THE TWENTY-SECOND IEEE CEMENT INDUSTRY TECHNICAL CONFERENCE

May 19-22, 1980

As of spring 1980 the Cement Industry Committee is organized to include:

— Fifty-six members plus:

- Seven additional members serving on the West Coast Subcommittee.
- Members of the Local Committee for the 1980–83 Conference Committees.

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- Automation
- Drives and Related Products
- General Practices and Process Equipment
- Power Generation and Distribution
- Maintenance and Safety
- West Coast Subcommittee

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- Energy Committee of the IAS
- Mining Safety Standards Committee of the IAS Standards Department
- Safety Committee of the IAS Standards Department
- Standards Projects Committee of the IAS Standards Department

It is hoped that the technical papers presented at this Conference will assist in increasing the understanding and professional stature of all those who prepared them and read them. Gratitude is expressed to the many Cement Industry Committee members who have given countless hours in discharging their roles as Committee members and in support of the activities of the Institute (IEEE). Gratitude is also expressed to the many cement producers and to those who supply equipment and services to them, and to all who are in attendance for their participation in the activities of this Twenty-Second IEEE Cement Industry Technical Conference.

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DRIVES

ELECTRICAL AND MECHANICAL CONSIDERATIONS IN THE APPLICATION OF LARGE A.C. MOTOR DRIVES

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IEEE CEMENT INDUSTRY TECHNICAL CONFERENCE

AT

TORONTO, CANADA

MAY, 1980

CH1527-1/80/0000-0001$00.75

ELECTRICAL AND MECHANICAL CONSIDERATIONS

IN THE APPLICATION OF LARGE A.C. MOTOR DRIVES

SUMMARY

Large motor enclosures should be carefully selected in accordance with the specific environmental conditions present in each application.

The advances in anti-friction bearing design allow the use of anti-friction bearings in increasingly larger ratings with satisfactory life with minimum maintenance.

With everincreasing energy costs, it is essential that each motor drive be specifically designed for its driven load to obtain the highest possible efficiency at reasonable cost.

Variable speed drive systems must be carefully evaluated with respect to power factor and efficiency requirements to ensure maximum energy conservation.

ELECTRICAL AND MECHANICAL CONSIDERATIONS

IN THE APPLICATION OF LARGE A.C. MOTOR DRIVES

I. INTRODUCTION

Modern, energy and capital efficient pyroprocessing and raw grinding installations have produced a significant change in the size of major process equipment and their drives in new cement plants.

I.D. fan drives specifically, have increased to very large sizes from long kilns to modern suspension preheater or precalciner kiln systems. Raw grinding systems drives have also increased in size as large single grinding units, particularly roller mills, are gaining preference in new plants.[1] Kiln drives, however, have decreased in size, as a result of a growing trend towards suspension preheater and, more recently, precalciner systems,[2] incorporating substantially smaller compact kilns. Figure 1 shows the largest drives in three recently built plants with capacities ranging from 2,000 to 3,200 Mg/day. As suggested in this figure, with the only exception of finish grinding units, the main process I.D. fans are usually the largest drives in a modern cement plant.

Large drives for finish mills are commonly synchronous motors and kiln drives are DC motors. Both of these applications have been well covered in the past and will not be further examined here.

This paper outlines mechanical and electrical considerations related to the effect of environment, power supply conditions, need for efficient use of energy and other factors in the application of large AC drives in cement plants.

II AMBIENT DUST AND MOTOR ENCLOSURES

Ambient Dust

Dust is an unavoidable nuisance around a cement plant. In spite of the use of costly equipment to control dust, there are always accumulations near installations and equipment. Machinery operating in areas exposed to ambient dust, particularly clinker and cement dust, should be protected against its detrimental effects, namely, build-up, wear and in certain cases, chemical attack.

Clinker is basically a mixture of very hard fused silicates, and abrasion may result when particles of clinker impinge on equipment surfaces.

In relation to build-up, one obvious consideration is that cement and clinker dust form very hard crusts in the presence of moisture and heat. Moisture arises from condensation in warm humid areas that cool down during plant stoppages.

Ambient clinker or cement dust may also result in chemical corrosion of metallic surfaces, as the hydration of clinker compounds yield alkaline liquids.

Base metals like aluminum and zinc, react with these alkaline solutions, resulting in corrosion of the metallic surfaces. If chlorides are present in the clinker or cement particles (as it may happen), this may result in severe galvanic corrosion.[3]

Copper, in general, is not affected by these alkaline liquids as it is a less base metal.

Ambient Dust and Motor Enclosures

The potential problem related to dust is the effect it could have on the motor ventilation system. Figure 2 is a squirrel cage induction motor rotor and shows the ventilating ducts evenly spaced throughout the iron. Similar vents are also located in the stator iron.

If the motor is to operate within its design temperature, it is essential that these vents remain clear.

If open drip-proof motors are used in cement plant applications, dust will always be present inside the motor. If the atmosphere is humid the dust particles will be damp and as they impinge on the iron, which is at temperatures in excess of 100°C, they could adhere and eventually create a build-up in the vents, frequently blocking them completely.

This would disrupt the normal flow of cooling air, allowing the operating temperature of the motor to rise possibly beyond the temperature capability of the insulation system, precipitating premature insulation failure. Consideration should be given to the use of RTD elements, particularly where motors are critical to the process or are otherwise costly to replace. Early indication of an overtemperature condition allows a planned shutdown of the unit for service before a total failure results.

In some cases, the build-up may create rotor unbalance and excessive vibration which, if not corrected, could lead to bearing failure.

II AMBIENT DUST AND MOTOR ENCLOSURES (continued)

Weather Protected Enclosure (WPI, ODP)

If the ambient dust is not too severe and the atmosphere is relatively dry, then the hazard of condensation forming on electrical insulation may be minimal during shutdown periods. This problem can be overcome by the use of space heaters.

Therefore, if the environment is relatively dry and the motor is equipped with space heaters, ODP or WPI enclosures could give satisfactory operation, in areas relatively low in ambient dust.

Filter Ventilated Enclosure

If the area is extremely dirty, ODP or WPI enclosures would not give satisfactory service, and it would be necessary to use some form of filtered enclosure. This could be a simple top hat with filter or the more complex WPII enclosure with filter. The filter should be designed to reduce dust particles to less than 5-10 µm. The entry hoods should be designed to prevent high velocity intake of dust laden air.

It is most important that filters be cleaned regularly. Clogged air filters reduce air flow resulting in increased temperature rise, and possible insulation failure. Thus it is also important either to install stator RTD's to monitor motor temperature or to have a manometer device to check the pressure drop across the filter.

If the atmosphere is extremely dirty, coupled with high humidity, the maintenance of the filters could become costly and time-consuming. There are cases on record where the filters were considered a nuisance and were discarded and the resultant build-up inside the motor led to early failure.

II AMBIENT DUST AND MOTOR ENCLOSURES (continued)

Filter Ventilated Enclosure (continued)

If the time between filter changes or cleaning is considered unacceptable, then some form of totally enclosed motors must be used.

Totally Enclosed Fan Cooled Motor (TEFC)

In ratings below 746 kW (1000 HP), it is possibly more convenient to use the standard TEFC motor. However, in ratings above 373 kW (500 HP), these can be quite costly.

Totally Enclosed Air-to-Air Cooled Motor (TEAAC)

In ratings above 746 kW (1000 HP), conventional fan cooled motors are usually not available. Tube type units are available, but they have drawbacks in extremely dirty and humid atmospheres in that the tubes tend to become clogged requiring a regular cleaning program.

Totally Enclosed Water-Air Cooled Motor (TEWAC)

The totally enclosed water-air cooled motor has been available for sometime.[4] It is relatively maintenance free, requiring cooling water quantities of approximately 0.22 m^3/h per kW of motor loss and operating water pressure is usually limited to 345 kPa. The cost is considerably below TEFC or tube type units, and compares very favourably with the cost of a WPII filtered unit. Glycol-water solutions should be considered for colder climates. In this case, the coolant flow rate should be increased as the efficiency of cooling with Glycol solutions is lower than that of water alone.

III POWER SUPPLY CHARACTERISTICS

Often cement plants are located in or are planned for areas where power systems do not have high fault capacities. The proper selection of large drives under these conditions demands particular attention to power supply characteristics.

Pre-Start Voltage

A large drive, being started in a sequence of start-up, will be connected to a power supply having a voltage which can be below the nominal system voltage. This lower voltage can result from minimum utility voltage and/or preloading of the plant substation. This minimum prestart voltage must be determined in order that the consequent calculations of voltage conditions during acceleration of the drive are comprehensive.

Starting Voltage

The voltage at the terminals of a motor during its acceleration is a function of the prestart voltage, the motor locked rotor impedance and the impedance of the system. The starting voltage will be depressed with respect to the prestart voltage during the acceleration of the motor. Consequently, the motor torque being proportional to the square of the voltage may be significantly decreased. The motor must be designed with sufficient torque to accelerate the load without overheating. The depressed system voltage during the load acceleration must be satisfactory to loads already running and also to the supplying utility.

Therefore, the major drives must be analyzed to determine which drive will create the greatest voltage depression[6]. This motor will then have to be designed with the proper starting torque and locked rotor current which will allow acceleration within the limits set by the power system.

Power Factor Correction

The current trend to conserve energy and resources requires that efficiency in the use of power and materials must be improved. Designing to achieve unity power factor in new or existing plants is consistent with these requirements as it minimizes losses in lines, transformers and cable systems. The reduction of losses provides more kW handling capacity per construction dollar and reduces the operating cost per production unit. The realization of unity power factor in a cement plant can be achieved with static correction or synchronous machines. Large drives for finish mills are commonly synchronous motors and in some plants provide sufficient power factor correction under normal full operating conditions. However, in plants where clinker production is greater than cement production capability, there is a necessity for additional correction in the clinker manufacturing departments which often can be best met with synchronous motors. Similarly, in plants served by two power transformers, the outage of one transformer may necessitate cement production outage. Again, synchronous motors can maximize clinker production with one transformer in service.

IV MOTOR PERFORMANCE SPECIFICATIONS

Let us suppose that to meet the requirement of the power system and to successfully accelerate the load a particular motor must have a minimum starting torque of 150% and the locked rotor current must be no greater than 550%.

These two criteria should not become a standard for all other large motors in the plant. High starting torques and low inrush currents have a marked effect on motor efficiency and in view of the desirability of energy conservation, every possible step should be taken to obtain maximum efficiency for each rating.

It is important to recognize that if the system disturbance created by a 2240 kW (3000 HP) motor with 550% inrush is acceptable, then the disturbance created by a 1120 kW (1500 HP) motor with 750% inrush would be equally acceptable.

It is not necessarily recommended taht large motors should be designed with 750% inrush, but it is recommended that each motor be designed to suit the specific drive requirements and standard requirements for locked rotor torques and locked rotor amps should be avoided.

Figure 3 shows a number of designs for a 746 kW (1000 HP) motor which would be available at the same cost.

Motor design is always a compromise between various parameters. It will be noted that locked rotor torque and locked rotor current have a marked effect on motor efficiency.

Given the choice, most users would choose design 4 or 5. Yet design 1 would satisfy 95% of all the applications encountered in industry generally. Unfortunately, there seems to be a general belief that excess torque is good and high inrush currents are bad.