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Study of Cable Manufacturing Industry with Special Reference to Ravicab Cables Private Limited at Bidadi, Ramanagara District, Karnataka, India

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***Abstract* – In this paper, cable manufacturing industry (Ravicab cables private limited) at Bidadi is considered for study. This cable industry is using three phase induction motor for its various operations. Mostly, mixing and pushing machine, take up machine, capstan machine and cable drawing machines are in the need of three phase induction motor. In order to control these three phase induction motors, speed controller is essential. Therefore in this study, overall operation of the cable industry, speed controller used in this industry and its defects are discussed. Especially in this industry, Potentiometer (Pot) operated PID (Proportional Derivative Integral) controller based speed controller is used. While using this type of PID based speed controller in the disturbance environment, performance of the speed controller is severely affected.Peformance deterioration of this PID based speed controller is delineated when voltage fluctuation is considered as disturbance environment and also for sudden load changes.**
***Keywords:* Bidadi, Pot, PID, capstan machine, voltage sag, voltage swell**

I. INTRODUCTION

Three phase induction motor plays a vital role for controlling the various operations in the cable manufacturing industry. Mostly this induction motors are operated under imbalance voltages [1].Moreover the use of energy efficient motors in a plant is low[3],[11].Thus an overview of the efficiencies of present-day induction motors are stated[4],[15].Standard applies to squirrel cage induction motors for various industrial applications are discussed [2],[5],[6].Besides study of different factors earlier to make the selection is needed[7].Alternative approach of speed estimation from transient to steady state is required[8],[14].At the same time sensorless induction motor control for industry applications is need to be emphasized [9],[10].Need of vector controlled induction motor drive is emerged [12],[13].Thus this study deals about the overall operation of the cable industry in the beginning. Then application of various horse power three phase induction motors used in this industry are discussed along with its speed controllers. Moreover demerits of the conventional PID based speed controller are emphasized. Instead of using conventional PID based controller, robust speed controller is suggested as a future work of this paper. In order to identify robust controller for the three phase induction motor various adaptive controller (i.e. Fuzzy logic controller, Neural network controller and Neuro-fuzzy controller) is to be used. Since every adaptive controller which is mentioned above has its own advantages, this study suggests that to interface the each adaptive controller individually with the induction motor. After interfacing each adaptive controller individually, performance based comparison chart will be made. In the comparison chart for various reference speeds, actual speed of the induction motor with respect to each speed controller is measured. Moreover Voltage fluctuation (i.e. Voltage sag and voltage swell) based disturbance environment and sudden changes in the load will also be formed in the closed loop control. Then it is easy to identify the suitable robust controller for the three phase induction motor based on its disturbance and load handling.

II. CABLE MANUFACTURING INDUSTRY OPERATION

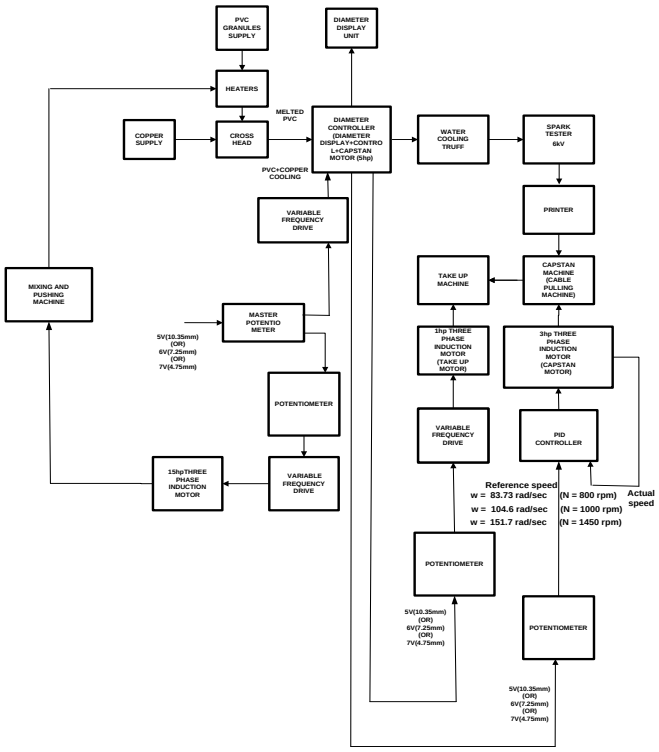

Fig. 1 Block diagram of cable manufacturing industry operation

Block diagram of cable manufacturing industry operation is shown in fig (1).It comprises various blocks.
The blocks are namely,

1. Extruder
2. Diameter controller
3. Capstan controller
   a. Capstan machine
   b. Three phase induction motor
   c. Potentiometer (Pot) operated PID based speed controller for 3hp capstan motor
4. Take up controller
   a. Take up machine
   b. Three phase induction motor (1hp take up motor)

All individual blocks will put together form the cable manufacturing process. Operation of this cable industry is delineated in the following.

A. Extruder

In the extruder, there are four blocks. The blocks are namely copper as input, cross head, PVC granules, heaters, mixing and pushing machine. PVC granules production normally refers to the manufacture of PVC resin. Three types of PVC manufacture exist: suspension polymerisation, emulsion polymerisation and bulk polymerisation. PVC made from suspension is the most common.

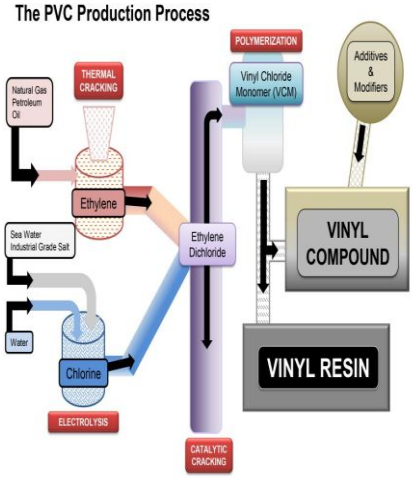

Fig. 2 Block diagram of PVC production

Block diagram of PVC production is shown in fig (2).Sea water and water is given as input to the chlorine. This process is called as electrolysis. On the other side, natural gas is given as input for the ethylene. This process is known as thermal cracking. Then, ethylene and chlorine is given as input to the catalytic cracking unit. From this catalytic cracking unit, ethylene dichloride is taken and given to the vinyl chloride for polymerization. After polymerization, vinyl resin is formed by using vinyl compound and additives. This is how PVC granules are produced. These PVC granules are given as input to the heater. Heater used here is working based on electric coils. These coils are energized by electric supply. Cross head is one of the major blocks of the extruder. This cross head is used to mix the copper and PVC granules which is passed via heater block. Finally, melted PVC is taken as output from the cross head. This melted PVC is given to the diameter controller unit. Heater is controlled by mixing and pushing machine. This machine is used to mix and push the PVC granules with the copper input. A 15hp three phase induction motor is involved for operating this mixing and pushing machine. This motor is controlled by using master pot. This master pot is controlled by the general pot which is commonly giving signals to the diameter controller and 15hp three phase induction motor. This pot is manually operated pot. Based on the requirement of the product, this pot is operated. For example, cable diameter is 4.75mm.Then 7V is applied to the diameter controller. In case, cable diameter is 7.25mm.Then pot produces 6V for achieving this diameter. The speed controller used here is olden day's pot with PID. It doesn't have sophisticated controller such as fuzzy, Neural network, Neuro-fuzzy controller [14], [15]. This PID based speed controller is severely affected from voltage imbalances as well as sudden changes in load.

B. Diameter controller

Diameter controller is connected with various blocks. The blocks are namely water cooling truff, spark tester, printer and capstan unit. Diameter controller is having the capability of controlling the diameter value. The diameter value can be varied based on the input voltage which arrives as input to the diameter controller. Input voltage of the diameter controller is decided by the pot. Diameter controller unit is also having the capstan motor which has the separate speed controller unit. Diameter can be displayed with the help of diameter display unit which is associated with the diameter controller. Water cooling truff is connected in series with the diameter controller unit. This water cooling truff is used here to cool the cable as well as copper core which is placed inside the cable. Spark tester is connected after the water cooling truff block. This spark tester is able to produce 6KV.This spark is used for testing the cable capability under high voltage [11], [13].Then, printer is used to print the name of the cable manufacturing company, diameter value of the cable and colour of the cable.

C. Capstan controller

Capstan controller comprises of the following blocks:

1. Capstan machine (or) cable pulling machine: Capstan machine is connected in series with the printer. It is used for pulling the cable which comes from the printer.Capastan machine is operated by 3hp three phase induction motor.

2. Three phase induction motor: A 3hp three phase induction motor which is used to run the capstan machine. This motor is a squirrel cage type induction motor [3], [4]. This motor speed is controlled by Pot operated PID based speed controller.

Three phase 3hp induction motor is used here as a capstan motor for the cable pulling. This motor is able to run at

various speeds such as ω=83.73 rad/sec (N=800 rpm), ω =104.6 rad/sec (N=1000 rpm), ω=151.7 rad/sec (N=1450 rpm).Even though three different speeds are available, only one speed is selected at a moment based on the requirement of the diameter of the cable [10] [12]. If the cable diameter is 4.75mm, then speed of the motor is ω=151.7 rad/sec (N=1450 rpm).In case cable diameter is 7.25mm, then speed of the induction motor is reduced from ω=151.7 rad/sec (N=1450 rpm) to ω=104.6 rad/sec (N=1000 rpm).Suppose cable diameter is 10.35mm, then speed of the induction motor is reduced from ω=104.6 rad/sec (N=1000 rpm) to ω =83.73 rad/sec (N=800 rpm).Besides low torque of the motor is needed for high speed of the motor which is used to pull low diameter (4.75mm) cable. On the other hand high torque of the motor is needed for low speed of the motor which is used to pull high diameter (10.35mm) cable. Therefore motor speed depends on the diameter of the cable. Moreover the role of speed controller for induction motor in cable industry is essential [9].

3. Potentiometer (Pot) operated PID based speed controller for 3hp capstan motor: Pot operated PID controller based speed controller is shown in fig. (3). This PID Speed controller used here is controlled by pot. This pot is manually set by the human by seeing the diameter of the cable which is going to be pulled by the 3hp capstan motor.

Fig. 3 Pot operated PID based speed controller

This kind of Pot operated PID based speed controller speed controller is olden day's controller because it is operated by pot setting [1], [2].

TABLE I PROPORTIONAL INTEGRAL DERIVATIVE SPEED CONTROLLER FOR 3HP CAPSTAN MOTOR

Proportional gain (K_p)	26
Integral gain(K_i)	39
Derivative gain(K_d)	0.09

PID controller block parameters are shown in table-1.This PID controller is working as speed controller for the 3hp three phase induction motor (capstan motor). In this closed loop control, proportional gain (K_p) is 26, integral gain (K_i) is 39 and derivative gain (K_d) is 0.09.These PID gain values are obtained from VFD (Variable frequency drive) which is used in cable industry.

Equation of the PID controller is of the following form,

$$u(t)=K_p e(t)+K_i\int e(t)dt+K_d(de/dt) \quad (1)$$

Where, K_p = Proportional gain

K_i = Integral gain

K_d = Derivative gain

e(t) = Error between actual speed and reference speed

u(t) = Control signal

Moreover, this PID based speed controller is severely affected by the disturbance signals such as voltage sag, voltage swell and load variation. Moreover voltage sag refers to sudden voltage drop in the AC three phase supply which affects the induction motor.Volatge swell refers to sudden voltage rise in the AC three phase supply which affects the induction motor. Load variation refers to load which is applied on the three phase induction motor shaft. This load on the shaft varies when diameter of the cable varies [6], [8]. Therefore based on this study, it is found that it is better to replace this Pot operated PID based speed controller by placing fuzzy controller in the outset. Then replace this fuzzy controller by Neural network controller and Neuro-fuzzy controller. Finally attach the robust controller for this 3hp three phase induction motor out of these three controllers. (i.e.Fuzzy logic controller, Neural network controller, Neuro-fuzzy controller).Moreover, it is also recommended that while designing the controller for this 3hp three phase induction motor (capstan motor), disturbance environment such as load variation in terms of load torque in newton metre, voltage sag and voltage swell signals should be included[5],[7].Similarly for other 1hp, 5hp,15hp motor PID controller can be replaced by robust controller.

D. Take up controller

Take up controller comprises of the following blocks.

1. Take up machine:

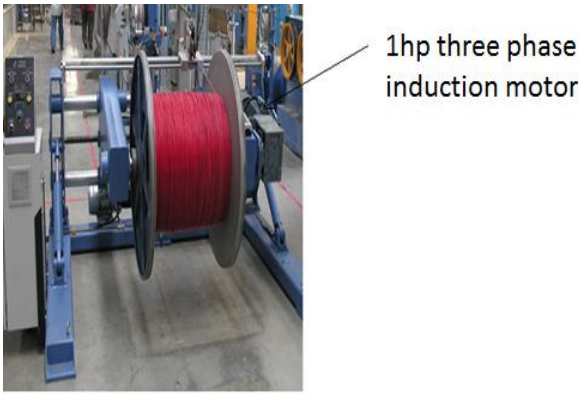

Fig. 4 Pictorial representation of take up machine with PVC layer

Pictorial representation of take up machine with PVC layer is shown in fig. (4). In this there is a bobbin. This bobbin is used to take up the cable which is used for commercial purpose.

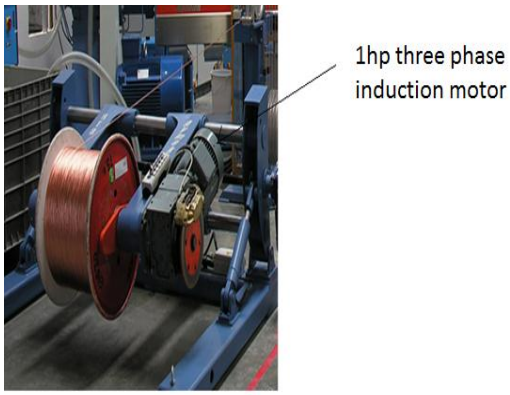

Fig. 5 Pictorial representation of take up machine without PVC layer

Pictorial representation of take up machine without PVC layer is shown in fig (5). In this machine, without PVC layer bare copper is taking up to the bobbin. This bobbin size can be selected based on the diameter of cable which is in terms of millimeters.

2. Three phase induction motor (1hp take up motor): 1hp three phase induction motor is used as a taker up motor. This motor comes after the capstan motor to roll the cable in the bobbin .

III. CABLE DRAWING PROCESS

This cable drawing process comprises of the various blocks namely payoff, wire drawing, annealing and three phase induction motor with controller. Cable drawing process is shown in fig (6).

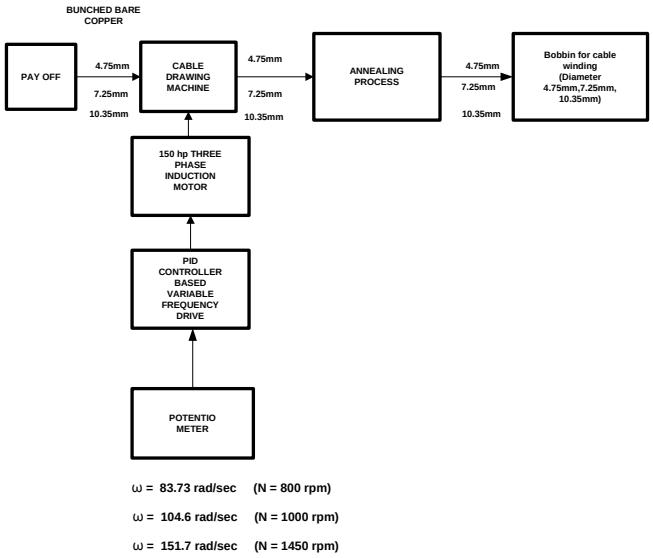

Fig. 6 Cable drawing process

A. Payoff

Cable payoff process is shown in fig (7). In this block there may be one (or) two bobbins. If one bobbin is there then it delivers cable from one bobbin. Suppose two bobbins are there, then dual cable payoff from two individual bobbin is possible. Cable drawing process is shown in fig. 6. In fig. 7, single bobbin is used for doing payoff (i.e. cable delivery) process.

Fig. 7 Cable payoff process

B. Cable annealing process

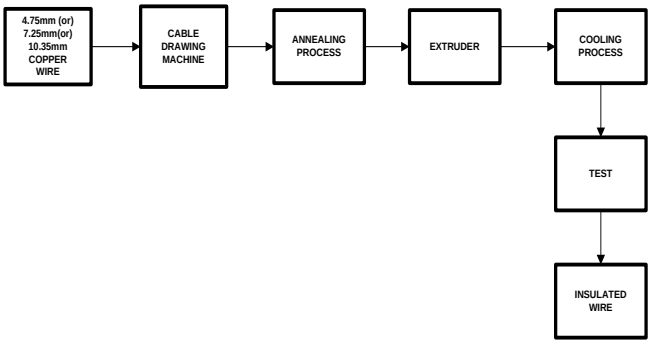

Fig. 8 Cable annealing process

Cable annealing process is shown in fig (8).In this process, 4.75mm, 7.25mm, 10.35mm copper wire is drawn from the bobbin (or) wire storage. Then wire drawing can be done with the help of wire drawing machine which is operated by 150hp three phase induction motor. After wire drawing, wire is taken into annealing process. Annealing is a heat treatment process which alters the microstructure of a material to change its mechanical or electrical properties. During this annealing process, wire (or) cable is exposed with heat followed by cooling slowly in order to remove internal stress and toughen it.Moreover, cable taken from annealing process is passed via extruder and testing unit. Finally, insulated wire take up is done by the bobbin.

IV.TWISTING AND STRANDING

Twisting and stranding is shown in fig (9).In this process, insulated wire take up by the bobbin in the previous stage is delivered(i.e. pay off) to the twister unit. Two bobbins (i.e. bobbin1 and bobbin2) are involved for delivering wires to the twister unit for twisting. Then twisted wire is taking up by another bobbin say bobbin 3.Besides like this bobbin 3, bobbin 4, bobbin 5 and bobbin 6 are formed by twisted pair wires. Finally, these bobbins 3,4,5,6 which are having twisted pair of cables which are passed via strander.

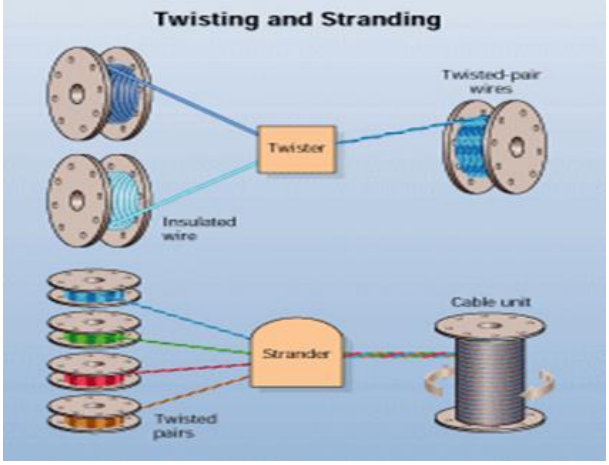

Fig. 9 Twisting and stranding

This strander merges bobbin 3,4,5,6 twisted pairs to form an ultimate cable unit.

V. CONCLUSION

Cable manufacturing industry (Ravicab cables private limited) at Bidadi is discussed. Cable industry operation has been studied with the help of extruder, diameter controller, capstan controller, take up controller, speed controller. Cable drawing process is explained by using payoff, wire drawing and annealing process, twisting and stranding process. In this cable industry three phase 1hp, 3hp, 5hp ,15hp and 150hp induction motors are utilized for making the various diameter cables such as 4.75mm, 7.25mm and 10.35mm.Moreover, it is found that PID controller based speed controller is used for all these three phase induction motors. This PID based speed controllers are greatly affected by disturbance signals such as voltage sag, voltage swell, and load variations. Hence, it is necessary to select and employ a novel robust controller for these induction motors. In order to find the robust controller, there is a necessary to interface various speed controllers individually. As a result of this study three phase induction motor is going to be interfaced with fuzzy logic, neural network and neuro-fuzzy controller seperately.Eventually this study contributes, a novel robust controller for vector controlled induction motor drive as a future work. Moreover in future, matlab Simulink based simulation and hardware implementation will be carried out for any one of the horse power motor (i.e. 1hp, 3 hp, 5 hp, 15 hp, 150hp).

REFERENCES

[1] Tsypkin, Mikhail, "The origin of the electromagnetic vibration of induction motors operating in modern industry: Practical experience—Analysis and diagnostics," *IEEE Transactions on Industry Applications*, Vol. 53, pp. 1669-1676, 2017.

[2] Herbert and Walt, "Totally enclosed fan cooled (TEFC) squirrel cage induction motor options," *Conference Record of Annual IEEE*, pp.17-25, November 2013.

[3] Arvinderjeet Singh, Baljinder Singh, "Energy Saving in Steel Industry by Replacing Standard Induction Motors With Energy Efficient Motors," *International Journal of Engineering Research & Technology*, Vol.3,pp. 1533-1536, 2014.

[4] N. J. Braun, "Some aspects of the application of induction motors to aircraft," *Transactions of the American Institute of Electrical Engineers*, Vol. 63, pp. 769-772, 1944.

[5] G. V. Sadler and A. W. Davey, "Applications of linear induction motors in industry," *IET Digital Library*, Vol.118, pp. 765-776, 1971.

[6] P. E. Radu Curiac and P. E. Sumit Singhal, "Rotor and stator stresses during starting of induction motors used in cement industry applications," In *Cement Ind. Tech.Con. Rec. IEEE*, pp. 1-11, June 2009.

[7] Dabbousi Rami, Djordje Savinovic and Yngve Anundsson, "A comparison between Induction & Synchronous motors for applications in the oil & gas industry," *In Petroleum and Chemical Ind. Tech. Con. PCIC.IEEE*, pp.1-7, October 2008.

[8] Goedtel, Alessandro and PJ Amaral Serni, "Recurrent neural network for induction motor speed estimation in industry applications," *In Electrotechnical Con, IEEE*, pp. 1134-1137, July 2006.

[9] G.Griva, C. Ilas, J. F. Eastham, Francesco Profumo and P. Vranka, "High performance sensorless control of induction motor drives for industry applications," *In Power Conversion Conference-Nagaoka, IEEE.*, pp. 535-539, August 1997.

[10] Yang, Shuying, Dawei Ding, Xi Li, Zhen Xie, Xing Zhang, and Liuchen Chang, "A novel online parameter estimation method for indirect field oriented induction motor drives," *IEEE Trans on Energy Conversion.*, Vol. 32, pp.1562–1573, 2017.

[11] Chandrakanth, S. Anil, Thanga Raj Chelliah, and S. P. Srivastava, "Efficiency determination of induction motor and its sensitivity analysis towards parameter variation," *International Journal of Artificial Intelligence and Soft Computing*, Vol. 4, pp. 144-163, 2014.

[12] Suhel, Shaikh Mohammed, and Rakesh Maurya, "Modelling, design and analysis of multi-phase induction motor," *International Journal of Power and Energy Conversion*, Vol. 8, pp. 186-203, 2017.

[13] S. Gairola and B. Singh, "Power quality improvement in vector controlled induction motor drive employing multipulse AC-DC converters," *International Journal of Industrial Electronics and Drives*, Vol.1, pp. 52-63, 2009.

[14] K. Nafeesa and Saly George, "Starting performance optimisation of two-leg AC voltage controller-fed three-phase induction motor drive," *International Journal of Power Electronics*, Vol. 5, pp. 236-247, 2013.

[15] J. Haataja and J. Pyrhonen, "Improving three-phase induction motor efficiency in Europe," *Power Engineering Journal*,Vol. 12, pp. 81-86, 1998.