Thyristor Controlled Variable Speed DC Motor Drive Systems

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The fundamental requirement of close control of overall speed of a continuous production unit is a vital factor affecting the quality of the finished product. Though various forms of speed control methods like Commutator motor, Eddy current coupling, open loop Rectifier panels, ward leonard system etc. are available, there has been an increasing demand for close loop Thyristor Controlled Variable Speed DC motor Drive systems. The Thyristor Controlled Drive Systems are the most modern form of speed control devices and have several advantages over other conventional speed as enumerated above. A comparative study of the various forms of speed control methods has been shown in Table I attached.

Thyristor Controlled Variable Speed DC motor Drive systems are basically divided into (a) Constant Torque speed drives and (b) constant Horsepower Drives. A combination of both systems can also be designed to meet specific applications.

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1. Constant Torque Drives

The system consists of a DC Shunt Wound motor and a Thyristor Convertor in a closed loop configuration. The DC Shunt Wound motor is powered by a variable voltage DC souree from a Thyristor Converter. The field of the DC motor is separately excited by a Diode Bridge Rectifier connected from within the equipment.

The system of control incorporates thyristors in the power control amplifiers which offer the maximum in reliability coupled with high efficiency, extremely fast response and minimum physical size in control equipment.

The system features :—

(a) AUTOMATIC SPEED REGULATION by a Speed Regulator Circuit.

The required control of motor speed is obtained by a closed loop feedback system in which a voltage signal proportional to the motor speed derived from either the Back EMF of the DC motor or a Tachogenerator mounted at the non drive end of the DC moter is fed back and compared with a highly stabilised reference voltage. The error is amplified and integrated to control the firing angles of the Thyristors in such a way as to minimise speed error.

Back EMF feedback systems give speed regulation of less than 2.5% while with Tachogenerator feedback less than 1% regulation can be achieved.

(b) AUTOMATIC CURRENT REGULATION by a Current Regulator Circuit.

A voltage signal proportional to the motor armature current is used as a current feedback signal. This signal is compared with the output of the speed regulator and the error is amplified and integrated to control the firing angle of the Thyristors in such a way as to continously control the armature current to within a prespecified adjustable current limit.

(c) VARIABLE PHASE ANGLE FIRING over full range by Firing Circuit.

A complete solid state firing circuit is provided to turn on Thyristors at appropriate phase angles, magnetically coupled with the thyristor gates for necessary isolation.

(d) AC TO DC CONVERSION with controlled output powers

by Thyristor/Diode Stack. A Thyristor/Diode Bridge is provided with necessary line chokes and RC Snubbers for dv/dt and di/dt protection to convert input AC power to output DC power with phase angle controlled by the firing circuit.

The Thyristor Bridge used could either be a Single phase Half controlled Bridge, single phase fully controlled, Three phase half controlled or Three phase Fully controlled. Generally for ratings upto 5 HP a single phase half controlled Bridge is used, and for ratings above, either a Three phase half controlled or three phase fully controlled depending on application.

(e) OTHER FEATURES of Electronic Control System

1. Stepless control of speed.
2. Range of Speed Variation from near zero to full rated speed. (The Thyristor Convertor will be capable of providing stepless speed control between 0 to full rated speed at constant torque. However, the lower limit for continuous duty speed variation will depend on design characteristics and cooling arrangement for the DC motors.)
3. Automatic overload protection for motor.
4. Soft Start Circuits to ensure that Thyristors are not accidentally fired during initial switching transients.
5. Controlled Acceleration to

TABLE–1
Comparative Study of Adjustable Speed Drives

Characteristics	Motor Generator Set	Thyristorised Drive	Eddy current Coupling	Autotransformer Rectifier Control
Application :				
Constant Torque	Yes	Yes	Yes	Yes
Constant H.P.	Yes	Yes	No	No
Variable Torque Ratings	Yes	Yes	Yes	Yes
Power Range(H.P.)	1–500	1/8–1–500 and above	1/8–200	¼–1–200
Speed Range	8:1	20:1	10:1	10:1
Speed Regulation	0–1 to 5%	.1 to 2.5%	1–5%	2–5%
Starting Torque	Full	Full	Fuller reducer	Full
System Performance:				
Multi-Motor Drive System	Yes	Yes	No	Yes
Winder/Unwinder System	Yes	Yes	No	No
Feed back Type:				
Field Control	Yes	Yes	No	Yes
Armature Control	Yes	Yes	No	Yes
Arm/Field Control	Yes	Yes	DC Excitation Wdg. Control	Yes
Speed Control :				
Remote	Yes	Yes	Yes	Yes
Rreset Run	Yes	Yes	Yes	Yes
Soft Start	Yes	Yes	Yes	Not Satisfactory
Timed Acceleration	Yes	Yes	Yes	Not Satisfactory
Reversing	Yes	Yes	No	Yes
Inching	Yes	Yes	Yes	Yes
Regenerative Braking	Yes	Yes	Yes	Yes
Dyanamic Braking	Yes	Yes	No	Yes
Efficiency :				
Drive Effiiciency at full speed	Good (70%appx.)	Best (98% appx.)	Fair	Fair
at low speed	Fair	Best	Poor	Poor
Overall efficiency	Good	Best	Fair	Fair
Maintenance :				
Drive Wear & Tear	Yes	No	Yes	Yes
Maintenance	Yes	Negligable	Easy	Easy
Drive Enclosure :				
Drip Proof	Yes	Yes	Yes	Yes
Totally enclosed	Yes	Yes	No	Yes
Explosion Proof	Yes	Yes	No	Yes
Mounting Space	Largest	Moderate	Larger	Large
Price	Highest	Moderate	Low	High

provide gradual acceleration of the motor speed even if the speed setting is changed abruptly.

6 'Electronic current limit to limit the value of maximum armature current in the circuit.

Various forms of protections are normally incorpoated in the Drives to protect the DC motor as well as the Thyristor.These include Quick acting fuses to protect the Thyristors, Thermal and Magnetic overload relays, Single phasing preventer, Field failure relay, interlocking relays, over current trip, adjustable current limit etc. Special customer interlocks can also be provided.

The optional features in these types of Drives would include Reversing, Inching at adjustable low speed, crawling at adjustable low speed, Dynamic braking under 'Normal Stop' or 'Emergency Stop' conditions, Regenerative Braking permitting controlled deceleration etc.

2. **Constant Horse Power Drives**

In Constant Torque Drive, the field of the DC motor is excited by Rectifier equipment giving a constant voltage. For constant Horse Power applications, Thyristor Convertor is introduced to power the field of the DC motor in addition to the Thyristor Convertor in the armature circuit. A Constant Tension setting potentiometer acts as the Reference and this is compared with the armature current feedback and the error amplified and integrated to contact the firing angles of the field convertor to keep the armature current constant.

By keeping the armature voltage and armature constant, the power is kept constant.

3. **Multimeter Drive Systems :**

Thyristor Controlled DC Motor Drive system can be used in line processes as Sectional Drive System, where a number of DC Shunt Wound motors are used to drive the individual sections of a line process machine. In such cases, each DC motor is powered by its own separate Thyristor Convertor, the Reference being derived from a common highly stable master source. Each motor convertor combination forms a closed loop system and the outputs of individual speed feedback signal are compared with the master reference voltage. Each section therefore is compared with a standard reference, which can be adjusted to obtain overall speed adjustment of the drive. Individual section adjuststment is achieved by means of the section speed control potentiometer which adjusts the individual section speeds against the master control reference. The Draw Control potentiometer provided for individual sections can be used to introduce specific speed differentials between adjacent motors in the line.

A combination of constant torque drives and constant Horse Power Drives can be incorporated in multimeter Sectional Drive systems to suit various application.

System Design :

The effectiveness of the variable speed drive system is measured in terms of the satisfactory overall performance of the system and the quality of the finished product. Thyristor Controlled Variable Speed DC motor Drive systems can be specially designed to meet the existing demands of various processes and industries.