Problem Identification in Vintage MK1 Coil Winding Machine: a Case Study

Uday Mali, Akash Lotke, Harshal Jangale, Kirankumar Kanole and Himadri Majumder

June 10, 2022

PROBLEM IDENTIFICATION IN VINTAGE MK1 COIL WINDING MACHINE : A CASE STUDY

Uday Mali, Akash Lotke , Harshal Jangale , Kirankumar Kanole
Dr.Himadri Majumder
Department of Mechanical Engineering
G.H.Raisoni College of Engineering and Management-412207, Maharashtra, India

Abstract

The coil winding machine is one of types of winding machine that available in industries today. From multi speed machines to medium, large and extra-large machines, these machines come in various types and categories, performing a range function. The common applications for a coil winding machine are to wind coils for transformer, inductor, motor, starter and chokes. To complete a coil using manual coil winding machine will be inconvenience and waste of time. Therefore, advancement of coil winding machine will be done in this project which is manufactured by Larsen & Toubro (L&T). Automation is a technology in which a process or procedure is accomplished by means of programmed instructions usually combined with automatic feedback control to ensure the proper execution of the instructions. Although automation can be used in a wide variety of application areas, the term is most closely associated with manufacturing. So based on Industry 4.0 we have done the changes in vintage MK1 coil winding machine and converted to automated coil winding machine.

Keywords: *Tensioning device,Automation,Stator,Servo motor.*

1. Introduction

The fourth industrial revolution (Industry 4.0) is the continuing automation of conventional manufacturing and industrial practices, using modern automated technology. Large-scale machine-to-machine communication (M2M) and the internet of things (IOT) are integrated for increased automation, improved communication and self-monitoring, and production of smart machines that can analyze and identify issues without the need for human intervention. So, based on the Industry 4.0 the title represents the Automation of the MK1 Coil Winding Machine to a Mechatronics Machine.

A winding machine winds a material such as metal wire, thread, or paper, onto a bobbin spool, core.Many industries use coil winding machine for coil winding. A simple winding machine usually has a core on a spindle and the user feeds wire and wound onto the core. The user maintain the spindle speed and feeds material through user hand, guiding it to control the tension and load.These simple machines may be of a bench top size .

MK1 Coil Winding Machine:

To complete a coil using mechanized coil winding machine will be inconvenience and waste of time. Furthermore, to have a good quality of automatic coil winding machine requires costly tools. Therefore, manufacturing of coil winding machine is done in this project which is controlled by servo motor using control panel.

Coil winding machines are the machines which are used to wind the coils for inductor , transformer,starter.Coil winding is the manufacturing of electromagnetic coils.Coils are used as a core part in a circuit and provide magnetic field to generators. The liner coil winding method in which wire is wound on to the rotating coil body. The shape and size of winding are design to fulfill the particular requirement. Inductance,insulation strength of magnetic field affect the design of coil winding. Coil winding can be divided into different groups according to type and the geometry of wound coil. The mass production of coil depend upon Automated machines.The electrical coil winding machines are used to wind the coils for various of the applications like motors,transformers, Inductor,starter..Coil winding components are used for various wire winding, wire welding, and wire bonding applications. Electrical coil winding machines are also used in automated coil winding and assembly,magnet wire winding, or air coil winding applications.

The electrical coil winding machine are available in both single spindle and multi spindle arrangement. Additional specifications include spindle speed,spindle motor power,spindle stop position,maximum rotation diameter, and various axis measurements.

The machine core body is made up of cast iron and covering is made of mild steel, and the machine also have virtual interface for intraction known as HMI(Human Machine Interface). The main motor of machine consist 3000 rpm (and it is manufactured by Siemens); A three AC servo motor is used for conveyor belt,paper feeding unit, cutting unit.

The components of the machines are distributed in various categories:

I. Headstock:

The headstock on the left side of the machine has a strong welded housing that accommodates the drive motor, belt drive, winding shaft. The exact position of the winding shaft (rotation eagle) can be determined by the position sensor.

II. Tailstock :

The tailstock is designed as a welded structure. The sleeve attached to the coating tip is opened by a pneumatic cylinder while the machine is running there is pressed with the sleeve mandrel attached to the tip. The operation of the sleeve is operated by a full button The tailstock can be released on the guide rail.

III. Usage Guide Device (Tensioner)

A tensor is a device that helps to create or maintain tension. The tensor controls the proper tension for winding. The use of two and felt wheels and wheeling pulleys is then wrapped around the dancer arm pulley and installed in the coil winder.

Fig. 1: Servo motor based Tensioner

IV. Insulation Feed Unit (Paper Feeding Mechanism)

The insulation feed unit has a supply roll that acts as insulation of the wire. The paper feeding roller is driven by the motor to create material tension in conjunction with the dancer system. Pneumatic cylinder on the dancer and closed with the help of travel measuring system Tension is controlled in the circuit.

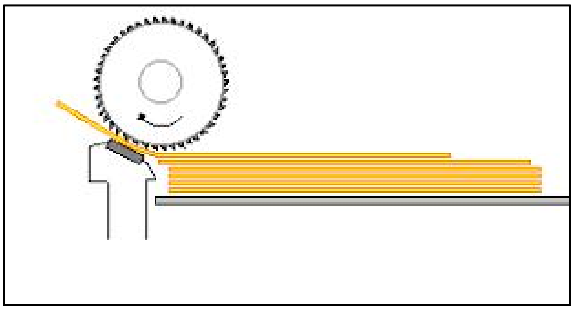


Fig.2: Paper Feeding Mechanism

V. Insulation Logitech Cutting Device (Slitting Cutter):

The insulation in the coil is a punch for cutting tissue paper which has the same cutting blades as the winding coil. It has a top and bottom blend that works like scissors and cuts paper.

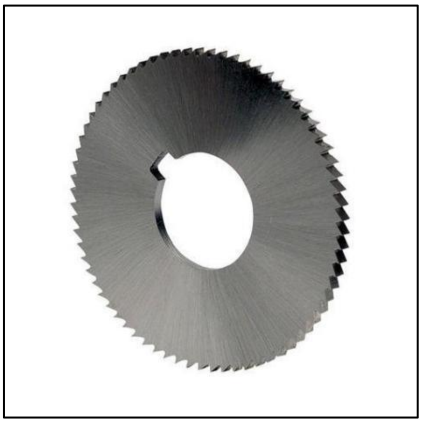


Fig.3: Slitting Cutter

Blance et al. (1) studied electric motors, the stator designs with tooth coils. Due to their non-circular shape, the tooth coils display a challenge for highly productive winding processes with a low coil resistance. With the use of a process model a prediction of the central process parameters, like the wire tension, can be achieved. Delis et al. (2) analyzed coil winding machine design is dictated by a coil's complication, material tension limitations, machine contrivance,operator intervention, production size. Dodds et al. (3) used control system for automated regulation of the tension of the copper wire in a coil winding machine for segmented tooth stator coils of permanent magnet synchronous motors is presented. The use of a transducer to directly measure the tension force is avoided. .Wang et al. (4) Based on the analysis of the disadvantage of present wire winding of the coil of electric welding machine, this paper studies thoroughly the problem of the wire winding of the coil of electric welding machine. Gokul et al. (5) studied electrical machines starting from motors,starter,generators to transformer are working with the coils of conductors placed for some function. Mostly the coils are carrying the current to generate the magnetic effect. The CAD and CAE design for the machine and calculations are presented in this paper.Wen et al. (6) carried out design and testing of tension control prototype systems to reduced these tension variations, which includes a fluid muscle powered take up arm, a fluid muscle wire accumulator and felt pad. First the model and their limitations for existing tensioning systems are identified. Then, they are theoretically analyzed system in simulations.Fazio et al. (7) addressed development of winding technique and automated technology, to automate winding of optical fiber in a quadrupole pattern, for interferometric fiber-optic gyros (IFOG's). An important of this work is developing winding processes that can proceed under tension, stably, without hands-on human efforts. A quadrupole winding pattern needs handling two supply spools and one product spool; supply spools takes turn being active, and tension control must be maintained during changes of spools.

2. Case Study

The automation and upcoming of the modern smart technologies has resulted in a revolution of many manufacturing processes and hence there is no anomaly for the vintage MK1 Coil Winding Machine. The use of automation, has enjoyed faster production time, improved packing accuracy. Those colossus leaps in efficiency have allowed the company to remain competitive on global level, expand their business , hire more employee and keep production at an increasing rate to meet the markets requirement and demand. A coil is a conducting wire in which a copper wire is wind in a helical form on an iron core. The coil produces electromagnets to store electromagnetic energy. Coils are widely used to eliminate power discrepancy.The coil winding machines we are using are completely tailored.The major abnormalities that were absorbed in the vintage coil winding machines . We are considering the data that we took from the production year 2019-20 and 2020-21.The observations that were noted from the five machines :

Machine No	1	2	3	4	5
Asset No	819512	125233	225685	285523	379865
Year of Manufacturing	1990	1995	2005	2007	2015

Problem	Causes
Paper Feeding Problem	Change in the Temperature and Humidity
Slitting Cutter Problem	Improper operation
Tensioner Problem	Losses in tension during the winding process.
Other Problems	Maintenance,Human-machine Interphase,Development,etc.

Table1: Abnormalities observed in the machines and their reasons

I. Paper Feeding Problem:

The paper that we use is very thin and reacts with the atmospheric temperature changes.When their is slight change in the temperature the paper gets shrink and contracts , which results in the improper paper feeding and cutting.

II. Slitting Cutter Problem:

The slitting cutter gets stuck during the operation and it dose not follow its defined path , which results in the in improper cutting of the coils which are produced in the coil wounding process.

III. Tensioner Problem:

Tensioner that are used in the vintage coil winding machines are simple and mechanically operated.The tensioner loses the tension during the coil winding and results in coil rejection.

IV. Other Problems:

This includes the general problems caused by an human error and power failures;Low weight spool,development(safety door fitment), energy loss(air,oil), absent or half day of an operator, new operator, inventory maintenance, breakdown, setting change,setup, rm shortage, mandrill vovel ,mandrill broken, cutter rotation,cutter problem, spools repaired and reused preventive maintenance wire problem,enlargement of wires, power failure 5's, improper training.

Losses due to Tensioners and Paper feeding problem in Hours

(From JAN'2020-DEC'2020)

Machine	M1	M2	M3	M4	M5
Losses due to Tensioner	49.55	31.14	37.14	40.15	10.19
Losses due to Paper feeding	75.26	70.72	90.58	95.26	60.12

We have considered the data of 5 different machines from January 2020 to December 2020 for the calculation of the tensioner and paper feeding problems.The loses in each machine were seem to be different for both the problems, machine -1 had 49.55 rejection per hour due to the tensioner and 75.26 rejection due to the paper feeding.Similarly the machine 2,3,4, and 5 loses are mentioned.

We have plotted the bar graph for the loses due to the tensioner and paper feeding in the year 2020,which is represented as follows:

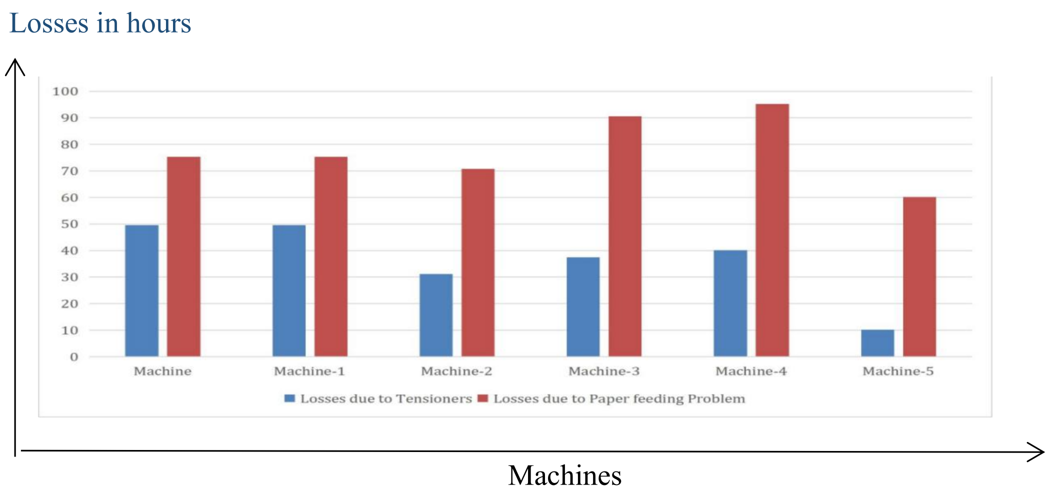


Fig. 4: Bar Graph representing losses due to tensioner and paper feeding problem.

In the above graph we seen the for different machines the losses are different, we see that machine 5 has the lowest number of losses.

Losses due to Tensioners and Paper feeding problem in Hours

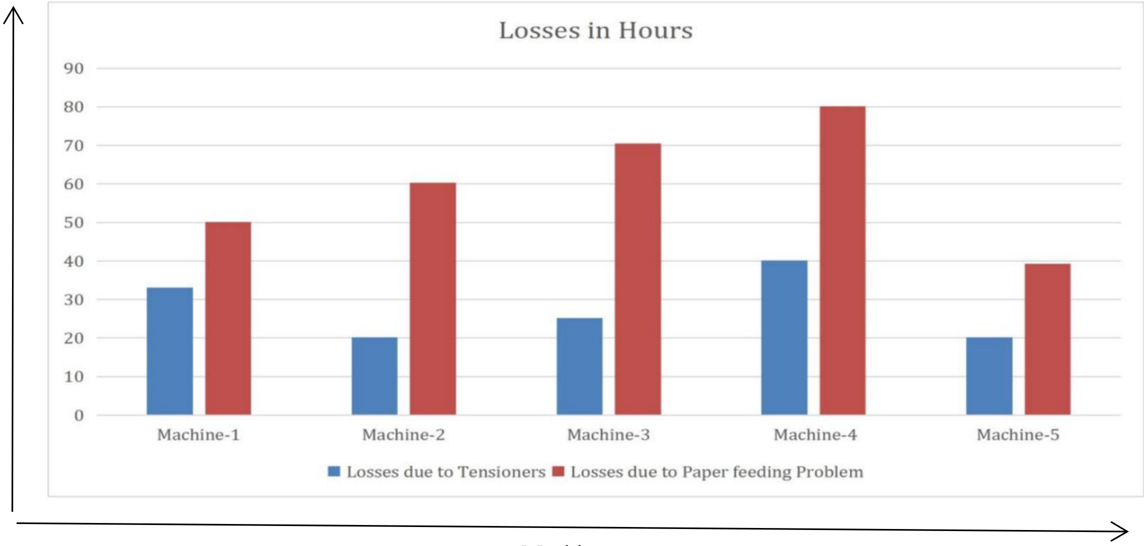
(From JAN'2021-SEP'2021)

Machine	M1	M2	M3	M4	M5
Losses due to tensioner	33.13	20.16	25.19	40.15	20.17
Losses due to paper feeding	50.12	60.29	70.54	80.12	39.32

We have considered the data of 5 different machines from January 2021 to September 2021 for the calculation of the tensioner and paper feeding problems.The loses in each machine were seem to be different for both the problems, machine -1 had 33.13 rejection per hour due to the tensioner and 50.1 rejection due to the paper feeding.Similarly the machine -2,3,4, and 5 loses are mentioned.

We have plotted the bar graph for the loses due to the tensioner and paper feeding in the year 2021,which is represented as follows:

Hours



Machines

Fig. 5: Bar Graph representing losses due to tensioner and paper feeding problem.

From the above graph we observe that the machine 4 has maximum loss due to the paper feeding and tensioner.

From figure 1 and figure 2: We observed that in few machines there was increase in losses from time duration and other machines were working similarly as they were working the previous year.

Total Pure Copper wire Scrap And Mix scrap(Cu+Paper) in KG

(From JAN’2020-DEC’2020)

Losses in Kg	Jan	Feb	Mar	May	Jun	Jul	Aug	Sep
Pure Copper wire Scrap in Kg	12.24	15.17	18.19	12.47	17.82	12.90	19.20	22.78
Mix Scrap (Cu+Paper) in Kg	102.33	115.78	101.42	93.24	85.93	90.05	75.24	97.10

Losses in Kg	Oct	Nov	Dec
Pure Copper wire Scrap in Kg	21.15	20.24	23.76
Mix Scrap (Cu+Paper) in Kg	100.22	110.57	106.87

In this case we considered the month wise data for Scrap produced during the manufacturing of the coils.We obtain the above data and noted it down.

We have plotted the bar graph for the Pure Copper wire Scrape and Mix Scrap in the year 2020,which is represented as follows:

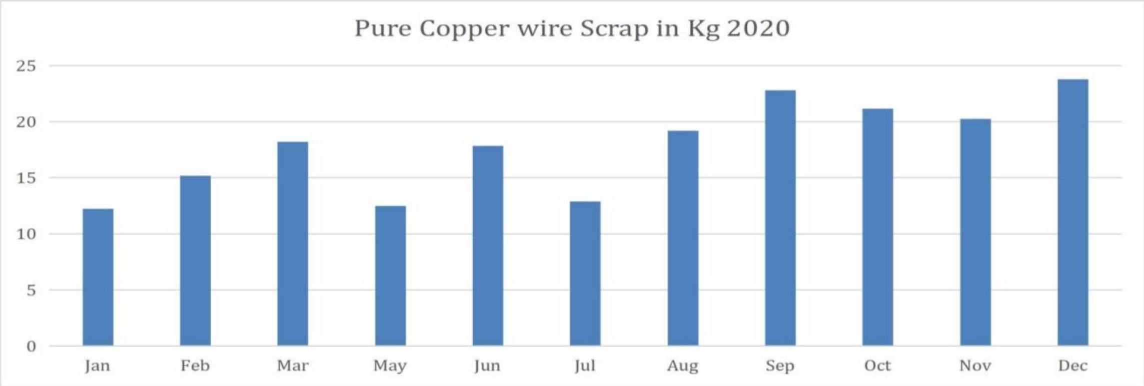


Fig.6 :Total Pure Copper wire Scrap (Cu) in KG

In the year 2020 the pure copper scrap was maximum in the month of December which was 25kg.

Fig.7: Total Pure Copper wire Scrap And Mix scrap(Cu+Paper) in KG

The total mix scrap of the year 2020 was 1078.75 kg and maximum mix scrap was in the month of February.

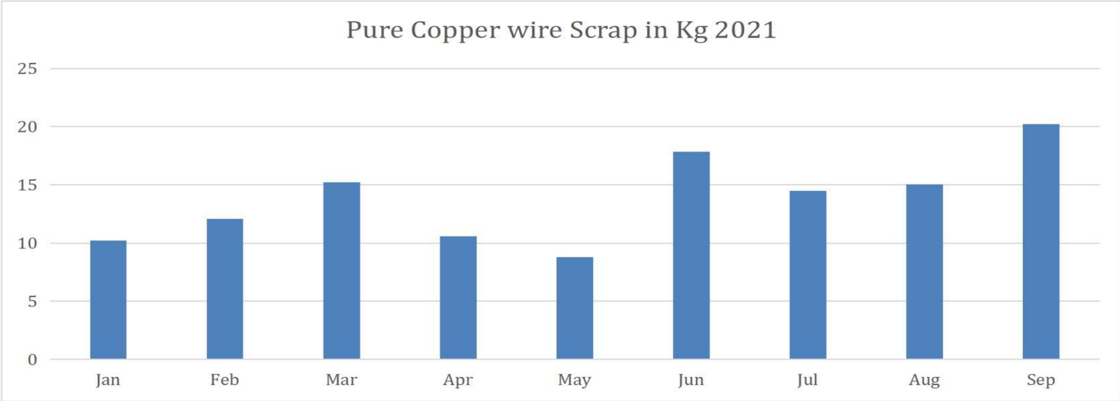
Total Pure Copper wire Scrap And Mix scrap(Cu+Paper) in KG

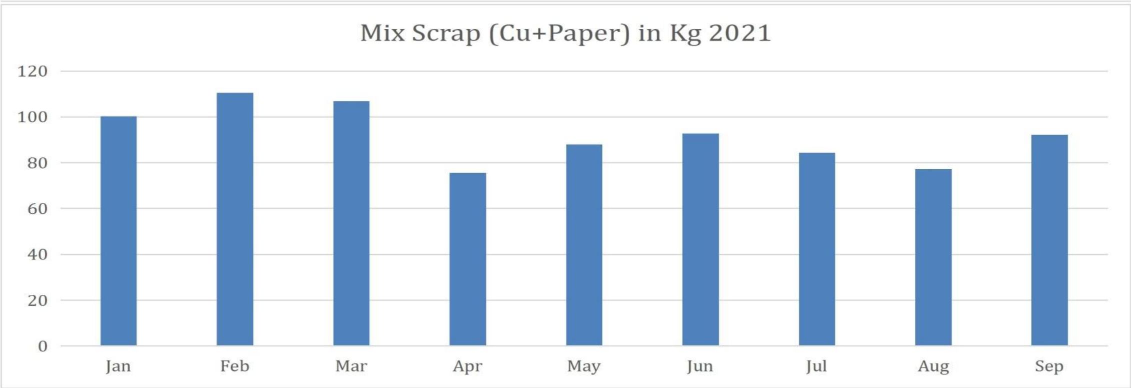
(From JAN'2021-SEP'2021)

Losses in Kg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Pure Copper wire Scrap in Kg 2021	10.24	12.1	15.2	10.59	8.79	17.82	14.48	15.02	20.21
Mix Scrap (Cu+Paper) in Kg 2021	100.22	110.57	106.87	75.48	87.92	92.82	84.41	77.12	92.12

We considered the month wise data for Scrap produced during the manufacturing of the coils in the year 2021.We obtain the above data and noted it down.

We have plotted the bar graph for the Pure Copper wire Scrape and Mix Scrap in the year 2021,which is represented as follows:





The total mix scrap that was produced in the year of 2021 was 827.53 kg.

Proposed Solutions:

I. Complete Automation of the machine .

II. Used of servo motor based Tensioner

III. Load cell installation under the Spools.

IV. Complete separate unit for Slitting Cutter ; basically on either side of the machine.

V. Using proper temperature sensing unit(or box) for Paper feeding.To avoid the shrinking of the paper.

VI. Addition of Safety Doors on the Machine, for maximum Security.

3. Conclusion.

By considering the observation that we made during this case study, we had studied the operations of 5 coil winding machines and noted the major problems faced during manufacturing and based on those problem we have proposed some solutions that can be taken into consideration.

References

1. Sell-Le Blanc F, Hofmann J, Simmler R, Fleischer J. Coil winding process modelling with deformation based wire tension analysis. CIRP Annals.

2. Delis JS. Design considerations, machinery and control options in coil winding. IEEE Electrical Insulation Magazine.

3. Dodds SJ, Sooriyakumar G. Observer based robust tension control for a segmented stator coil winding machine.

4. Wang YQ, Wang XJ, Hua SM. Computer Numerical Controlled Coil Winding of the Electric Welding Machine. InApplied Mechanics and Materials.

5. GOKUL TK, DAGADU SS, TANAJI TV, SHIVAJI DP, DIXIT V. Design And Manufacturing Of Filler Wire Rewinding Machine. International Journal of Innovations in Engineering Research and Technology.

6. Wen P, Stapleton C, Li Y. Tension control of a winding machine for rectangular coils. In2008 10th International Conference on Control, Automation, Robotics and Vision.

7. De Fazio TL, Belsley KL, Smith RH, Shank GB, Culver WH. Development issues for automating quadrupole-pattern optical-fiber coil-winding for fiber-optic gyro manufacture