1990 IEEE Cement Industry Technical Conference XXXII

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Tarpon Springs, Florida — May 22-24, 1990

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THE THIRTY-SECOND IEEE CEMENT INDUSTRY TECHNICAL CONFERENCE

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FOREWORD

THE THIRTY-SECOND IEEE CEMENT INDUSTRY TECHNICAL CONFERENCE

May 22-24, 1990
INNISBROOK RESORT, TARPONS SPRINGS, FLORIDA, USA

Sponsored by
THE INDUSTRY APPLICATIONS SOCIETY'S
CEMENT INDUSTRY COMMITTEE
OF THE
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

The technical papers in this Conference Record have been prepared using guidelines from the "Author's Guide" of the Industry Applications Society (IAS) modified by the Cement Industry Committee. The IAS is comprised of twnety-eight Technical Committees including the Cement Industry Committee.

This year's Annual IEEE Cement Industry Technical Conference completes thirty-two years of such Conferences. This is the second time that Tarpon Springs has been selected as the site, the first being in 1979.

The papers included in this Record are written and are presented to comply with the scope for the Cement Industry Committee which has been established by the IEEE Industry Applications Society. In substance, this scope is:

"The development and application of electrical systems, apparatus, devices, and controls to the processes and equipment for which the emphases or dominant factors specifically relate to the cement manufacturing industry; the promotion of safe, reliable, and economic installations; the encouragement of energy conservation; and the creation of voluntary engineering standards and recommended practices."

The dedicated work by many Cement Industry Members supporting the activities of the Institute (IEEE) is appreciated. Thanks also to the many cement industry related firms & employees and others who attend this Thirty-Second IEEE Cement Industry Technical Conference.

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2nd	1960	5/17-19/60	Milwaukee, WI	W. A. Allan	V. B. Murdock	316
3rd	1961	4/18-20/61	Detroit, MI	J. F. Hower	L. E. Swanson	307
4th	1962	4/3-5/62	St. Louis, MO	J. F. Hower	J. B. Woodward	437
5th	1963	4/23-25/63	Cleveland, OH	R. J. Jager	G. E. MacDonald	304
6th	1964	4/14-17/64	Pasadena, CA	R. J. Jager	D. B. Carson	433
7th	1965	5/11-13/65	Allentown, PA	H. P. Cassel	C. A. Zimmerman	601
8th	1966	5/17-19/66	Denver, CO	H. P. Cassel	W. A. Walkling	436
9th	1967	5/16-19/67	Albany, NY	L. E. Swanson	J. R. Kelley, Jr.	479
10th	1968	5/20-24/68	St. Louis, MO	L. E. Swanson	A. C. Lordi	515
11th	1969	5/13-15/69	Toronto, Ontario	A. C. Lordi	J. A. Allan	501
12th	1970	5/12-14/70	Indianapolis, IN	A. C. Lordi	G. F. Messinger	453
13th	1971	5/10-13/71	Seattle, WA	J. A. Allan	F. J. Bauer	370
14th	1972	5/16-18/72	Detroit, MI	J. A. Allan	L. E. Swanson	464
15th	1973	4/30-5/3/73	Miami, FL	R. P. Kistler	L. W. Copple	503
16th	1974	5/13-16/74	Mexico City, Mexico	R. P. Kistler	R. J. Plass	676
17th	1975	5/5-8/75	Montreal, Quebec	F. J. Bauer	M. S. Jackson	583
18th	1976	5/17-20/76	Tucson, AZ	F. J. Bauer	J. A. Vidergar	587
19th	1977	5/16-19/77	Omaha, NE	R. C. White	F. E. Staples & R. F. Palmer	570
20th	1978	5/15-18/78	Roanoke, VA	R. C. White	K. C. Wiles	677
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23rd	1981	5/12-14/81	Lancaster, PA	L. L. Warner	N. W. Biege	841
24th	1982	5/24-26/82	Vancouver, BC	L. L. Warner	B. T. Price	595
25th	1983	5/22-27/83	San Antonio, TX	N. Roistacher	U. Alsguth	622
26th	1984	5/22-24/84	Anaheim, CA	N. Roistacher	J. A. Vidergar	563
27th	1985	5/20-22/85	New Orleans, LA	R. J. Krekel	L. C. Cockrell	595
28th	1986	5/19-22/86	Salt Lake City, UT	R. J. Krekel	R. W. Riegel	490
29th	1987	5/26-28/87	San Francisco, CA	R. F. Palmer	C. D. Maars	557
30th	1988	5/24-26/88	Quebec City, Quebec	R. F. Palmer	A. Morneau	560
31st	1989	5/15-17/89	Denver, CO	Ib Bentzen-Bilkvist	Ed Parker	546
32nd	1990	5/22-24/90	Tarpon Springs, FL	Ib Bentzen-Bilkvist	E.A. Buehler	
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SOLID STATE ENERGY SAVERS FOR MOTORS IN THE CEMENT INDUSTRY

by Walter J. Lukitsch, P.E.
Allen-Bradley Company, Milwaukee, WI

ABSTRACT

Energy saving is a topic which continues to draw interest of most readers. The deluge of articles and data dispersed in the mid 70's has subsided. These articles deal mainly with Solid State Energy Saving as a result of work done at NASA by Frank Nola. Now the purchase of Solid State Motor Controllers with energy saver features continues to grow. Also, on the increase is the usage power factor correction capacitors due to the trend of utilities to charge for poor power factors. In the cement industry, the question has been asked which method should be used? This may not be the proper question. The purpose of this paper is to review the Solid State energy savers and their applications. In addition, the proper application of energy savers with power factor correction capacitors will be discussed.

Solid State Energy Savers

Electric motors are used in many applications in the cement industry. From conveyors to crushers, fans to pumps, compressors to dust collectors. If this industry is typical of others, anywhere from 58-64% of all electricity used is consumed by the electric motor. This is one reason that the energy saver topic has focused around motors and controls.

Solid State energy savers first hit the headlines with the issuance of the NASA or nola power factor controller in the mid 70's. Articles written at that time taught this to be the answer to energy saving.

From original analog devices, Solid State Energy Savers have evolved into microprocessor based devices capable of initiating responses in a fraction of a sign wave. All of these devices work on one basic principle. That principle is the fact that when a motor is running unloaded or lightly loaded, the motor voltage can be reduced. This voltage reduction results in energy savings from reduced magnetic and resistive losses.

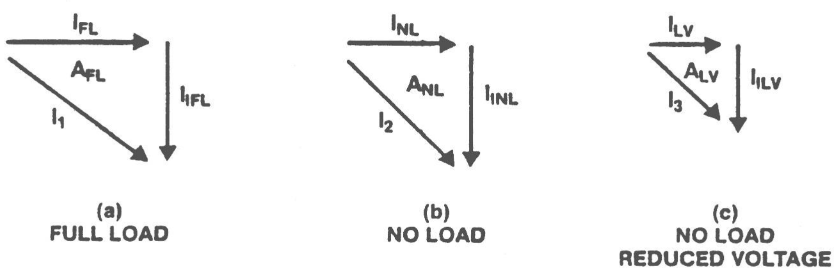
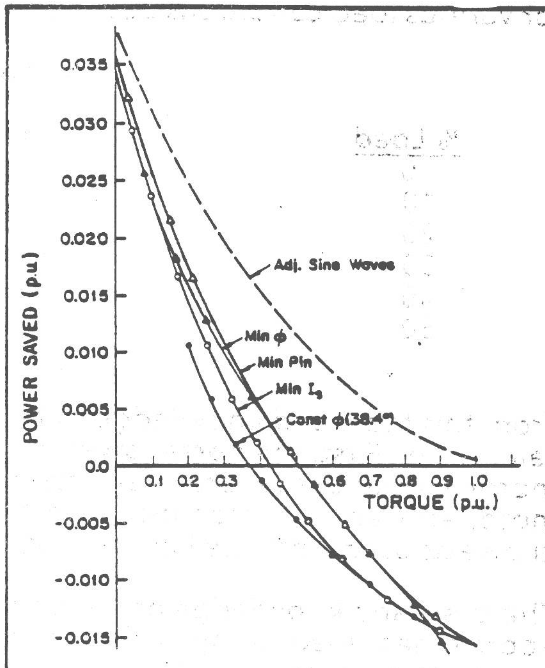


FIGURE !

Figure 1A through 1C show the various current phasors for different motor conditions. The fully loaded motor is shown in 1A while the unloaded without energy saver is shown in 1B. Figure 1C shows the result of reducing the voltage to the motor in the unloaded condition. In figure 1A and 1B the imaginary component is the same since full voltage is applied to the motor. In figure 1C the imaginary component is reduced and the real component is also reduced since the reduced current and magnetic flux results in lower resistive and magnetic losses.

The most effective way of saving energy would be to apply a pure sine wave at a reduced voltage. Figure 2 shows this as a optimum method of saving energy on a lightly loaded motor. The other methods from constant phase angle to minimum delay angle are less effective than the pure sine wave. However, they are practical to accomplish using thyristors to reduce the RMS voltage on the motor. The thyristor or SCR will not turn on until the signal is applied to the gate lead. When the signal is applied as the sine waves voltage goes positive, the thyristor will conduct a full half cycle and the output wave form will therefore look like a sine wave.

If the signal to turn on the SCR is delayed until after the input sine wave is positive a partial sine wave will be seen on the output. The result is a reduced RMS voltage applied to the motor. Typical voltage are current wave form are shown in figure 3. By the use of feedback such as current voltage and current zero crossing, the analog circuit or microprocessor can adjust the firing angle so that the voltage applied to the motor adjusts to compensate for the load changes.



Power Saved in Per Unit as a Function of Per Unit Load Torque for Ideal Sine Wave Controller and the SCR Controller with Four Practical Control Algorithms.

FIGURE 2

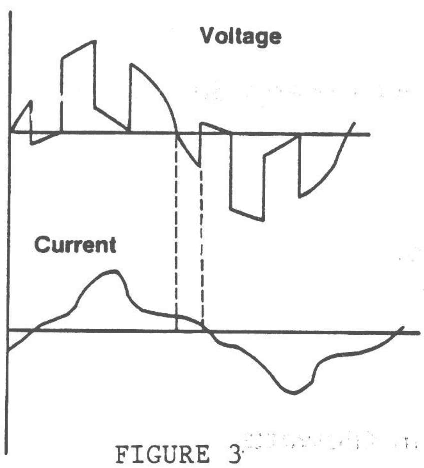


FIGURE 3
TYPICAL WAVEFORMS

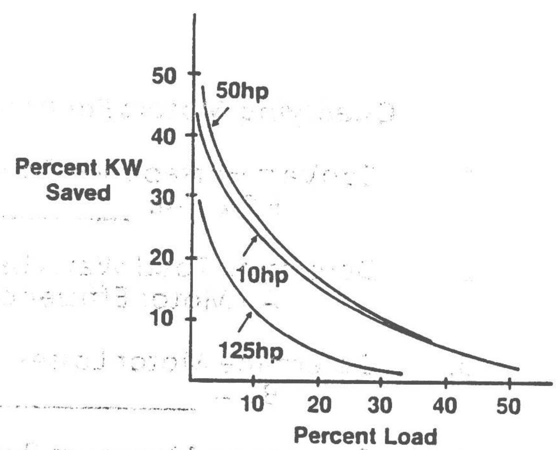


FIGURE 4
% SAVED VS % LOAD

When applying Solid State energy savers, the obvious question becomes how much energy and therefore dollars can be saved with their use. Much testing has been done is two types of savings which can be expected from these units. Figure 4 shows tests run on several motors. As with the theoretical savings shown on Figure 2 the savings approaches zero at loads between 30 and 50% of full load. Alternately, maximum savings occur at no load. If the range of savings at no load is 20-50% and no savings occurs between a range of 20 and 50%, a chart can be developed for various load conditions. Table 1 indicates a range of values which could be expected for various load conditions between no load and 50% load.

TABLE 1
Motor Loss Savings

% Load	Min. Savings	Max. Savings
0	20	50
10	10	35
20	0	20
30	—	15
40	—	5
50	—	0

From this table and knowledge of the application, energy savings can now be calculated. First, the horsepower must be converted to kilowatts. Knowing the motor efficiency the total watts can be determined by dividing the kilowatts by the motor efficiency. Motor losses can now be determined by subtracting the total kilowatts used from the kilowatt rating of the motor.

The chart and knowledge of the application must now be used. Knowing the approximate load rating, judgment must be made to determine whether the minimum percent savings or maximum percentage savings or some figure in between can be used to determine the potential savings. Once the potential savings is figured by multiplying the losses by the percent potential savings, the total kilowatts saved per year is then determined by multiplying the potential savings times the hours per year the motor is operated at that condition. Knowing the electrical rate the total savings per year is now determined by multiplying it times the kilowatts saved per year. Table 2 below summarizes this process.

TABLE 2
Qualifying Motors For Possible Application Of Energy Savers

1. ConVert Horsepower To Kilowatts
   HP x .746 ____________A.
2. Determine Total Watts Used By The Motor
   A - Motor Efficiency ____________B.
3. Determine Motor Losses
   B - A ____________C.
4. Calculation Maximum Potential Savings in Kilowatts
   C x 0.5 ____________D.
5. Determine Kilowatt-Hours Saved per Year
   D x Number of Hours Motor Operates At No Load
6. Determine Estimated Dollar Savings Per Year
   F x Cost Of Electricity Per Kilowatt - Hour ____________F.

Using a computer can simplify this method and even create multiple iterations for various conditions. Iterations are important if the motor can operate for lengths of time in various load levels. Table 3 shows the type of input which can be set up for the computer program and also shows the type of output which can be presented. This information can be printed to the screen, printer or another data file as also shown in Table 3

TABLE 3
Computer Input & Output Format
Input

Today's Date:

Name:

1. Motor Horsepower	=	100
2. Hours Run Per Day At Reduced Load	=	14
3. Days Per Week	=	6
4. Kilowatt Hour Cost In Cents	=	6.5
5. Estimated Percent Losses Saved	=	40
6. Efficiency	=	84

Output

Prepared 00-00-1990
By: XXXX XXXXXX

Horsepower	=	100
Kilowatt Hour Cost	=	$.065/KWHR
Estimated Efficiency	=	84%
Estimated Energy Savings Per Cent	=	40%
Estimated Savings Per Year	=	$1613.74

POWER FACTOR CAPACITORS

Power factor capacitors are widely used throughout the industry. When applied to individual motors, the capacitors rating are typically sized for the motor running at full load. Capacitor manufacturers provide recommended ratings that will improve the power factor. These individual motor capacitors are placed after the motor starter. Some users locate them in the control cabinet while others install them at the motor.

SOLID STATE ENERGY SAVERS AND POWER FACTOR CAPACITORS

Some applications may be upgraded to include Solid State Motor Controllers with energy saving feature. If these installations have power factor correction capacitors installed either at the motor terminals or after the existing contactor changes must be made.

The reason for this is that capacitors in the output circuit can damage thyristors. An uncharged capacitor is equivalent to a short circuit when a voltage is applied. These