Thyristor Converters For Paper Machine Drives

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1. Introduction :

In the field of Paper Machine drives, the DC motor continues to hold a dominating position. Its control methods have, however, changed considerably over the years. Crude rheostatic adjustments have given way to refined automatic regulators giving a very high order of control accuracy. Emergence of power semiconductor devices such as thyristors has changed the engineering concepts regarding converting AC power into controlled DC power.

Ward-Leonard sets, transductors and mercury arc converters have been replaced by thyristos converter equipment going upto hundreds of horse power. Thyristor converters are superior because of their excellent control response, high degree of efficiency and reliability, minimal maintenance requirement due to absence of any moving parts, low weight and space requirements, etc.

Thyristor converters for use with paper machines have been available in the Western Countries for about a decade. It is a welcome development that manufacture of Thyristor Converter equipment has commenced in India recently. The ratings of thyristor converters at present available in India are limited mainly by the current and peak inverse voltage ratings of indigenously manufactured thyristor, cells for which a maximum rating of 320 Amps. Average 1200 Volts PIV is available, resulting into a single converter rating of about 500/600 HP. Such an arrangement envisages use of upto 4 thyristors in parallel per bridge arm since using a higher number will make the problem of simultaneous firing more difficult.

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2. Regulating Systems :

The last few years have seen many advances in regulating system design. This has been due partly to improved transistors making it possible to build industrial operational amplifiers, which have a high gain and low drift and partly to the demand for greater accuracies and faster responses. Further the techniques used in analogue computers have led to the use of standardized amplifiers and grouping of circuit computers in modular forms in such a way that many different control functions can be obtained from a standard range of modules.

Many regulating systsms control more than one variable, among the most common being those which control both the speed of a machine and the maximum value of its armature current. The primary function of such a system is to control speed but if the current becomes excessive, a subsidiary system over-rides the main control to limit the current.

3. Modular Construction :

The modular unit comprises the power complement consisting of one or two thyristor bridges with associated fuses and reactors, gate control circuits, amplifiers and other auxiliaries needed for closed loop control. This electronic equipment is supplemented with the necessary switchgear, protective and supervisory elements.

In most control circuits it will be found that a number of standard circuits (such as firing circuits in conjunction with thyristors as also the amplifiers and power supplies in conjunction with mixing circuits) are used in combination to provide the gain characteristic and general performance required by the system. Because a number of basic control functions are repeated in different systems, it has been possible to design standard units which can be used to provide the desired functions in a wide variety of systems. The high gain operational amplifier is the device which most obviously becomes a standard unit, while limit feedback and ramp features are also items which can be treated in this way. Further a single unit, provided it is made sufficiently versatile, can be used for most mixing circuits and associated functions.

The main cost of producing a control system is in the designing,

drawing and general specification of new units. The electronic components used in the units are mass produced and so are cheap, and assembly costs are also low provided the units are produced in reasonable quantities. By adopting a standard modular construction, system design time is reduced and costs lowered correspondingly. In addition, specially designed systems based on the available modules can be produced without incurring high initial costs.

By standardizing two dimensions on all units, viz. height and depth, a modular construction can be used, and a common mounting and connecting arrangement adopted. For ease of maintenance circuits are arranged on plug in type printed circuit modules.

Varying circuit complexities and volume of components are accommodated by different module widths. Mechanical coding arrangements are normally used so that a module cannot be harmed, or cause damage, by being plugged into the wrong position. All adjustments can be made from the front without any of the modules having to be withdrawn. Such standard modules can be built up into a very wide variety of systems.

Test sockets are provided on each module and wandering leads can be connected to meters mounted or a monitoring module so that test readings can be made at various points in the system. To assist in commissioning or fault finding a test module can also be provided to feed signals into various parts of the system, while extension boards enable readings to be taken at points not covered by the test sockets. A safety circuit connection on each module ensures that all the modules are properly in place and that test switches are in the "run" position before the drive can be started.

4. Basic Types of Converters

Electrically the converters are basically divided into two areas corresponding the modes of DC drive operation.

4.1. Single—quadrant drive for unidirectional drives requiring motoring torques only.

These units have a single ended or one way converter which is either semi controlled consisting of a hybrid thyristor diode bridge or a fully controlled bridge consisting of thyristors only.

In India the price of thyristors being much higher than the diodes of equivalent rating, a semi controlled bridge offers a much more economical proposition than a fully controlled bridge. The fully controlled bridge offers the advantage of lower reactive power demand when operating on partial output settings, and lesser effect on power system voltage distortion. It is, therefore, used with larger HP ratings while the semi-controlled bridge is found adequate for smaller ratings.

4.2. Multi-quadrant drive for reversing drives requiring motoring as well as regenerative braking torques.

This comprises two fully controlled thyristor bridges connected inversely parallel with each other. Only one of the two bridges is operating at any one instant. They permit contactless reversal of armature current and consequently the torque of the drive. The control circuit in this case is more complex than in single quadrant application since in addition to its analogue function of ocntrolling the conduction angle of the bridge, it has to perform a logic function of inhibiting or enabling one of the bridges to conduct depending on the direction of torque desired.

5. Protection Equipment

Adequate protection is necessary to thyristor converters for reliable operation.

5.1. Protection against excessive rate of rise of voltage (dv/dt) and current (di/dt). These are provided by use of RC surge suppression networks and reactors respectively.

5.2. Short Circuit Protection
Thyristor grade rectifier fuses used in the bridge arms provide this protection.

5.3. Over current Protection–Current Limit.

The control circuit incorporates such limits in the closed loop design. If the current drawn by the load tends to increase beyond the limit, the control circuit so retards the firing pulses as to reduce the converter output voltage suffi-

ciently to keep the output current within the set limit.

Besides the above, conventional thermal overload relays are provided. Instantaneous overload relays can be also provided where called for.

5.4. Field Loss relay.

A current sensing type field loss relay is provided to prevent run away condition of the drive motor in case of loss of field.

6. Supplementary Equipment

In many applications, process oriented requirements are imposed on the drive. These are most easily fulfilled if a number of standard modules, supplementary to the basic units, are available. Some of these are mentioned below—

6.1. Motorised reference Potentiometer.

Such a unit is required in cases where it is necessary to be able to set the operating parameters. such as the drive speed, from a remote place by means of push button operation.

6.2. Acceleration-Deceleration Control

By using a solid state ramp unit on the input side of the speed controller, an independent control of acceleration and deceleration rates is achieved.

6.3. Field weakening control

Often higher speeds at reduced torques are required from DC drives (e. g. centre driven winders). This can best be achieved by weakening the motor field.

The field weakening control unit consists of a thyristor bridge feeding the motor field and being controlled by a supplementary control loop of the main control circuit which ensures an automatic reduction of field current when the armature voltage reaches a preset value.

6.4. Draw Control—Individual or Progressive

This is an important facility required by most paper machine drives. Individual draw control will adjust the speed of only the concerned section while the progressive draw control will proportionately adjust the speeds of all the subsequent down stream sections.

7. Conclusions:

Universal use of thyristor converters for paper machine drives has now been made feasible by the commencement of indigenous manufacture of this equipment. Main advantages of using thyristor converters in place of conventional equipments can be summarized as follows—

a/– Faster dynamic response, superior operating accuracies and controlability.

b/– Very low maintenance costs due to entirely static equipment coupled with low 'down time' in case of faults due to modular approach to equipment design.

c/– Lower operating costs due to higher working efficiencies even at low operating levels.

d/– Lower erection and installation costs due to absence of heavy foundations (as required for Ward–Leonard sets) and low space requirement.

Larsen & Toubro Limited are now in a position to offer thyristor converters for various drives required by the paper industry. Such equipment is manufactured at their Powai Works, Bombay–72, utilizing all indigenous components and hardware. The equipment is backed up by an expert team of systems designers with intimate knowledge of paper industry application know-how. Maintenance and spares problem is minimised by modular construction comprising standard modules which are readily available.