INTERNATIONAL JOURNAL FOR TRENDS IN ENGINEERING & TECHNOLOGY,
VOLUME 3 ISSUE 2 – FEBRUARY 2015 – ISSN: 2349 – 9303

Flow Control Using Variable Frequency Drive In Water Treatment Process of Deinked Pulp Plant

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Abstract— Water scarcity is a major problem in the current scenario, so consumption of water should be reduced in industries. The pulp and paper(P&P) industry is one of the heaviest users of water. Water is used in nearly every step of the manufacturing process. To control the consumption of large amounts of fresh water in industries, water treatment process is important. This project is done at Tamilnadu Newsprint and Papers Limited, Karur under the area of deinked pulp plant and the process of water treatment. In water treatment process chemical dosage flow added should be correct according to the inlet flow. In our project Variable Frequency Drive is used instead of control valve. According to the inlet flow induction motor speed is controlled by using VFD, then chemical dosage flow, is controlled. The method of speed control used here is vector control. In this process by using VFD, leakage of chemicals is minimised and the precise control of chemical dosage flow is improved.

Index Terms— Flow control, Variable Frequency Drive, Vector Control, Water Treatment.

1 INTRODUCTION

IN water treatment process chemicals are added to the feed flow of water. Dosage of individually selected chemicals is done in proportion to the incoming feed flow. In the input element of the microflotation basin the feed flow is distributed evenly throughout the basin width, and then the dispersion water is added. Dispersion water is fraction prepared from clarified water and air-saturated in the pressurized dispersion vessel..

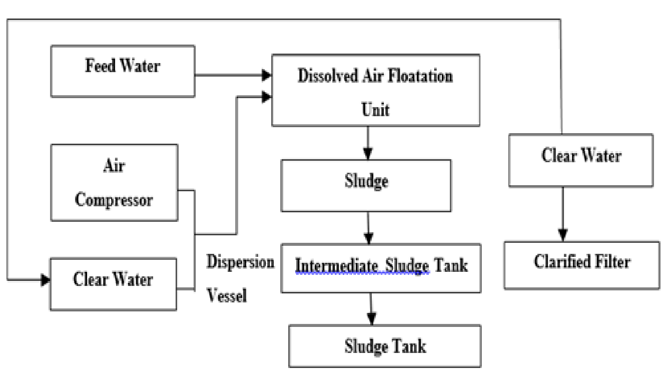

Fig. 1. Block Diagram of Water Treatment Process

Microbubbles are the separating force of the process, collecting, like adhesive, solid particles from the water and forming surface sludge. This process is called “microfloatation”. The dispersion water amount is typically 15 – 25 % of the feed volume. Sludge forming on the surface is removed with two sludge rollers and taken to the sludge compartment, then depending on the surrounding process, removed as free flow, or using a pump. The heavy particles settling to the bottom of the basin from the bottom sludge. This bottom sludge is removed few times per day with bottom sludge scraper, conveyor and pump. The optimal interval for bottom sludge removal is established at start-up of equipment. The clarified water is removed from the basin as free flow, or using a pump. The water level in the flotation basin is controlled by the control system, consisting of level measurement and control valve at the outlet pipe. In this project instead of control valve VFD is used to control the chemical dosage flow by controlling the speed of induction motor. Vector control is the most suitable method of speed control in an induction motor.

2 MAIN PARTS AND FUNCTION OF THE EQUIPMENT IN WATER TREATMENT PROCESS

2.1 Coagulation Tank

When inorganic coagulant is used for max purification, the equipment should be equipped with separate coagulation tanks. The water flow needs 3 – 5 min delay before the actual flotation basin. Depending on construction, the coagulation tank has 1 or 2 blade agitators.

2.2 Floatation Basin

In the forepart of the actual flotation section, dispersion water made from clarified water is added to the feed flow. The mixture of feed water and dispersion water is led over the guide plate to the flotation section where solid particles attach to the bubbles. Bubble-solids agglomerates rise up to the water surface, forming sludge layer.

2.3 Sludge Removal Systems

Surface sludge is removed with two sludge rollers [8]. Roller 1 slows down the flow on the basin surface and compresses sludge between the sludge rollers. Roller 2 having rubber blades scrapes off the sludge to the sludge compartment. The rotation speed of the rollers is adjustable individually. The sludge goes to the next stage of the process, applying gravity or pump. When a pump is used, it is controlled with sludge compartment level measurement. Bottom sludge is removed a few times a day with removal system. It can be mixed with surface sludge, or be rejected separately. If surface sludge is returned to the process, as raw material or return sludge, separate treatment of bottom sludge is recommended.

When the pause time for bottom sludge removal has expired, bottom sludge scraper starts. Scraper operating time can be set. The scraper scrapes the bottom of the flotation basin, compressing this sludge into the bottom sludge channel in the forepart of the basin. When the scraper stops, the conveyor starts to move the collected sludge to the bottom sludge box and to the pump, which has started at the same time as the conveyor. The operating time of the combined conveyor-pump can be set.

2.4 Dispersion Water system

Part of clarified water is pumped to a dispersion tank with centrifugal pump. Pressurized air is added to the dispersion tank. The water is pumped through the dispersion nozzle, which forms droplets resulting maximal air dissolving.Dispersion tank water level is approx. 45 – 50 %, providing sufficient time for air to dissolve. From the tank, the dispersion water flows to the manifold, to be evenly distributed in the flotation basin. The typical dispersion water amount is 15 – 25 % of the feed flow and is automatically controlled.Dispersion tank level is controlled with a control valve before dispersion water manifold. Optimal dispersion pressure (normally between 4 – 6 bar) is set at start-up of equipment.

2.5 Pumps

2.5.1 Dispersion Water Pump

For dispersion water, the standard centrifugal pump is used. The head is set to 75 m, flow at max 25 % of the feed flow.

2.5 2. Sludge Pump

Due to air content in the sludge, eccentric screw pump is recommended.size of surface sludge pump is dimensioned according to the amount and consistency of sludge.

3 EXISTING METHOD

In the existing method control valve is used to control the chemical flow according to the inlet flow of water. But this existing method has some disadvantages which include leakage of chemicals, control valve maintenance, minimum life time of control valve. Apart from this, in the water treatment process the usage of control valve leads to leakage of chemicals which decreases the economical growth of the industry. Thus the usage of the control valve in water treatment process is considered to be not suitable.

4 PROPOSED METHOD

The main objective of this project is to control the chemical dosage flow according to the inlet flow of water, to get efficient outlet clarified water. There are many problems arose in the existing method by using of control valves. To avoid the leakage of chemicals in this project Variable Frequency Drive is proposed to control the chemical flow according to the inlet flow of water thereby improving the efficiency of the outlet water.

4.1 Flow Control using VFD

A VFD can be used to control both the speed and torque of a standard induction AC electric motor [7]. It varies both the frequency and amperes of the AC waveform being delivered to the motor saving money in electricity.It has energy saving mechanism and low motor starting current [3].

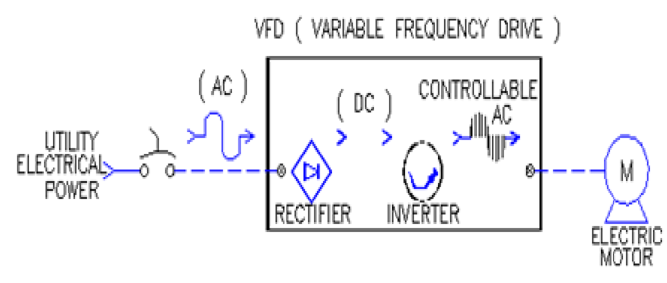

Fig. 2. Block Diagram of Variable Frequency Drive

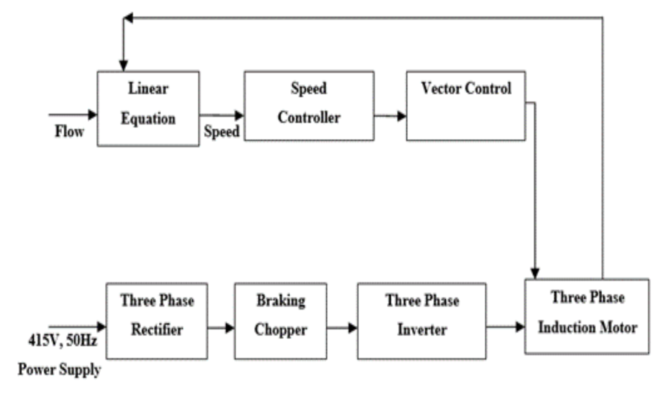

Fig. 3. Block Diagram of Proposed Method

4.2 Rectifier

The rectifier is used to convert the AC into DC power. The first stage of an AC frequency converter is the conversion of a 3-phase AC power supply to a smooth DC voltage and current. Simple bi-stable devices, such as the diode and thyristor, can effectively be used for this purpose.

4.3 Inverter

The Insulated Gate Bipolar Transistor (IGBT) is an attempt to unite the best features of the bipolar junction transistor and the MOSFET technologies [1]. The construction of the IGBT is similar to a MOSFET with an additional layer to provide conductivity modulation, which is the reason for the low conduction voltage of the power BJT

4.4 Vector Control of an AC Induction Machines

The technique of vector control has only become possible as a result of the large strides made in solid-state electronics, both with microprocessors and power electronics. It has been promoted as an AC drive equivalent to DC drives and claimed to be suitable for even the most demanding drive applications and this is where the confusion arises. The efficiency of fans delivering air for combustion is low and the introduction of flow (air volume) control by Variable Frequency Drive (VFD) instead of conventional dampers will increase efficiency and save approximately 30 percent of energy used by constant speed motors [6].Vector controlled induction motor (IM) drives are wide spread electromechanical conversion systems for high-dynamic performance applications [4].

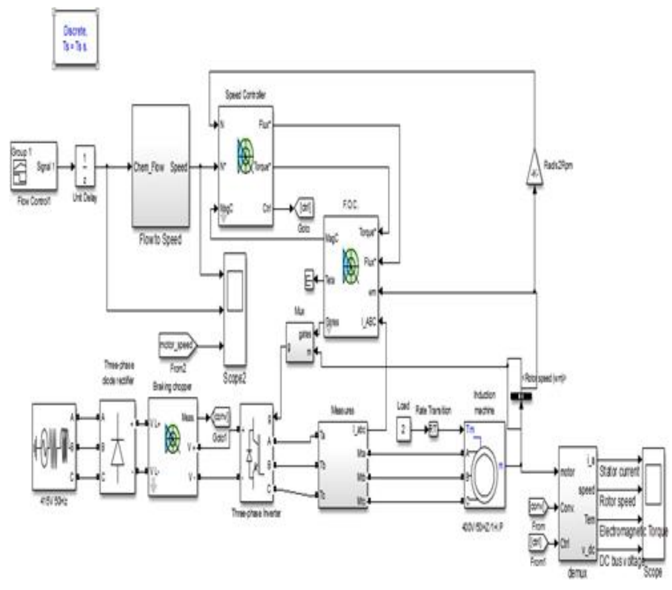

Fig. 4. Simulink Block of Vector Control

Vector control (or field oriented control) offers more precise control of Ac motors compared to scalar control. They are therefore used in high performance drives where oscillations in air gap flux

linkages are intolerable, e.g. robotic actuators, centrifuges, servos, etc.Vector control is the most popular control technique of AC induction motors. In special reference frames, the expression for the electromagnetic torque of the smooth-air-gap machine is similar to the expression for the torque of the separately excited DC machine [2].In the case of induction machines, the control is usually performed in the reference frame (d-q) attached to the rotor flux space vector. That's why the implementation of vector control requires information on the modulus and the space angle (position) of the rotor flux space vector. The stator currents of the induction machine are separated into flux- and torque-producing components by utilizing transformation to the d-q coordinate system, whose direct axis (d) is aligned with the rotor flux space vector. That means that the q-axis component of the rotor flux space vector is always zero.

4.5 Steps For Vector Control

The Vector control steps are followed by,

1. Measure the motor quantities (phase voltages and currents)
2. Transform them to the 2-phase system (α,β) using a Clarkess transformation
3. Calculate the rotor flux space vector magnitude and position angle
4. Transform stator currents to the d-q co-ordinate system using a Park transformation
5. The stator current torque - (I_{sq}) and flux- (I_{sd}) producing components are separately controlled
6. The output stator voltage space vector is calculated using the decoupling block
7. An inverse park transformation transforms the stator voltage space vector back from the d-q coordinate system to the 2-phase system fixed with the stator Using the space vector modulation, the output 3-phase voltage is generated

4.6 Space Vector Definition and Projection

The three-phase voltages, currents and fluxes of AC-motors can be analyzed in terms of complex space vectors, With regard to the currents [5]. The space vector can be defined as follows: Assuming that i_a, i_b, i_c are the instantaneous currents in the stator phases. Then the complex stator current vector i_s is defined by the spatial operators. The following diagram shows the stator current complex space vector,

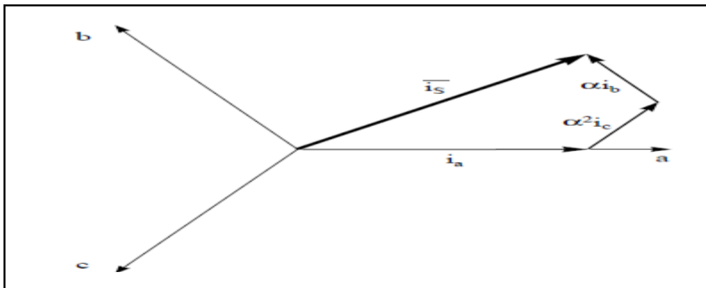

Fig. 5. Stator Current Space Vector and its Component in (a,b,c)

Where (a,b,c) are the three phase system axes. This current space vector depicts the three phase sinusoidal system. It still needs to be transformed into a two time invariant Co-ordinate system. This transformation can be split into two steps

1. (a,b,c) =>(α,β) (the Clarke transformation) which outputs a two co-ordinate time variant system
2. (α,β) =>(d,q) (the Park transformation) which outputs a two co- ordinate time invariant system

5 RESULT ND DISCUSSION

The following specification of an induction motor is used in this project

Power=1e3
Voltage=415v
Frequency=50Hz
Stator resistance=14.85e-3
Stator inductance=0.3027e-3
Rotor resistance=9.295e-3

Rotor inductance=0.3027e-3
Mutual inductance=10.46e-3

According to the inlet flow of water the variable frequency drive speed was adjusted thereby varying the chemical flow.i.e for the inlet flow of 8510 lph , the speed is expected as 485rpm and for the inlet flow is 8514lph the expected speed is 488 rpm.

TABLE I

DATA BASE FOR FLOW OF WATER VS SPEED OF THE DRIVE

Inlet flow(lph)	**Speed**(rpm)
8510	485
8514	488
8518	491
8523	494
8527	497
8533	500
8539	503
8544	508
8549	510
8553	512
8558	518
8562	520
8567	523
8571	525

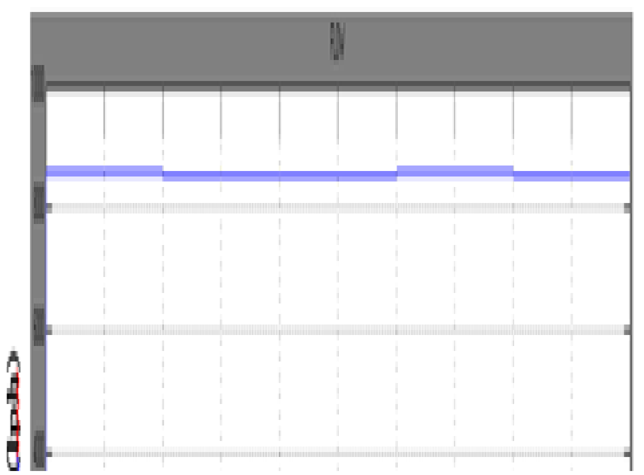

Figure 7 shows the result for an inlet flow water 8544lph and corresponding speed of the drive is 508 rpm.This speed along with the speed of the induction motor is given as inputs to the speed controller.The speed controller uses vector control method and produces the speed as 508 rpm.

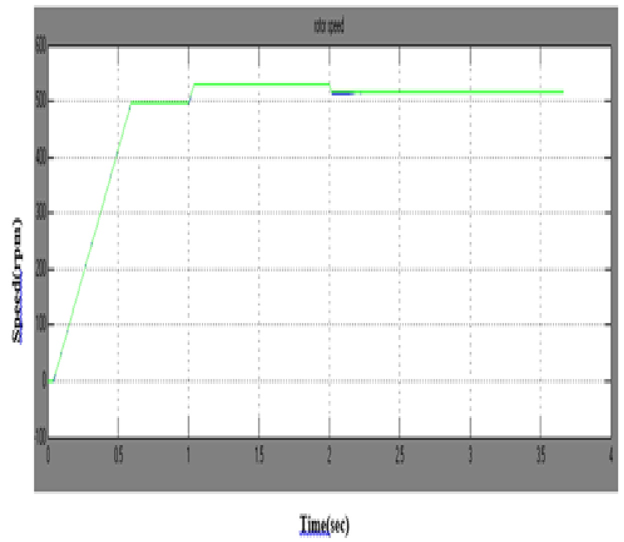

Fig. 7. Rotor Speed of an Induction Motor at 508 rpm

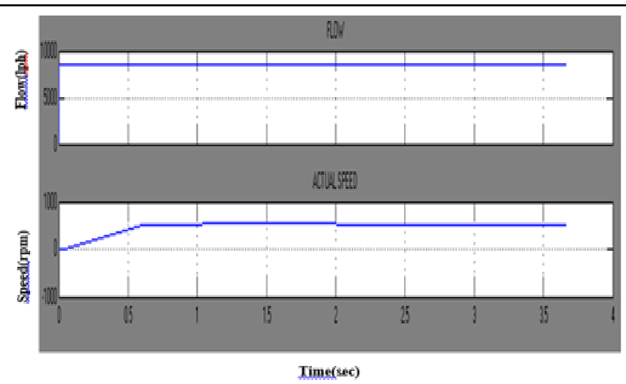

Fig .8. Inlet Flow of Water 8549lph and Expected Speed

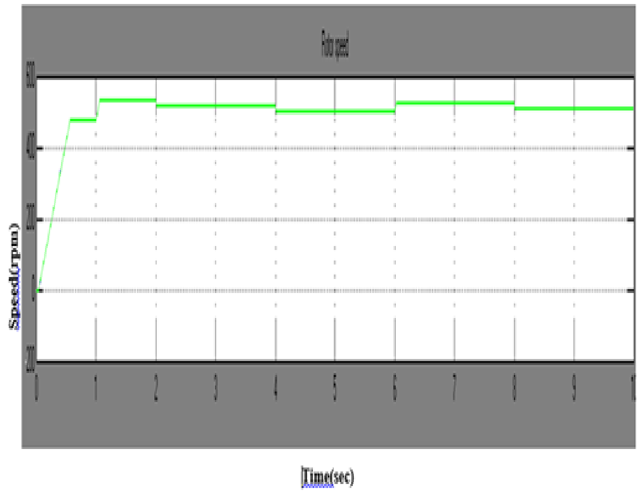

Fig. 9. Rotor Speed of an Induction Motor at 510 rpm

Figure 9 shows the result for an inlet flow of water 8549lph and the corresponding speed of the drive is 510rpm. This speed along with the speed of the induction motor is given as inputs to the speed controller. The speed controller uses vector control method and produces the speed as 510 rpm

6 CONCLUSION

The flow control using a variable frequency drive is more efficient than control valve because the precise control of chemical flow is possible and variable frequency drive has the energy saving mechanism. Hence it can be used to control the chemical flow precisely. The speed control of induction motor is achieved by a vector control method which gives the suitable speed adjustment

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