

# VEICHI

## Ball Mill Variable Frequency Integrated Control System





Shenzhen Veichi Electric Co., Ltd is a high-tech enterprise that is professionally engaged in the development, manufacturing and marketing of industrial automation control products, and committed to becoming a global leading provider of industrial automation control products and system solutions.

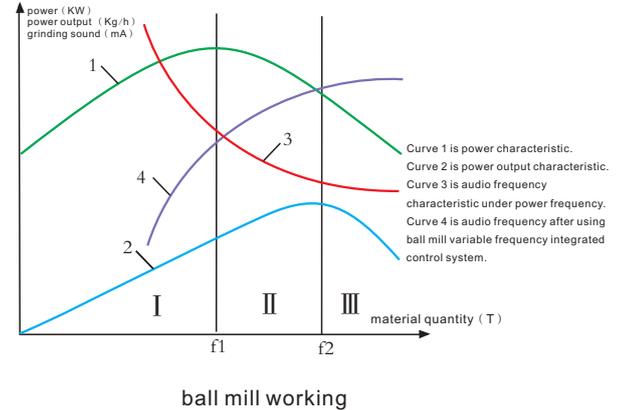
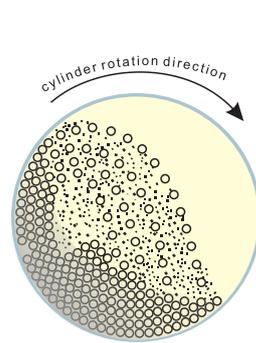
The company owns powerful R&D team, relatively perfect production system, independent intellectual property and manufacturing bases in Shenzhen and Suzhou. To improve our R&D strength, we keep on introducing advanced overseas technology and broadening our partnerships with first-class universities and research institutions.

The main products of Veichi Electric include a variety of Variable Frequency Drive(VFD), Servo Drive System, Photovoltaic Inverter, PLC, HMI, Automation Equipment, etc, which are widely used in industries such as oil&gas, chemical industry, ceramic, crane&hoist, metallurgy, electrical cable and wire, plastic, print and package, textile, metal work and cable, coal mining and municipal engineering. Suitable solutions and products are always ready to meet the demands and improve comprehensive competitiveness of users.

With the spirit of "Innovation is the lifeblood of Veichi", we're committed to becoming one of the leading providers of electric drives, industrial control and green energy products. Veichi has set up more than 40 brand offices in China and dozens of partners in Asia, Europe and Africa. Veichi has been named Chinese Electric Industry's Top Ten National Brands, Chinese Electric Industry Top Ten Satisfying Brands and Top Ten National Brands of Inverter Industry. Veichi products have become the first choice of many enterprises.

## ▶ Ball Milling Machine Working Principle

From the feed device, material enters into the ball mill compartment where there is ladder plate or corrugated plate with grinding balls of various specifications. In order to make the material and grinding balls distributed uniformly and avoid starting difficulties caused by uneven weight distribution, it requires to start auxiliary equipment during feeding, and this process is also known as swing mill. After the material is evenly distributed in the compartment, the cylinder rotates producing centrifugal force which drives grinding balls to a certain height and then falls to let the materials be struck and grinded. Powder material will be discharged through the discharge device completing milling process.



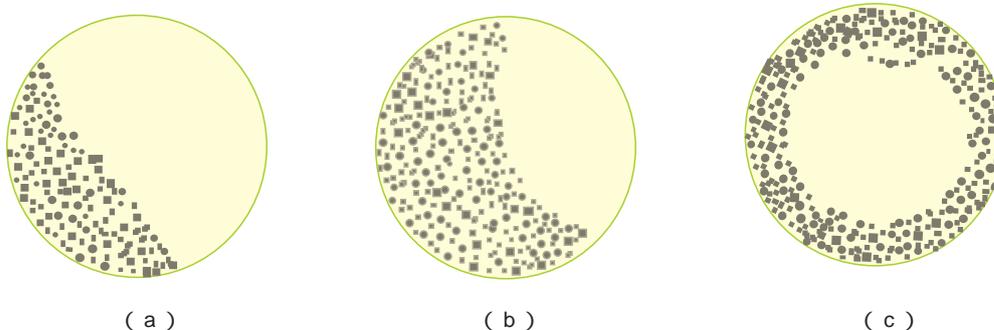
## ▶ Great Necessity of Equipping Ball Mill Machine with Variable Frequency

With the increasing market competition, how to save energy and reduce producing costs are common concerned topics of all enterprises. Therefore, minimizing power consumption of ball milling machine and saving energy are of great significances in improving the economic efficiency of enterprises.

1. The existing start-up mode and control mode of ball milling machine is not energy-saving that we can save a lot of electricity through frequency transformation.
2. The ball mill machine suffers a large impact force under the existing startup mode, so the bearings and gear reducer are more prone to damage causing large maintenance costs.
3. The ball mill machine suffers a large impact force under the existing startup mode (generally 7 to 8 times of the rated current). It will cause voltage fluctuations and voltage drops, what's worse, it may lead to other equipments tripping or fault, affecting the normal producing.
4. The common drive mode of ball mill: three-phase AC motor – hydraulic coupling – gear reducer – belt pulley reducer. Since the ball mill belongs to the constant torque load, its speed regulation efficiency is equal to speed regulation ratio that a large part of energy is wasted in the fluid coupling increased energy consumption of ball mill machine.

## ▶ Ball Mill Energy-Saving Principle

Usually ball mill operates at fixed running speed, and the cylinder speed is determined by belt pulley and gear reduction mechanism (or hydraulic coupling). The rotating speed of ball mill directly affects the movement of steel balls and the grinding process of material. At different rotating speed, the movement status of steel balls and material inside the cylinder are as follows:



- (a) When at low speed, steel ball and materials ascend along with the cylinder inner wall, and when the angle between material & steel ball and horizontal is equal or greater than natural inclination angle, the ball and material will slide down along the slope that it cannot form an enough fall. Therefore, the grinding effect to material is small and the working efficiency of ball mill is very low.
- (b) When the cylinder rotating speed is at a certain value between the above two ones, steel balls ascend to a certain height and then fall along the parabola, which has the largest impact effect to materials. In this situation, ball mill has the highest grinding efficiency and this speed is called the optimum working speed.
- (c) If the cylinder speed is very high, the material and steel ball will not separate from the cylinder inner wall under the impact of the centrifugal force, instead, they rotate along with the cylinder inner wall. In this case, the balls have no impact effect to materials and the ball mill grinding efficiency is lower.

Critical speed of ball mill  $n_{ij}$  :  $n_{ij}=42.3/\sqrt{D}$  ( r/min ) ( D stands for cylinder inner diameter )

Best working speed of ball mill  $n_{zj}$  :  $n_{zj}=0.765n_{ij}$  ( r/min )

## Energy Saving Principle

Wet ball mill (ceramic enterprises) selection and configuration is determined by the cylinder diameter, processing requirements and yielding capacity. Ball mill includes electric motor (driving force) reducer, fluid coupling, auxiliary motor, brake coil, belt pulley, cylinder and etc. Original control system runs at a constant speed, we can only determine the necessary time of manufacturing each specific product through experience and experimentation. As the ball mill starting torque is extremely large, so it is difficult to start.

On the basis of countless experiences and data summary, we have specially developed AC60Q variable frequency integrated control system for ball mill. Its working process and energy saving principle are just as the Image 2 shows.

Working Process of Ball Mill: Ball mill is a movement-based system that material grinding process takes place between medium and medium or between medium and liner plate. Medium movement includes parabolic mode (suitable for coarse grinding), cascading mode (suitable for fine grinding), and centrifugal mode (no grinding effect). Its stress diagram is shown in Image 1.

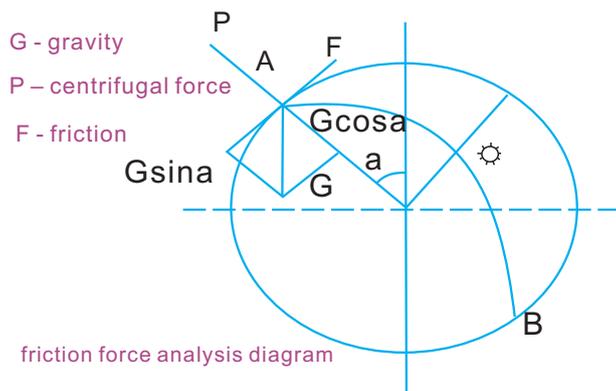


Image 1

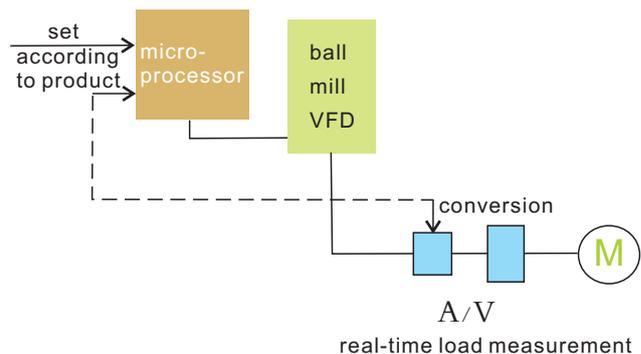


Image 2

Usually the best operating speed is 70% to 80% of the critical speed, indicating that the operating speed is adjustable but within a small adjustment range. The error between the actual operating speed and optimum operating speed is less than 10%, therefore, if we use variable frequency and speed regulating to search the best operating speed, the grinding efficiency will be improved and energy-saving effect will reach 15%. At this time if we can change the speed of ball mill to a certain speed, the grinding media and the material will achieve full friction which greatly improves the grinding efficiency (if we reduce the operating speed of ball mill irrationally, it can not only reach the grinding effect, but also get just the opposite).

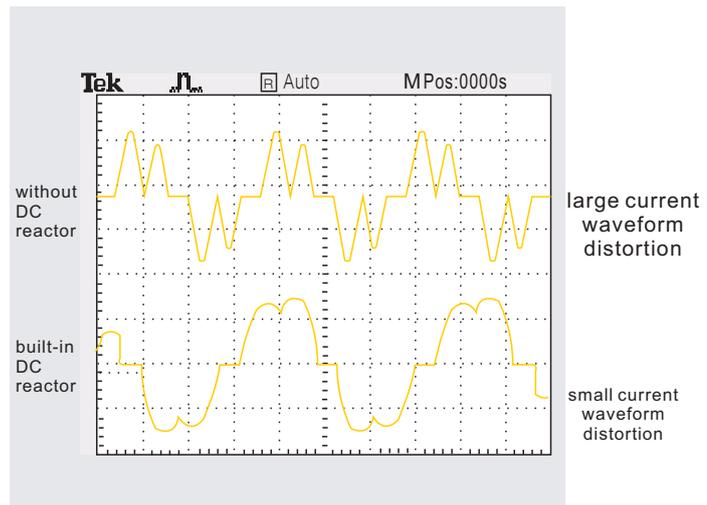
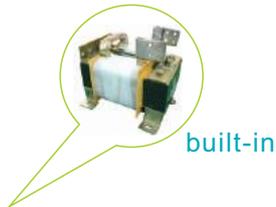
Veichi AC60Q is specially designed based on our experience and the ball mill speed calculation formula. It can adjust the cylinder running speed according to the relationship between grinding medium and the material so as to decrease the grinding time and improve the ball milling efficiency.

## Variable Frequency Ball Mill Scheme

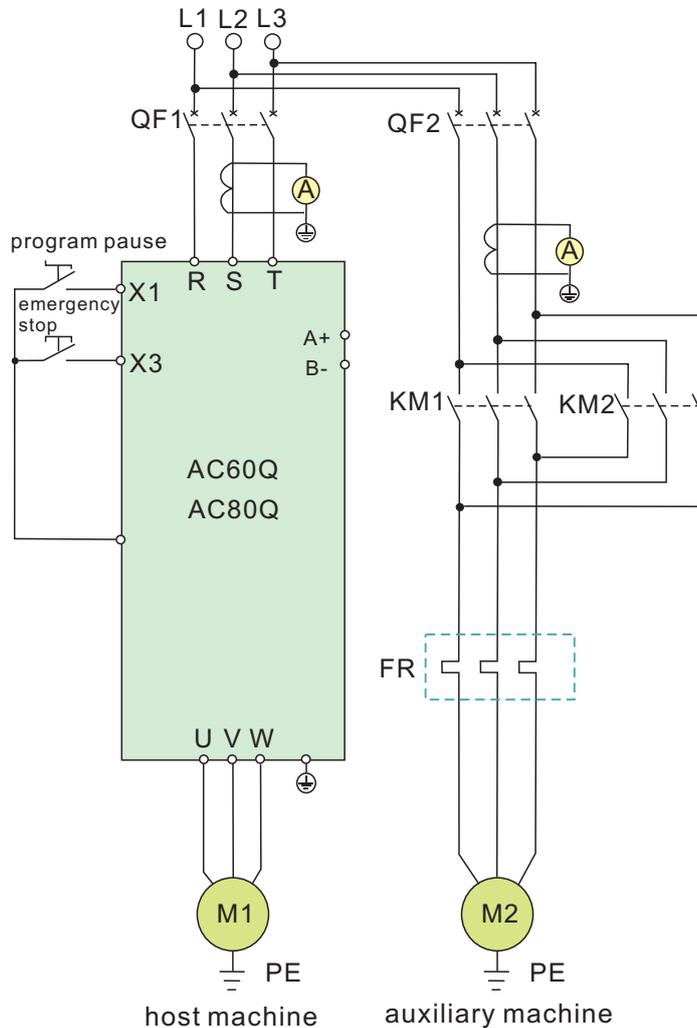
### Variable Frequency Ball Mill System Features

1. Has sufficient starting torque that it can reach 180% of rated torque output at low speeds. It meets the large load requirements of ball mill, and maintains the motor with steady operation state when the equipment is running at variable frequency, ensuring the motor has constant power characteristics.
2. The ball mill frequency control and speed regulation system makes ball mill running reliably at low speed, ensuring the normal process control requirements. It extends service life of ball mill and reduces maintenance costs.
3. We can set different speed for different time frames according to the requirements of different grinding products. Customers can freely select or set speed (through micro processor).
4. It can automatically track the optimum operating current of motor in real time so as to adjust the corresponding output voltage and current, achieving the best economic operation status.
5. Humanized design integrated with main and auxiliary machine. The low-voltage device inside cabinet are of international brands, and it can monitor variable frequency drive and relevant electrical parameters in real time.
6. The entire system has full protections such as over-voltage, over-current, overload, stall protection and etc.
7. In any acceleration time and any impact load conditions, ball mill variable frequency system can run stably without tripping, improving working efficiency in energy-saving conditions.
8. Soft-start function and low peak current, there is no impact to the grid, completely avoiding electrical shocks and reducing the mechanical vibration. It extends the life of equipment.
9. Ball mill variable frequency system has parameter copy function, easy to operate and use.
10. Adopting independent air duct design that it fully meets the cooling requirements, ensuring the high stability of components inside the frequency inverter system.

### Effect Contrast Chart (Built-in DC Reactor)



## ● Working Principle of Ball Mill Variable Frequency Integrated Control System



### ● Ball Mill Variable Frequency Integrated Control System Description

1. The variable frequency control technology transforms the ball mill drive system to meet low running speed and high starting torque requirements, and makes ball mill running speed continuously adjustable. There is no shock current when the motor starts running, enough starting torque and full protection functions. It ensures the process control quality and reduces the maintenance cost.
2. It is available of achieving automatic control and avoiding the voltage rise caused by large inertia, which guarantees the normal operation of ball mill.
3. On the load independent condition, it can maintain the highest motor efficiency with the automatic voltage regulating function of VFD.
4. Through VFD, you can easily set the ball mill downtime and automatic shutdown after milling process is finished. It makes the operation more intelligent and humanized.
5. Intelligent human-machine interface (LCD display) for monitoring the VFD parameters.

## ▶ Variable Frequency System Energy Saving Effect Analysis

### Variable Frequency System Energy Saving Effect Analysis

Taking ball mill machine of one ceramics factory for example: the ball mill motor is of 160KW and 300A rated current. The cylinder speed is 30r/min, each work cycle is 5s, the current range is 145A to 210A which is equivalent to 48% - 70% of the rated current (145A in 4s, 210A in 1s).

**A. Before Energy-Saving Transformation**

Power consumption at high load state:

$$P_{10} = 160 \times 0.70 / 0.83 = 134.9 \text{ (KW)}$$

The motor efficiency is 0.83 with 70% load.

Power consumption at light load state:

$$P_{11} = 160 \times 0.48 / 0.7 = 109.7 \text{ (KW)}$$

The motor efficiency is 0.7 with 48% load.

$$P \text{ (power consumption per hour before transformation)} = (P_{10} \times 1 + P_{11} \times 4) / 5 = 114.7 \text{ (KW)}$$

**B. After Energy-Saving Transformation**

Power consumption at high load state:

$$P_{20} = 160 \times 0.7 / 0.9 = 124.5 \text{ (KW)}$$

The motor efficiency is 0.9 with 70% load and voltage control.

Power consumption at light load state:

$$P_{21} = 160 \times 0.48 / 0.88 = 87.3 \text{ (KW)}$$

The motor efficiency is 0.88 with 48% load and voltage control.

**C. The Annual Energy Saving Rate with AC60Q VFD's Automatic Voltage Regulation Function**

$$P \text{ (power consumption per hour after transformation)} = (P_{20} \times 1 + P_{21} \times 4) / 5 = 94.7 \text{ (KW)}$$

Calculated by 320 days per year and 20 hours per day, the electricity saving is

$$\text{The energy saving rate is } (114.7 - 94.7) / 114.7 \approx 17\%$$

**D. Total Energy Saving Rate**

If we remove the fluid coupling with AC60Q ball mill variable frequency integrated control system and compensation capacitor, the energy saving rate will be 5%. Adding the energy-saving rate under VFD automatic voltage regulation mode, the total energy saving rate will be 22%.

Ball Mill Tonnage (T)	Motor Power (KW)	VFD Model	Ball Capacity (T)	Dimension (L x W x D) (mm)
18	90	AC60Q-T3-93G	20~22	1600 x 600 x 500
20	110	AC60Q-T3-110G	22~24	
30	110	AC60Q-T3-110G	32~35	
38	132	AC60Q-T3-132G	38~40	
40	132	AC60Q-T3-132G	42~45	
40	160	AC60Q-T3-160G	42~45	2000 x 650 x 550
60	200	AC60Q-T3-200G	60~65	
60	220	AC60Q-T3-220G	60~65	2000 x 730 x 550
60	250	AC60Q-T3-250G	60~65	
100	250	AC60Q-T3-250G	100~105	
100	280	AC60Q-T3-280G	100~105	

**Conclusion**

Practice shows that Veichi Electric ball mill variable frequency integrated control system is very successful in ceramics industry energy saving field. It is different from common variable frequency drives, soft-starter and power factor compensator, which is an organic combination of the three ones. AC60Q effectively overcomes the starting difficulty of ball mill along with good economic benefits, which has become the preferred choice for ceramic enterprises. As people have a higher level of acceptance to VFD and its application experience, the Veichi AC60 series VFD has a more broad application prospect in ceramic industry.

# VEICHI

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