic system and depend on the load, power ratio, and hours available for operation. The payback period ranges from 2-to 3 years.
Potential for energy savings	Energy consumption for an all-electric injection mold can be reduced by 50-75% compared to the hydraulic injection molding.

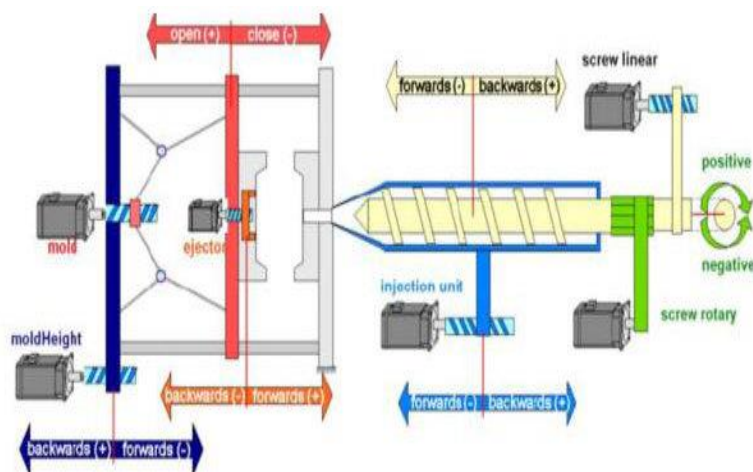


Figure 7: Install all-electric injection molding when purchasing a new machine

TIM6: Replace the heating system of the injection machine

Solution	Replace the existing heating system with contacted heat transfer electromagnetic heating system.
Status and technical plan	The heating (drying) system of current plastic injection molding machines is using a resistance heating system, the current heating method is mainly transmitted by contacting the thermistor surface, so only the contacted area is heated, thus causing a large part of energy loss. The thermal efficiency is very low, at about 50%: while about 20% of the energy is lost due to the thermistor self-heating before heat transfer, 30% of the energy is lost during contacted heat transfer. Therefore, it is necessary to replace it with an electromagnetic heating system to save energy, efficiency and fast heating time, accurate temperature control.
Economic benefit	Very low replacement costs, with 30% of the initial investment cost only to replace certain parts
Potential for energy savings	Save energy, more efficient and fast heating time, and precise temperature control. The energy-saving potential is about 40%, Resistance heating system's energy consumption is about 6.8% of the total amount for the injection molding process.
Another benefit	Zero environmental emissions

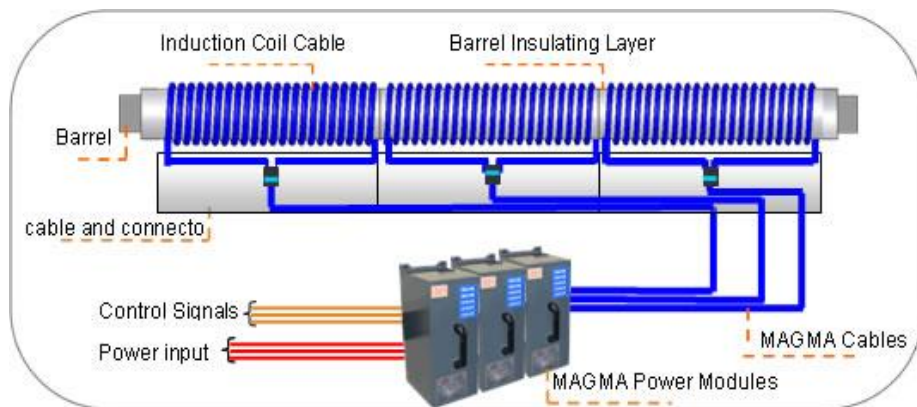




Figure 8: Replace the cylinder barrel heating system for the plastic injection molding machine

2.4 General equipment

The technical best practices found in this section primarily address production processes and applications unique to the plastics industry.

G1: Set the humidity sensor control for the drying tank

Solution	Install humidity sensor for dryer barrel to control operation based on humidity signal.
Status and technical plan	Currently, the dryer does not have a sensor, so it works continuously until the set temperature is reached, then stops idling. Therefore, there is a case where the humidity is much lower than required, leading to energy loss and vice versa when the dryer stops even when the humidity of the resin is not satisfied.
Economic benefit	The benefits depend on the amount of electricity saved.
Potential for energy savings	The energy-saving potential is about 10-20% of the total electricity consumption of the dryer

G2: Replace the drying system with the granulator

Solution	Replace the drying system with the granulator
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Status and technical plan	In many enterprises, the granulators use resistance heating systems; This heating system has low efficiency, energy is wasted. Therefore, it is necessary to replace the resistance heating system of the granulator with an electromagnetic heating system
Economic benefit	The benefit depends on the amount of energy saved, and the payback period is about 17 months.
Tiềm năng tiết kiệm năng lượng	Potential savings of about 10% of the total energy consumption of the granulator.

G3: Replace the expansion valve for the chiller

Solution	Replaced the old Chiller thermal throttle with an electronic throttle
Status and technical plan	At enterprises, chillers are using thermal expansion valves (TEVs), which are used to control the flow of liquid gas (liquid refrigerant) injected into the evaporator, however, these valves do not Works well with large variations in pressure. This can lead to damage if liquid gas enters the compressor as well as saving more energy. Therefore, it is necessary to replace the Chiller thermal throttle valves with electronic throttle valves (EDV). The electronic throttle valve is a device used to control the flow of refrigerant entering the evaporator in a precise amount. The electronic expansion valve will optimize efficiency and save energy in two ways: - The valves will accurately measure the overheating after the evaporator and the refrigerant flow into the evaporator, which helps optimize energy usage by keeping the refrigerant's temperature at the lowest level. - The valve allows the compressor to release the reduced pressure because we need the difference of the open pressure to be smaller than the thermostat valve. When the discharge pressure of the compressor is allowed to change the temperature of the condenser, the cooling cycle becomes more efficient.

Economic benefit	The benefits depend on the amount of electricity saved, and the payback period is under 1 year.
Potential for energy savings	The energy-saving potential is about 5-15% of the total electricity consumption of the chiller system.

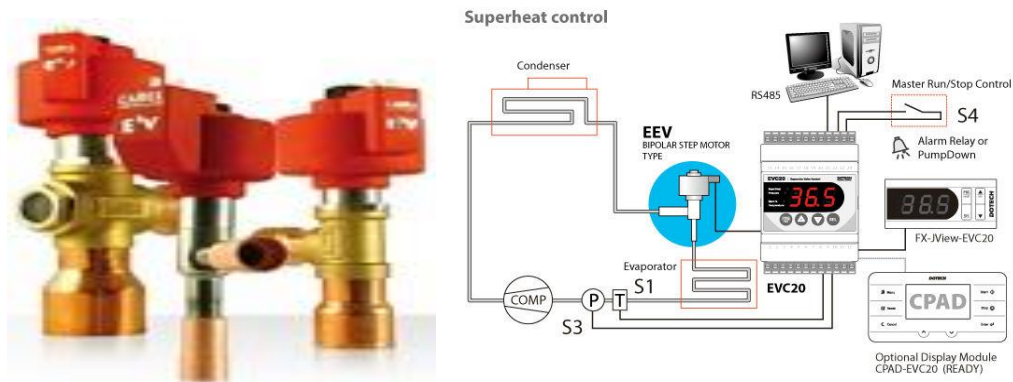


Figure 9: Expansion valves in the chiller system

G4: Installing equipment to control and control temperature for molds

Solution	Installing equipment to control and control temperature for molds
Status and technical plan	The temperature control unit (TCU) is used to maintain the mold temperature at a predetermined level. TCUs are available from various manufacturers and are commonly used in many types of plastic production, including vacuum heat forming, blow molding, and injection molding. The best practice recommendation is to control the TCU manually or automatically by using an electric heater to provide heat to the mold. Some processes do not require heat (only cooling), so the devices do not include a built-in heating element.
Economic benefit	Depends on how this solution is implemented; Research about the installation of automatic control will be more efficient but at an additional cost.
Potential for energy savings	Potential savings of about 10% of the power consumption

**AGENCY FOR INNOVATION, GREEN TRANSITION
AND INDUSTRY PROMOTION
MINISTRY OF INDUSTRY AND TRADE**

- 📍 54 Hai Ba Trung, Cua Nam Ward, Hanoi
- ☎ 024. 2220 5528

