# Application of electromagnetic heating energy-saving device in injection molding machine (extruder)

Tao YongLiang[1], Xun Shanglun[2], Zheng Yingjie[3], Qiu Feng[4], Gao Tingwen[1], Tian Shuzhu[5]

(1.Chongqing Chuanyi Engineering Plastic Co.LTD., Chongqing 400712, China;
2.Shenzhen ShouNeng Energy Saving Equipment Co.Ltd., Shenzhen 518122, Guangdong, China;
3.Chongqing Damaodi Weixi Auto Parts Co. LTD., Chongqing 402761, China;
4.College of Materials and New Energy, Chongqing University of Science and Technology,Chongqing 401331, China;
5.Intelligent Manufacturing College of Guangdong Lingnan Vocational and Technical College,Guangzhou 510663, Guangdong, China)

**Abstract:** The injection molding industry is characterized by high energy consumption and high carbon emissions. Injection molding machines (extruder) occupy a central position in the injection molding process. Currently, energy-saving and emission-reduction improvements for injection molding machines (extruder) are an important direction for the industry to reduce carbon emissions and increase efficiency. This article introduces an electromagnetic energy-saving heating device suitable for the material cylinder of injection molding machines (extruder). Through experimental comparisons between resistance heating coils and electromagnetic heating coils, the significant application advantages of electromagnetic heating coils are clarified, and practical application cases in equipment such as injection molding machines (extruder) are listed. Through quantitative calculation of electricity savings, readers can intuitively understand the energy-saving benefits of electromagnetic heating coils, indicating that this device has good application prospects in the field of material cylinder heating.

**Key words:** "dual carbon" goals; injection molding machine; extruder; resistance heating; electromagnetic heating; energy conservation and emission reduction

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An injection molding machine is a primary molding equipment that utilizes plastic molding molds to produce plastic products of various shapes from thermoplastic (thermosetting) plastics. In the manufacturing industry, injection molding machines are one of the most energy-consuming devices, with a large number in use and a typical service life of around 20 years. According to relevant literature, in a developed city in the south, the carbon emissions from plastic products account for a relatively high proportion of the manufacturing industry. Its industrial added value accounts for 3.25% of the manufacturing industry's output value, electricity consumption accounts for 10.62% of the manufacturing industry's energy consumption, and the carbon emissions from the plastic products industry in 2010 were 3.294 million tons.

The extruder is an essential equipment for processing plastic raw material particles, mixing and granulating for material modification, and extruding processed products. Its power consumption is similar to that of an injection molding machine. It can be seen that injection molding machines (extruders) are highly energy-consuming devices, and the higher the energy consumption, the proportional increase

**Biography:** Tao Yongliang (1956–), a professor-level senior engineer, primarily engages in research on the application and molding processes of polymer materials.

in carbon emissions. On September 22, 2020, during the general debate of the 75th session of the United Nations General Assembly, China pledged to the world that it would strive to peak carbon dioxide emissions by 2030 and achieve carbon neutrality by 2060 (referred to as the "dual carbon" goals). In the face of the "dual carbon" goals, energy-saving improvements for injection molding machines (extruders) are an imperative path.

## 1 Basic overview of energy consumption of injection molding machines (extruders)

The injection molding process involves injecting molten polymer melt into the mold cavity, which is then opened and the plastic part is ejected after the polymer melt solidifies. The specific actions include: mold clamping → forward movement of the injection seat → injection → pressure maintaining → cooling (pre-plasticization) → backward movement of the injection seat → mold opening → ejection of the plastic part → return of the ejector pin → mold clamping. Through this process analysis, it is evident that an injection molding machine requires an operating power system and a polymer heating system, namely the power part and the heating part, both of which require electrical energy for support. In traditional hydraulic injection molding machines, hydraulic oil pumps account for more than 80% of the electricity consumption, while other components such as barrel heating account for about 15%, and electrical control and other miscellaneous components account for 5%. Among them, barrel heating is an essential step for melting the polymer. The power consumption of extruders and injection molding machines is similar, with extruders using die heads to extrude filaments or products, and injection molding machines using molds to produce products.

An extruder transforms solid plastic into a uniform melt through heating, pressurizing, and shearing, and then delivers the melt to the next process. During operation, raw materials are fed into the barrel through the feed port and are propelled forward as the screw rotates. Once the raw materials enter the barrel, they are heated by a heater outside the barrel, causing them to soften and melt. The screw ensures that the material undergoes shearing, compression, and mixing during the forward propulsion process, which helps to mix the materials evenly and ensures the quality of the melt. The molten material passes through the extruder head, which is a crucial part that determines the shape of the product. Depending on production requirements, the head can be replaced with different molds to produce products with different cross-sections. Some products are granulated after extrusion, while others are extruded into the desired shape according to the die. In the plastic extrusion industry, the electric energy used to heat the barrel typically accounts for less than that used to drive the motor. For small and medium-sized equipment that use traditional resistance heating, other energy consumptions (such as heating, cooling, and auxiliary systems), including the heating of the barrel, account for 20% to 40% of the total electric energy. To achieve energy saving and low carbon emission for injection molding machines (extruders), it is necessary to reduce the power consumption of the hydraulic oil pump. This not only provides a new approach for improving the power of injection molding machines (extruders), but also requires reducing the power consumption for barrel heating. By applying electromagnetic heating energy-saving devices on injection molding machines (extruders), we can improve the barrel heating method of injection molding machines (extruders) and minimize electricity use.

## 2 Electromagnetic energy-saving heating device for material cylinder

The traditional heating method for the material cylinder of an injection molding machine (extruder) is through the use of a resistance heating coil. This resistance heating coil generates heat through the resistive heating effect of electricity. The inner wall of the heating coil is installed on the outer wall of the material cylinder (also known as the barrel), and it requires close contact (contact conduction) to transfer the heat to the material cylinder. Currently, resistance heating coils have advantages such as simple structure, low price, and convenient installation and use. In contact heat transfer, the vibration phenomenon during high-speed operation of the injection molding machine (extruder) can also affect the heating effect of the heating coil. Additionally, the outer ring of the heating coil is exposed to the air, which emits a lot of heat, resulting in significant heat loss, which can reach up to 50%, thus leading to increased energy consumption. The outer ring of the heating coil exposed to the outside has a significant impact on the production environment in summer and poses certain safety risks.

The electromagnetic heating coil (leak-proof rubber) represents a technological innovation based on traditional resistance heating coils, replacing resistance heating with electromagnetic heating, resulting in significant improvements in energy efficiency and safety indicators. Its principle involves converting alternating current into a high-frequency circuit through an electromagnetic heating controller, which generates a high-frequency magnetic field through the electromagnetic heating coil (i.e., high-frequency coil), causing the iron molecules in the material cylinder to resonate and generate heat, thus achieving the purpose of heating. The electromagnetic heating coil comprises an inner cylinder base with positioning function (made of high-temperature resistant material), an electromagnetic induction coil, and is equipped with coil positioning edges and temperature measurement point positioning gaps. The electromagnetic induction coil is a single-layer or double-layer (multi-layer) coil wound around the inner cylinder base with multiple wires, depending on the power selection of the heater. As shown in Figure 1.

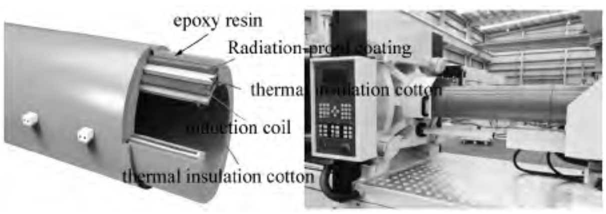



**Figure 1 Schematic diagram of electromagnetic heating coil structure and installation (Internet image)**

Electromagnetic heating coils can be selected for high-frequency heating of plastic machinery barrels in injection molding machines, film blowing machines, and extruders, allowing the barrel body to generate heat without dissipating it, reducing shear forces. Compared to resistance heating coils of the same specification and model, the entire set of electromagnetic heating coils can save 40% to 50% of electricity. The surface temperature of the outer ring of a resistance heating coil is 236°C, while that of an electromagnetic heating coil is 47°C, reducing the temperature in the workshop by 3 to 6°C, greatly saving electricity costs and achieving energy conservation and emission reduction. Generally, the total investment can be recovered in 5 months, and the service life is long. Electromagnetic heating coils have been widely used. Nowadays, there is also "nano-infrared heating", which uses carbon fiber or quartz tubes to directly heat the surface of the barrel with high-temperature light sources, achieving direct heat transfer from the heating coil to the barrel, resulting in even better energy-saving effects.

### 2.1 Experimental comparison between resistance heating coils and electromagnetic heating coils

To enhance everyone's understanding of electromagnetic heating coils, relevant data was obtained through experiments involving resistance heating coils and electromagnetic heating coils (as shown in Figure 2). The resistance heating coil was applied to the material cylinder, while the electromagnetic heating coil was used on the flange plate, allowing for experimentation and comparison. The experiments revealed that:

(1)The electromagnetic heating coil preheats and starts up quickly, shortening the overall heating time.

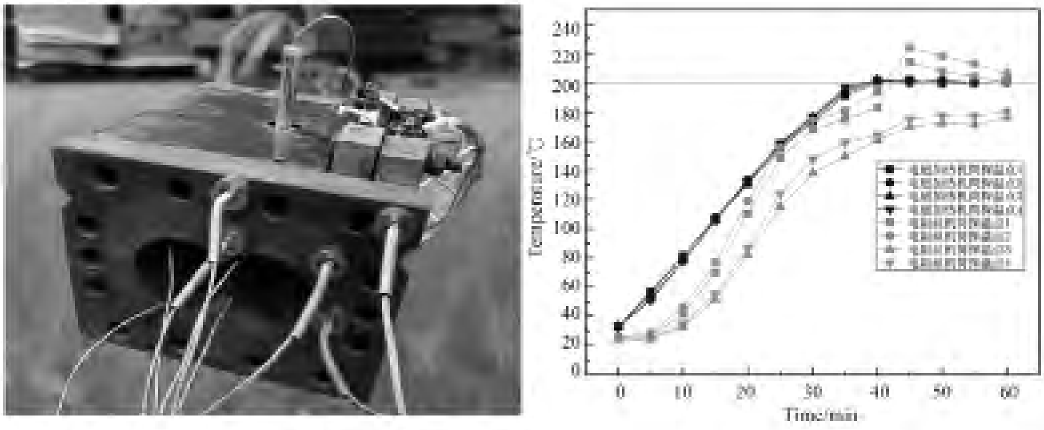
(2)Using electromagnetic heating results in faster and more uniform temperature rise, solving issues such as inaccurate temperature control and long thermal buffering time that exist in traditional conduction-based heating.

(3)Electromagnetic heating ensures synchronous heating of the barrel and flange, improving overall temperature uniformity.

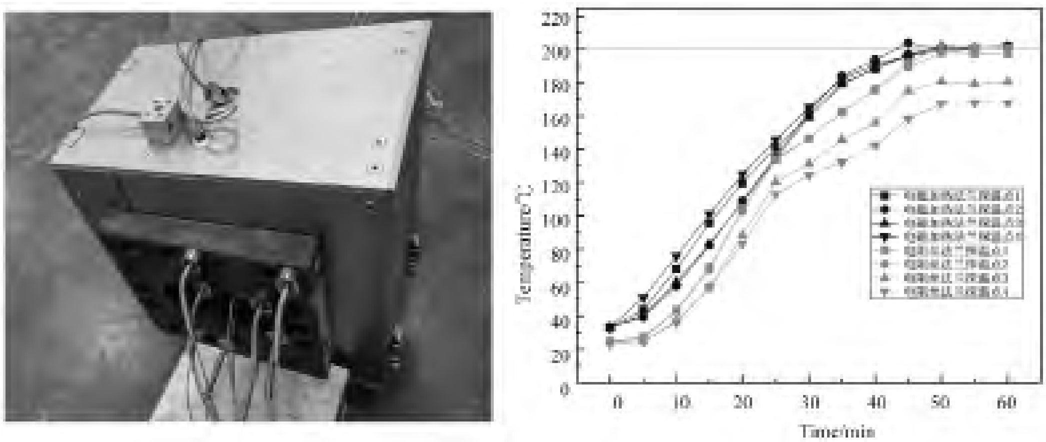
(4)The electromagnetic heating coil is easy to install and maintain, and has strong versatility.

### 2.2 Application advantages of electromagnetic heating coils

After years of application in injection molding machines (extruders), electromagnetic heating coils have essentially formed unique advantages: First, compared to traditional resistance wire heating methods such as cast copper and cast aluminum infrared rays, they save 40-60% energy; second, the surface temperature of the heating coil is low, with almost no heat emitted into the workshop, improving the working environment for operators; third, the surface of the heating coil is equipped with a temperature sensor, which cuts off the heating signal and alarms when the temperature is out of control or the heating is abnormal. The surface temperature of




(a) Comparison between resistance wire heating experiment and barrel experiment




(b) Comparison of electromagnetic heating experiment and flange experiment

**Figure 2 Experiment and comparison of resistance wire heating and electromagnetic heating**

the heating coil is 40-50°C, which is safe to touch and easy to maintain, and it has electromagnetic shielding effect; fourth, it shortens the heating time. Electromagnetic heating coils shorten the preheating time by 30% compared to resistance heating coils, and the heating is more uniform; fifth, the electromagnetic power supply can be used for curve heating, achieving precise temperature control, improving product quality, and high production efficiency.

## 2.3 Application of electromagnetic heating coil on injection molding machine

BU650T is an injection molding machine with a clamping force of 650 t and an injection volume of 4,000 g. It is a widely used large-to-medium-sized injection molding machine in injection molding factories. The material cylinder of the injection molding machine is heated by a resistive heating coil assembly, with an hourly electricity consumption of 9 kW.h (degrees). When using an electromagnetic heating coil assembly, the hourly electricity consumption is 5.4 kW.h (degrees), saving 3.6 kW.h (degrees) per hour. Therefore, using an electromagnetic heating coil assembly saves 40% of the electricity compared to resistive heating coils per hour, resulting in significant energy savings. The annual electricity savings are 5.4×22×26×12=37,0656 kW.h (degrees) (calculated based on working 22 hours per day and 26 days per month). For an injection molding machine, the annual electricity savings are considerable. The electromagnetic heating coil adopts a snap-fit installation method, which is easy to disassemble and has strong interchangeability. The electromagnetic power supply is placed on the side of the main heating equipment to avoid wire interference and facilitate operation. The overall structure is compact, the layout is reasonable, and space is saved. The maintenance cost in the later stage is greatly reduced. As shown in Figure 3.

(a) Schematic diagram of the original resistance heating coil

(b) Schematic diagram of electromagnetic heating coil

**Figure 3 Schematic diagram of two types of heating coil installations**

## 2.4 Application of electromagnetic heating coil on extruder

The parallel twin-screw extruder (with a screw diameter of 65mm) is a kind of extruder commonly used by users, which can be used for extrusion granulation or for extruding products. The extruder uses resistance heating coils, consuming 17 kW.h (degrees) of electricity per hour. Switching to electromagnetic heating coils reduces the electricity consumption to 8.5 kW.h (degrees) per hour. Therefore, using electromagnetic heating coils saves 50% of the energy compared to resistance heating coils per hour, which means half the electricity is saved.

A certain material modification enterprise has 4 units of extruders of the same model, saving 8.5×4=34.0 kW.h (degrees) per hour, and 34×22×26×12=233,376 kW.h (degrees) per year (calculated based on working 22 hours per day and 26 days per month). The total annual savings in standard coal are 28.7 t, and the reduction in carbon dioxide emissions is 133 t. Due to the higher plasticizing capacity, the customer's screw speed has increased from 70% to 100%, resulting in a 30% increase in production capacity.

Based on the industrial electricity price of 0.8 yuan per kilowatt-hour, the annual investment income is 233,376 × 0.8 yuan = 186,700 yuan (electricity cost). The total investment for this project is 120,000 yuan, with an investment recovery period of 0.64 years. Adding a 30% increase in production capacity, the investment can be recovered within 0.5 years. The workshop temperature is reduced by 2℃, improving safety. The surface temperature of the heating coil is 50℃ and can be touched, enhancing the comfort level of workers' work environment and meeting occupational health standards. As shown in Figure 4.

(a) Schematic diagram of the original resistance heating coil

(b) Schematic diagram of electromagnetic heating coil

**Figure 4 Schematic diagram of two types of heating coil installations**

The parallel twin-screw extruder (screw diameter 75 mm) uses a resistance heating coil set with an hourly energy consumption of 29.1 kW.h (degrees), and switches to an electromagnetic heating coil set with an hourly energy consumption of 9.3 kW.h (degrees). Using the electromagnetic heating coil set saves 19.8 kW.h (degrees) of electricity per hour compared to the resistance heating coil, with an hourly electricity saving rate of 68%. As shown in Figure 5.

(a) Schematic diagram of the original resistance heating coil

(b) Schematic diagram of electromagnetic heating coil

**Figure 5 Schematic diagram of two types of heating coils installation**

## 2.5 Other applications of electromagnetic heating coils

The electromagnetic heating coil is not only applied in injection molding machines and extruders, but also can be used in equipment similar to barrel heating, such as multi-layer co-extrusion casting machines, sheet extruders, film blowing machines, blow (suction) molding machines, and hollow building machines. As shown in Figure 6.

(a) 4-layer co-extrusion casting machine

(b) Sheet extruder

**Figure 6 Other uses of electromagnetic heating coils**

## 3 Conclusion

According to reports, the production and incineration of plastics in 2019 will generate over 850 million tons of carbon dioxide equivalents, equivalent to the emissions from 189 500-megawatt coal-fired power plants. It is estimated that from now until 2050, global plastic production and incineration will cumulatively emit 56 billion tons of carbon dioxide equivalents, accounting for 10% to 13% of the total carbon budget that can be "spent" by mid-century based on current emission reduction commitments. By the end of this century, emissions related to plastics could account for half of the total carbon budget. These data indicate that the carbon emissions from the plastic industry are still significant, and the road to emission reduction is long and arduous. An important way for the plastic industry to reduce emissions is by conserving electric energy, controlling product quality, and producing more qualified products. Implementing energy conservation, emission reduction, cost reduction, and efficiency improvement is the foundation for achieving the "dual carbon" goals. Empowering carbon reduction with AI provides a continuous driving force for the intelligent manufacturing upgrade and green transformation of the plastic industry. A series of measures will be implemented to reduce emissions, allowing electromagnetic heating devices to contribute their modest efforts to mitigating the global greenhouse effect.