Effective Electrical Maintenance and Trouble Free Operation in Pulp and Paper Mills

M. Ekambaram,

Dynaspede Integrated Systems (P) Ltd., S-505, Surya Kiran Complex, SD. Road, Secunderabad (A.P.)

ABSTRACT

Energy plays an important role in the development of the Pulp and Paper Industry. On average, energy costs represent between 15% and 25% of pulp and paper manufacturing costs. Pulp and Paper Mills are in a way mainly dependent on Electrical Drives for their Effective performance. In this paper, It is our effort to identify the Right drive technology for right applications, Comparison on performance levels of various forms drives. The effective maintenance strategies required to keep them performing without major break down, the adaptable advancements in their technology.

INTRODUCTION

The near-zero downtime requirements of around-the-clock production demand predictable, dependable motor/ system performance. To achieve this, clear understanding by the Electrical Managers of the basic characteristics of various forms of drives/ systems, there pros and cons related to applications, their ability to predict malfunctioning and ensure availability of spares in future etc. become important criteria for bringing out best performance from any drive/system employed. As any maintenance Manager will concur, that any system can keep on performing at highest level of order for ever, if the conditions match exactly the conditions prevailed in the previous minute from the time the system was commissioned successfully. In other words, it becomes mandatory for the Electrical manager in a Pulp and Paper Mill to ensure same condition to all the systems at all times, be it Electrical/ Electronics/ Mechanical/ Pneumatic/ Hydraulic/ Instrumentation without allowing the components to age. This is impossible. Hence a properly planned out selection of system and Preventive Maintenance Strategy in conjunction with introduction of state of Art Instrumentation become a bare minimum necessity in the severest conditions existing in Pulp and Paper Mills. The ideal situation would be selection of right form drive based on application driven implementation, backed by periodic planned out preventive maintenance and close back up service by manufacturers of equipments. In addition to above, implementation of self-analytical systems to better production, can bring about reduced breakdown time and increased MT BF. One more main aspect of field maintenance activity is identification of indigenous manufacturer of components for replacing foreign origin components. This plays a very important role as spares of indigenously manufactured systems will be available easily and troubleshooting becomes easy, as the technology has been built up indigenously.

The following may need to be addressed by Pulp and Paper Industry Electrical Managers before deciding upon right form of electrical drives or right method or maintaining them.

- Identification and freezing of application characteristics.
- Knowing the basic characteristics of various forms of electric drives and systems.
- Deciding on the level of accuracy required in any specific application.
- Identification most suitable Electrical Rotating machine based on evaluation of characteristics of type of drive matching the demands of application, evaluation of Energy efficiency, performance, life, reliability, ruggedness, MT BF, maintainability, flexibility of setting of parameters etc. factors of the drives. Expected life span of the drive technology should also be one prime factor for the selection.
- Adaptation of state of art instrumentation techniques to obtain better performance and increased life from old machines.
- Beware of new methods of energy saving measures, their advantages, and weaknesses.
- Appreciating the virtues of older forms of drives.

Pulp buildup can increase motor rewinds more than 85%

Pulp buildup on electric motors is the leading cause of early motor failure and reduced motor performance. Most pulp and paper mills indicate the motors see light to heavy coatings of pulp and more than 50% of air intakes blocked. Under these conditions motors can experience temperature loss of up to 30°C when operating at 75% of rated load. This translates into a increased frequency for motor rewinds in some cases by as much as 93%.

Pulp coating on the motor frame and pulp blocking of the airflow are believed to be the major contributors to motor overheating and more frequent motor rewinds. In 1983-84, the Savannah Mill of Union camp corp. initiated a study into the causes of failure of NEMA frame motors to determine the steps that might be taken to prevent these failures. In early 1985, a joint study by Union Camp Corp. and General Electric Co. was conducted to determine the effect on motor life of pulp covering the motor frame, including partial blockage of the air inlets. The term "motor life" as used here is defined as the time to the first failure (rewind). The study was limited to 460-V, 3-phase, 60-Hz, premium high efficiency, totally enclosed, fan cooled, ac induction motors in NEMA frame size 449-T and smaller.

Tests on motors covered with pulp

Three motors were dynamometer tested under six specific conditions. In each case, data were taken for 0%, 37.5%, 75% and 115% load, except when there were risks of overheating the bearings or insulation system. Table 1 summarizes results for loads of 75-100% as this is typical in the pulp and paper industry.

Effect of temperature on insulation life

For many insulation materials, when operated within the thermal limits, each 10°C rise in temperature reduces the insulation life by half. The data developed in these tests illustrates the importance of maintaining full inflow through the cooling fans and into the air intakes. The tests also demonstrated that even major oversizing of motors will not dramatically improve insulation life of motors operated under severely detrimental environmental (Tests D-F).

Effect of temperature on bearing life

These tests indicated that some premature bearing failure may actually be the result of pulp coating on the motor frame causing excessive bearing temperatures. The pulp coating, with accompanying decreased airflow, increased the bearing temperature rise by 28-43°C above ambient temperature for loads in the range of 75-100% of rated capacity.

Results of tests

The tests show that there is serious additional heating resulting from pulp contamination.

Test D: A motor with both a light coating of pulp and 50% of the air intake blocked, operating at 75-100% load, is likely to require rewinding 75% to 85% more frequently than a normal motor. Unfortunately, many of the motors in the pulp and paper industry operate within this range and fail within 2-4 years.

Test F is somewhat misleading because motors in this category typically have more than 50% of the air intake blocked, further reducing the insulation lifetime.

Solutions

These tests demonstrate the clear need for preventive measures to keep pulp off the motors and to protect the air intakes from blockage. A Motor Cover was designed to accomplish this with a simple design that relies on standard NEMA frame sizes. The Motor Cover keeps pulp off the cooling fans and air intake. The addition of frontal splashguards to the cover face further reduces blockage of air intakes.

Drive selection

- There is, as yet, no right drive for all applications.
- The Drive Selection is purely application based.
- Proper drive selection presupposes a deep study and proper understanding of the application.
- The best technology is an appropriate technology and not necessarily the latest.

Comparative study of predominant forms of drives:

The comparative study of various forms of drives presently being employed in pulp and paper mills is made in Table 2.

AC variable frequency drives

The following parameters are of great importance to bring out the best performance form of AC drives:

Table 1

Test	Test Condition		Percentage increase in number of rewinds
	Cooling fans	Air Intake	
A	Clean	0% Blockage	No effect (100% life) 18-25 vrs
B	Clean	50% Blockage	40%
C	Light pulp	0% Blockage	50%
D	Light pulp	50% Blockage	75% to 85%
E	Heavy pulp	0% Blockage	75% to 82%
F	Heavy pulp	50% Blockage	87% to 93%

Table 2 : Comparision of drives

Performance Criteria	Eddy current drive	DC drive	AC Frequency drive
Initial cost	Moderate	Relatively expensive	More expensive DC drive
Power to weight ratio	Poorest (bulky)	Bulkier than AC Drive	Excellent
Controllability	Good adequate for most applications, choice of both speed or trque control. But for 4 quadrant speed and tarque control eddy current tranmissions need to be employed	Excellent for speed control as well as traque controls, for 4 Quadrant speed and tarque control back to back due controlled bridge rectifier controls need to be employed	Excellent for speed Control for traque control vector drives are required for 4 Quadrant speed and tarque controls split type controlled Rectifier and inverter configuration needs to be employed.
Response time Speed holding ability against load fluctuations	Relatively slow? 200 ms 2% of top speed (normal) 1% with special controls	Fast response < 100 ms 2% with armature currnet feed back. 0.5% or better with speed Feedback	Fast response < 50 ms 1% normal 0.5% or better with feedback
Starting torque	High starting toruqe = pullout tarque of the motor used > 200% is standard.	100% rated torques as starting tarque the same can be improved by employing compound motor	Max. of upto 150% of rated tarque that too with only full Vector controls at all frequencies unless drive is derated at an additional cost.
Speed range	10:1	50:1 can be achieved Tarque ripple at low speeds is the limiting factor.	3:1 using standard motor, has to be derated for higher speed ranges.
Efficiency	Nearly 83% at top speed low at lower speeds	Excellent at all speeds when controller- motor combination is considered only marginally lower than AC frequency drives	Excellent overall efficiency however, depends on motor and transmission efficiencies
Power handling	Max. 200 watts through Electronic controller	100% of drive rating through electronic controller	100% of the Drive rating through electronic controller
Reliability Maintainability	Excellent Excellent	Moderate Poorest (Only the motor)	Good Relatively poorer to ECDs especially true for inverter grade AC induction motors.
Repairs	Infrequent; simple	Motor- most frequent among the three controller- infrequent	Infrequent; requires speed knowledge especially in case invertier grade motor rewinding
Cost of spares	Low, control unit is common for all ratings upto 75 HP	More expensive than ECDs but compardly lesser to vfds	Expensive
Noise immunity	Excellent totally immune to both conducted and radiated noise	Excellent, fairly immune to external noise	Special noise protection measures needed, specially on multi-motor applications and when operating on noisy lines
Tolerance to external disturbances	Extremely tolerant to supply voltage and frequency variations	Fairly tolerant to supply voltages and frequency variations.	Sensitive and will trip
Generated electromagnetic noise and harmonics	Near Zero, does not introduce harmonics hence does not require external filtering	High, requires filtering harmonics generated	High on both generated electro magnetic noise as well as harmonics. Requires external filtering

Limitation of location of motor with respect to controller	No limitations, motor and Coupling can be located at for off locations and still be effectively controlled by the controller	The motor can be located at for off locations as compared AC frequency drives	Due to reflected wove conditions, the controller needs to be located fairly doser to motor or very specid percoutions to be taken
Immunity to atmospheric conditons	Very tolerant, can perform well nearly in all conditons	Fairly tolerant but for present generation high density PCBs	Least tolerant due to highly dense component lay out conditions of the present generation drives.
Application based efficiency comparison	1) Const. Torque/HP - least efficient among the three 2) Centrifugd Characteristics- efficiency approches the actual figures of the other tow drives	1) Const. Torque/HP much better efficient than ECDs 2) Centrifugal Characteristics- efficient as good as AC dirve excepting for poor maintainablity of the motor	1) Const. Torque/HP most efficient among the three. 2) Centrifugal Characteristics- most efficient but actual energy saving as compared to other two forms of drive is only marginaly more.

- Optimized motor designs that match cooling capabilities to specific application requirements.
- Specialty design requirements such as Arctic-duty, high-altitude, high efficiency, or low-noise.
- Form wound or random insulation for low voltage (320-575 v) applications.
- Form wound insulation for medium voltage (2.3-6.6 kv) applications.
- Extensive speed range capabilities including vector drive control down to zero speed as well as extended operation above base speed into constant horsepower ranges.
- Sleeve or anti-friction bearings
- NEMA and IEC compliance.

Root causes or reflected wave conditions prevalent in AC drives and correctives actions:

AC drives with IGBT (Insulated Gate Bipolar Transistors) power semiconductors located at a distance from the motor have the potential of producing reflected waves. These waves can cause high voltage spikes at the motor's terminals, which can produce destructive conditions to the motor's insulation and result in motor failure. Awareness of the conditions, which can produce reflected waves and appropriate motor selection will ensure motor service life at the lowest cost possible.

Motor considerations

While the PWM motor waveform does provide motor performance advantages, it can also create voltages that can stress the motor insulation system and lead to motor damage. The chart (Fig. 1) shows the typical PWM output waveform from the drive at the drive output terminals. The waveform on the lower left chart shows the same waveform at the motor terminals. Notice that the reflected wave phenomenon has raised the peak voltage level of the waveform at the motor.

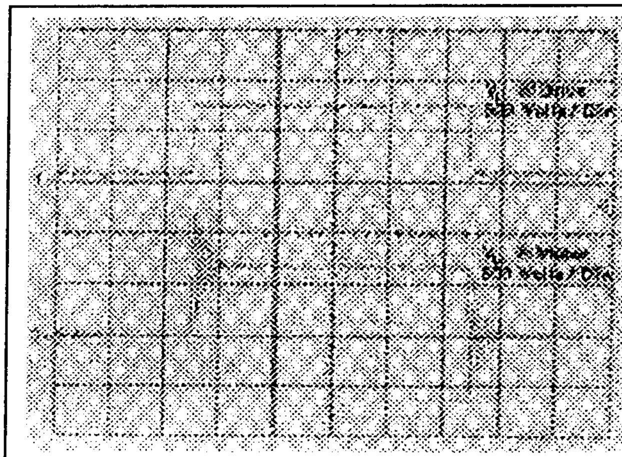

Fig. 1

Noise consider actions

The possibility of common mode noise requires particular attention during installation. Depending on the lead length between the drive and motor, a common mode choke may be required at the drive output to prevent noise from interfering with drive operation. The choke reduces high frequency current to ground. Conducted ground currents can find their way into CNC, PLC and computer grounds creating noise problems with these devices. One solution is to provide shielded insulated power leads to the motor. Faster rise times (dv/df) and higher carrier frequencies can also produce increased radiated noise from the drive. Wireless drive designs and effective ground planes within the drive minimize problems involving RFI (Radio frequency interference)

The evolution of IGBT drives

Most of today's drives are using the latest generation I GBTs that offer the advantages for drive design that has been previously discussed. These drives also present the possibility that the output waveform at the motor can have peak amplitudes two to three times the DC bus voltage. As a result, these voltages can potentially stress and damage the insulation system in some of today's motor. As IGBT bdsed AC drives continue to evolve, the insulation systems for the motors that are used with them have also been evolving. There have been advances in materials, manufacturing processes, and in insulations systems.

Dynamometers and loading devices

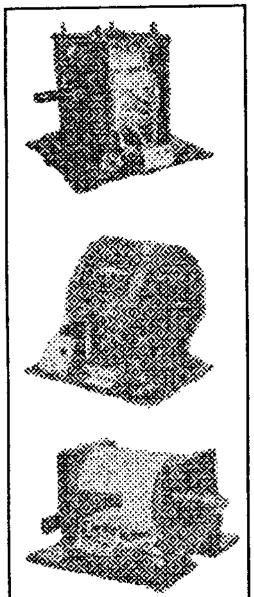

Fig. 2

Eddy current forms of dynamometers (Fig. 2) are in a wide range of power up tic 350 kW in air-cooded or water cooled models. Options indude swinging arm type with in-built torque sensors in foot/flange mounting versions and variety of control options. Low inertia-to power ratio of these forms of electronically controlled loading devices make them suitable for dynamic study under varying time-load profiles.

Pneumatic dynamometers for applications demanding medium power absorption at low to medium speed ranges with torque stability right down to zero speed. These dynamometers are self-ventilated types, needing no special external cooling arrangements. Pneumatic dynamometers lend themselves for easy and automatic control of load torque from remote locations by direct torque sensing and feedback control through suitable electro-Pneumatic converters.

Powder Dynamometers for artificial loading of small motors under varying speeds are available right down to zero speed (stalling conditions). They operate on the principle of magnetic particle braking under the influence of a magnetic field, controlled through associated electronic exciter unit. They are particularly useful for loading various forms of prime movers or actuators at low power levels. Air-cooled and water cooled models are offered to cover a wide range of power. These forms of dynamometers being unsuitable for vertical mounting are offered strictly in base mounted constructions.

Hybrid dynamometers: Also known as tandem dynamometers are combinations of any two forms of dynamometers described above. A judicious selection and sizing of units provide a combination with extended speed and power ranges as needed for load testing of hydraulic motors, servo motors etc. Gradual and bump less changeover is ensured by a PLC or PC based control system tailored for individual applications.

AC dynamometers- A combination of an AC motor operating with a integrally mounted magnetic partide torque valve forming on AC regenerative loading arrangement. The breaking torque is precisely set and controlled. The regenerated power is made use of to power other auxiliary driving motors in the system.

Torque units

Foursquare form of load testing of power transmission components demands precise setting and dynamic control of torque within a mechanically synchronous loop. Dynaspede offers proprietary loading devices for such specialized applications. Dynaspede Torquers are tailored solutions, for such applications. This consists of a heliplanetary form of transmission with an electronically controlled torque source at its input.

The following factors have to be considered very carefully while rewinding of any inverter grade motor for getting performance as near to any newly manufactured inverter Grade Motor.

Magnet wire

Slot insulation

Coil head insulation

Insulating resin

Assembly techniques

Assembly techniques

How the insulation system is assembled together and processed can greatly affect its final quality. An insulation system is more that the sum of its parts because of these manufacturing techniques. The winding design can improve an insulation system by keeping conductors with a high difference in electrical potential as far apart from each other as physically possible. In addition, the process by which resin is applied can greatly affect insulation performance. Some resins are applied by a dipping process and then the windings are baked to help the material flow throughout the entire winding. Other windings have the resin flowing over the start or before it is baked. Another method is a VPI or vacuum pressure impregnation. This method forces the resin into the windings to increase the thickness of the coating by eliminating voids. Many of these processes can be performed multiple times to improve the system as well as variable-speed applications changes and AC drives continue to evolve, motor insulation systems are also changing. When early PWM modulation designs caused expensive motor heating, greater thermal endurance was added to AC motors by using higher classes of insulation materials. With concerns about high dielectric stresses caused by the current generation of IGBT based AC drives, efforts have been focused on better: phase insulation, resins, magnet wire and manufacturing techniques to help eliminate the possibility of motor failures.

Testing of rewound motors for their performance

After the process of rewinding of any motor, it also becomes matter of top priority to ascertain torquetransmitting capabilities of the rewound motor at the rated speed. In other words it is necessary to ascertain the speed-torque characteristics of any rewound motor before retrofitting the same in to the application. For this purpose Torque loading devices and motor test benches are available in various capacities. This infrastructure of testing the motors especially rewound one will help in repeated breakdown of motors thereby saving production down time. This aspect of testing also helps in power factor measurement of a rewound motor under loaded condition prior to retrofitting. Few of the Torque-speed measuring devices are illustrated below.

Modern techniques of electric/electronic system maintenance management

1) The identification of point of problem in any present generation Digital systems has becomes very simple due to the Self-Analytical nature and software driven trouble-shooting procedures introduced in this system. This is one of the features, which reduces break down time of any system driven equipment, has lead to their maximum popularity among the users. This in addition to the systems flexibility to programme the application profiles suiting to load characteristics has garnered tremendous support among the actual users.
2) The advances in the instrumentation especially high accuracy sensor have also made online corrective action possible and easy, without having to depend upon manual intervention. These units help in continuously monitoring parameters such as draw, tension, pressure, flow, temperature, CD tension profile, thickness measurements etc. and continuous corrections for deviations ultimately result in better productivity as well as reduced break down of equipment components.
3) The advances made in the Electrical to Pneumatic converters also have helped in revitalizing the Pneumatic actuators such as brakes, Cylinders, air motors etc. that can be controlled with precision through digital techniques.
4) In addition to the above the present day application of computers in data collection of failure frequencies, nature of failures etc. and statistical analysis of these failure have led to better understanding of working of equipments as well as better planning of proper preventive maintenance schedule for the plant and machinery.

Case studies

1) In one of the premier mills, in the utilities section, small component costing Rs. 200/- each was failing very often and they had to replace the same 150 times over a period of 6 months. With ingenuity they had realized the additional and spare capabilities available in the digested system that was controlling this section, brought about software changes and additions in movement logic thereby avoiding any more breakdown of such small and article components.
2) In another application the non-reversible power transmission nature of a mechanical transmission was exploited to reduce break downs that was resulting in high losses in production and to the equipment.

Advancements in instrumentation

Tension sensing load cells

High accuracy class strain gauge based load cell type tension transducers are available indigenously manufactured in the country for felt, wire and paper tension measurements. These are of various ratings suiting to paper machine requirements as well as Secondary Converting machine requirements. Load cells from 20kgs to 3000 Kgs ratings are available in self-mounting as well as Under Pillow Block mounting versions. This high accuracy class highly liner load cells in conjunction with interfacing electronics generate 0-10 Vdc or 4-20 mA signals proportional to actual tension measured. The signals can be tarred and spaonned to suit to application requirement. These electronic output signals can be interfaced to DCS existing in the pulp and paper mills and numerous control features can be achieved. These load cells are basically site calibrated, based on standard known weights and periodically calibrate able by the users (Fig. 3).

Electronic torque measuring systems for AC induction motors

TrimTorq (Fig. 4) is a low cost electronic torque sensor for indirect electronic computation and monitoring of torque delivered by ac motors. This form of torque sensing admirably meets many applications where reliability, repeatability and cost often outweighs the need to monitor the absolute value or accuracy of torque measurement. Same models can be used for motors from fractional through integral horsepower range. Standard features include pre-settable under load and

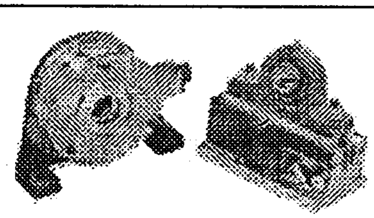
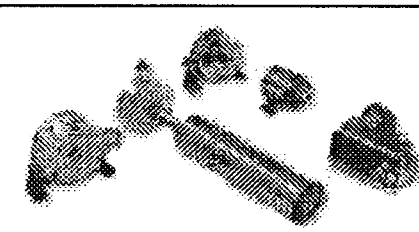

Fig. 3

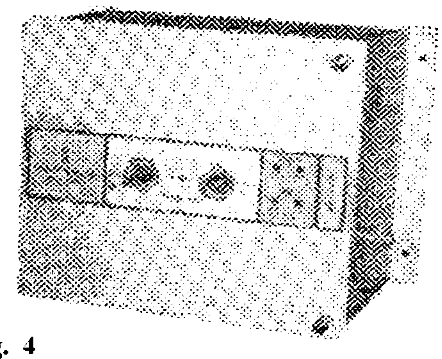

Fig. 4

overload limits with potential-free contacts for controlling auxiliaries or providing interlocks. We deal for retrofitting on machines driven by fixed speed ac motors. to monitor machine loading or to provide protection against overloading.

PLC driven solutions for customized applications

Custom-built PLC based control configurations are available suiting to numerous maintenance and breakdown related problems.

Speed sensors

Indigenously available in High/Low resolution, Linear/ Nonlinear, AC Sinusoidal/ DC, Single phase/ Poly phase speed sensors to suit to variety of requirements can be adopted for measurement of machine speed/draw etc.

Static eliminating solutions

In the dry section of paper making static electricity poses big problem. Active as well as passive static elimination devices reduce this problem of static electricity thereby avoiding untoward accident. These devices also cater to the wide length requirements of paper mills very effectively.

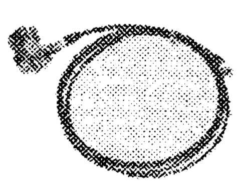

Fig. 5

Accelerometers

For shock and vibration measurement, Piezoelectric accelerometers, based on indigenously developed NPL technology, are among the latest introductions to dynaspede's family of transducers, offered for all strategic segments of industry, defense and aviation. In an all stainless steel construction with a Hex base of 18 mm, total height of 23 mm and a mass of 40 gms, these transducers are guaranteed for a measurement range of 20 Hz to 8000 Hz for vibration and shock below 2000g (Fig. 5).

Pneumatic brakes and unwind tension control systems

The advances made in the Pneumatic Disc Brakes technology (Fig. 6) combined with that in electro pneumatic converters make it possible to control system on the unwind side of sheeters/ cutter machines. They

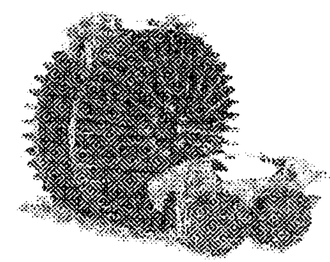

Fig. 6

offer high thermal capacity coupled with "tosiie to board" sensitivity. The original develop-ment of the dual disc, multiple-range air-cooled brake virtually eliminated the need for water cooling and effectively put an end to traditional "piggy-back" products. The major design criteria in the development of this series were that each size in the series should have the capacity of the next larger size in the earlier Series.

The advent of Electro-Pneumatic converters also made it possible to apply PLC based radius computations based Multi Channel Automatic Tension Control systems to control the breaking torque exerted by these state of art Pneumatic Brakes especially needed for precision Sheeters/ Cutters at their Unwinds.

CONCLUSION

We have tried in this paper to elaborate the basic characteristics and comparative study of electrical systems predominantly employed in the pulp and paper mills, the possible few root causes of repeated failures, the corrective actions that are required/ carried out in such instances and tried to identify few of the technical advancements that can be adopted to pulp and paper segment for the betterment of productivity. Once we are sure on the fundamentals of technology, the effective and successful maintenance is totally dependent on ability to improvise corrective techniques by the technical personnel, standing up to demanding situations.

ACKNOWLEDGEMENT

We are thankful to the organizers of this seminar for having given us the opportunity to address this forum.

REFERENCES

1. Information collated by way of market survey, Interaction with various Paper mills and site experiences by M/s Dynaspede Integrated systems (P) Ltd.
2. Published articles by Rockwell Automation- Reliance Electric.
3. R.P. Derrick, W.J. Martiny, and W.J. McDonald, An article summarized and reprinted from may 1987 Tappi J. article.
4. 4 Published articles by various other leading motor and drive manufacturers.