A Noble Approach of Process Automation in Galvanized Nut, Bolt Manufacturing Industry

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ABSTRACT

Corrosion costs money", The Columbus battle institute estimates that corrosion costs Americans more than $ 220 billion annually, about 4.3% of the gross natural product [1].Now a days due to increase of pollution, the rate of corrosion is also increasing day-by-day mainly in India, so, to save the steel structures, galvanizing is the best and the simplest solution. Due to this reason galvanizing industries are increasing day-by-day since mid of 1700s.Galvanizing is a controlled metallurgical combination of zinc and steel that can provide a corrosion resistance in a wide variety of environment. In fact, the galvanized metal corrosion resistance factor can be some 70 to 80 times greater that the base metal material. Keeping in mind the importance of this industry, a noble approach of process automation in galvanized nut-bolt manufacturing plant is presented here as nuts and bolts are the prime ingredient of any structure. In this paper the main objectives of any industry like survival, profit maximization, profit satisfying and sales growth are fulfilled. Furthermore the environmental aspects i.e. pollution control and energy saving are also considered in this paper. The whole automation process is done using programmable logic controller (PLC) which has number of unique advantages like being faster, reliable, requires less maintenance and reprogrammable. The whole system has been designed and tested using GE, FANUC PLC.

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1. INTRODUCTION

The first patented galvanized process was by the French chemist Sorel in 1836 [1] and from then it is taking a major share in the global market for producing corrosion free, high quality long lasting products. The entire process, described in this paper is fully automatic and continuous type which increases the production rate [2]. It also increases the quality of the product and decreases the production cost. Number of sensors are used in each and every critical point which reduces the unwanted running of machineries. Here automatic plant lighting control system is also provided so that the energy consumption is reduced. The overall automation process is divided into various segments. Those are pre manufacturing treatment, nut making process, bolt making process, galvanizing process, plant lighting control system. The entire process is shown in the Figure 1.

2. PRE-MANUFACTURING TREATMENT

At first, if the diameter of the wire rod is greater than the required diameter then they are fed to a rod drawing machine to reduce the diameter, but it is not shown here. Then the raw steel wire rod is heated up to 250°C in an air furnace. After that the hot wire rod is dipped into H2SO4 solution to remove any rust and dust particles. Then it is dipped into a clean water chamber for cooling.

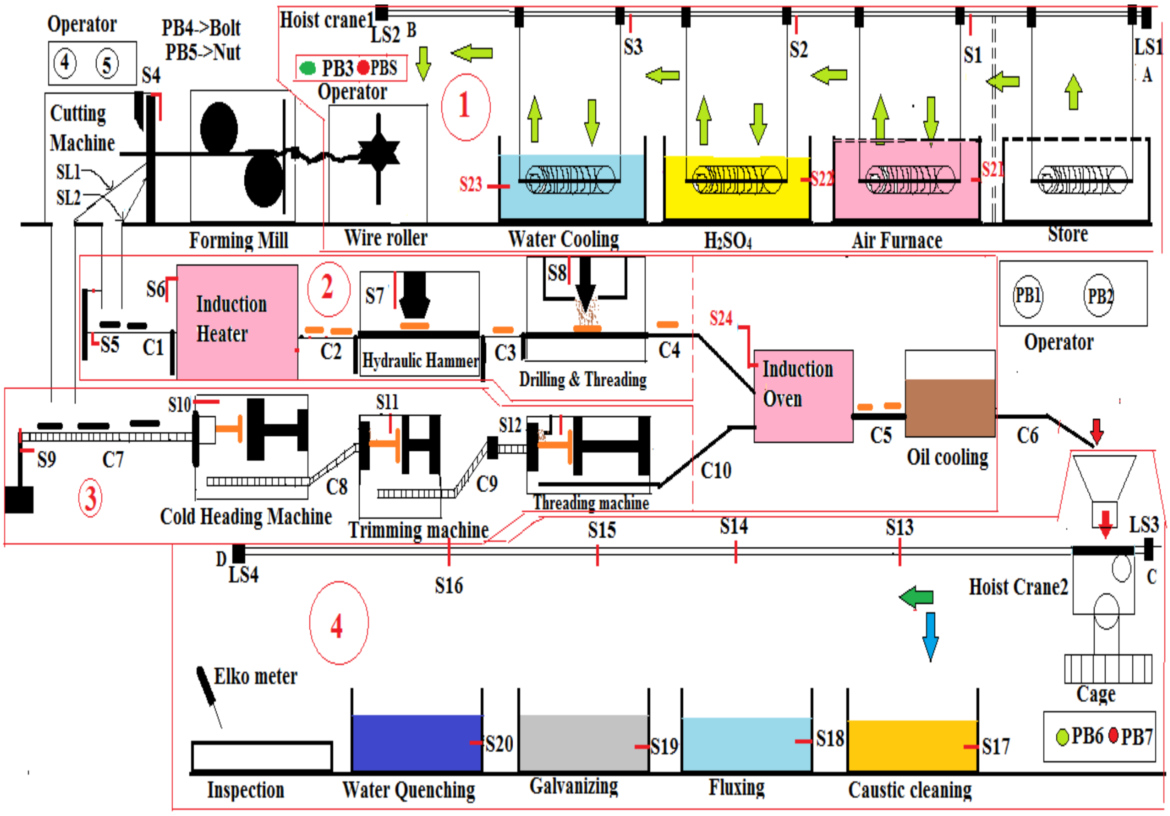

Figure 1.Process diagram of galvanized nuts and bolts manufacturing plant

This treatment prevents the steel from rusting and lubricates the steel to make forming easier. This entire process is done using hoistcrane1 and to control it six proximity sensors, four limit switches and a thermocouple is used.

2.1. Automation of hoist crane1 control

To control the hoist crane a PLC unit is used. It takes the required decision depending upon the various field level input signals. Then the decision is sent to hoist crane1 as an output signal [3].

2.1.1. Input

Proximity sensors [S(1-3), S(21-23)], Limit switches (LS1, LS2, LSA, LSB), Push Button (PB1, PB2), Thermocouple(TC)

2.1.2. Output

Forward Motor (FM), Reverse Motor (RM), Up Motor (UM), Down Motor (DM), Air furnace (AF)

2.1.3. Process Description

In case of hoist crain1 control system there are vertical and horizontal paths for the crane movement. To control the vertical moment there are two limit switches LSA, LSB and to control the horizontal movement there are also two limit switches LS1 and LS2. In this section there are two pits and one air furnace. So to stop the hoist just above those pits and the air furnace, three proximity sensors S1, S2, S3 are used. After loading the cage of the hoist crane with raw wire rod, an operator starts the entire process by pressing a push button PB1. As soon as the operator presses PB1, the up motor (UM) starts and the cage move upwards. The up motor continues until it reaches LSA. At point A, LSA and LS1 are on, so the forward motor (FM) starts running. The cage moves toward the air furnace (AF) and resets the limit switch LSA. S1 senses the incoming crane and stops the forward motor. LSA remains in reset condition. Then down motor (DM) starts and the cage moves downward. When the cage reaches inside the air furnace, the down motor is stopped by the limit switch LSB. Simultaneously sensor S19 starts the air furnace. After a time delay, required for heating, when the temperature of the wire rod attends the required value (250)°C. Then the output of the thermocouple (TC) is digital 1 which starts the upper motor (UM) and it runs until LSA is on. Now S1 and LSA are ON so the forward motor starts again and resets the limit switch LSA. Then the cage moves towards the first pit i.e. H2SO4 container. S2 senses the incoming crane and stops the forward motor. LSA remains in reset condition. Then Down Motor (DM) starts and the cage dipped into H2SO4 solution for cleaning. After some time delay, required for cleaning, the up motor starts and runes until it reached LSA. The time delay is achieved with the help of PLC timer operation which is turned on by the sensor S22. Then the cycle is repeated again for water cooling but the time setting of the timer is different. At last when the crane reached the point B, LS2 stops the forward motor and the down motor starts automatically. Then the cleaned wire rod coil is loaded in the wire holding device manually .This process requires some time. Then UM starts automatically. At last when LS2 and LSA are on, the reverse motor(RM) starts and the cage moves toward the initial point A. When the empty cage reached the point A, the output of LS1 is on which stops the reverse motor. Push button PB2 is provided to stop the process manually. The overall process is shown in section 1 of fig1.

2.1.4. PLC program

Here the PLC is programmed using ladder logic method. The programming required to control the hoist crane1 is shown in Figure 2.

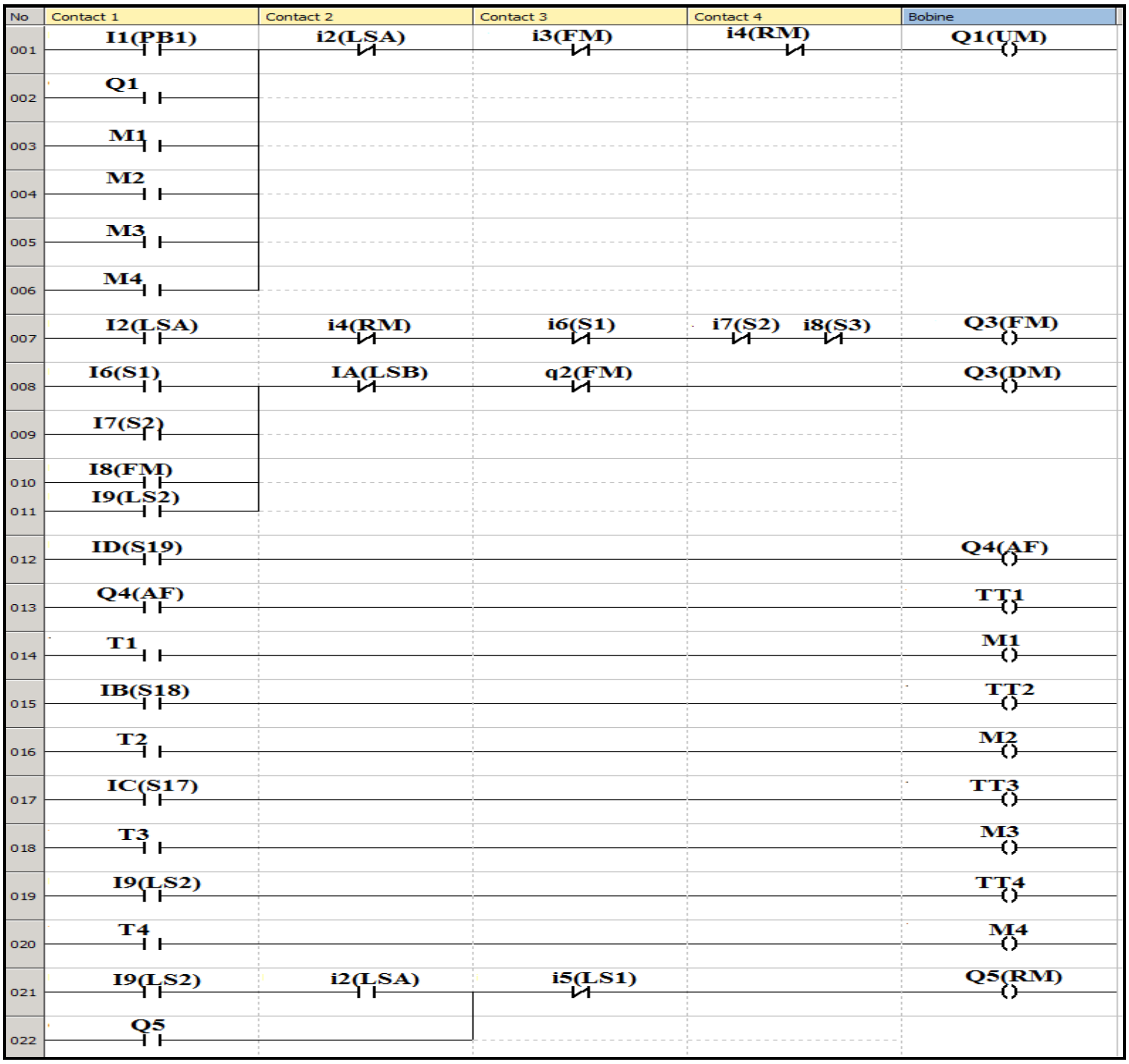

Figure 2. PLC program for hoist1 control

3. NUT MAKING PROCESS

A nut is a piece of metal wire rod with a threaded hole used for fastening purpose. The quality of a nut depends upon the composition of it's raw metal. The recommended composition is carbon (0.22 to 0.23%), Phosphorus (0.40%), Manganese (0.39 to 0.60%), Sulphur (0.50%)[4]. The basic manufacturing method is the forcing of unheated metal to flow into dies to change it's shape. Then the cleaned and treated wire rod is connected to a forming machine (FM) for straightening. After that it goes to the cutting machine to cut the rod into desired size for nut manufacturing. Then the pieces go to an induction heater for heating up to 1200° C and then they are transferred to a hydraulic hammer mechanism to give them the most common hexagonal shape. Then the nuts are drilled and threaded into a drilling and threading machine simultaneously with controlled lubricating mechanism to reduce wear and tear. Now the finished nuts are sent to an oven at 870°C for about an hour. This process gives the required strength to nuts. At last they are rapidly cooled in an oil chamber for about 5minutes and sent to the galvanizing section. Various conveyors and sensors are used between intermediate stage to transfer the material and to control the operation respectively. The overall process is shown in the section2 of fig1.

3.1. Process flow diagram

The process flow of nut making process is shown in the Figure 3 [5].

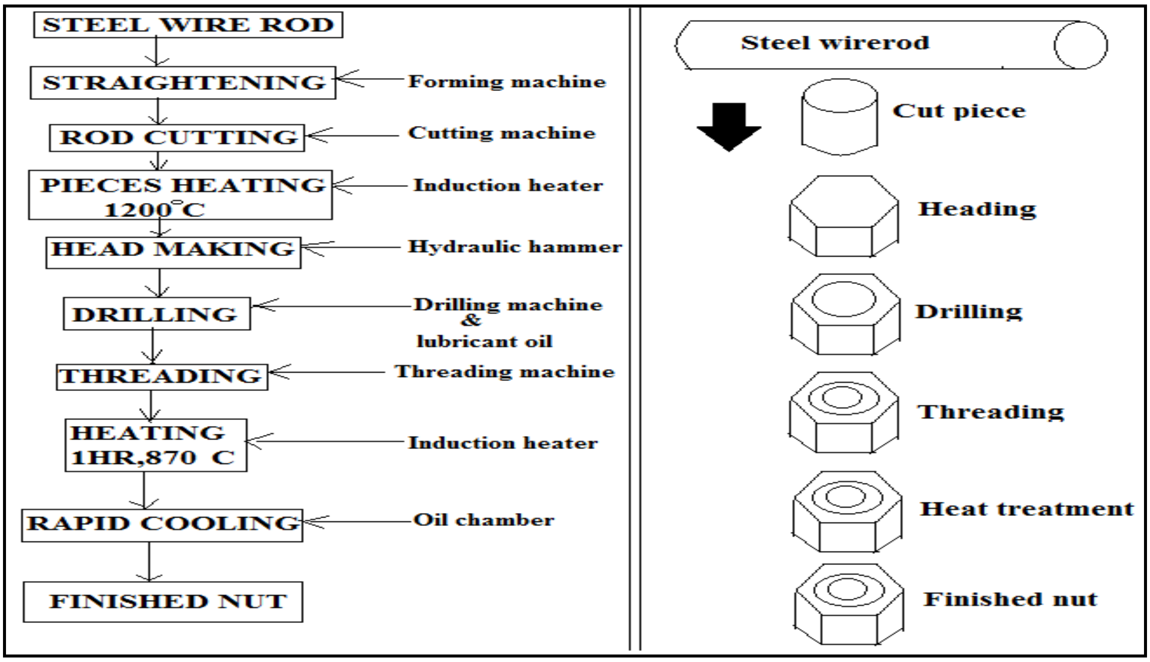

Figure 3. Process flow diagram of nut making

3.2. Automation of nut making process

To make this process fully automatic a PLC unit is used. PLC takes real time decision depending upon the various field level input signals from various sensors placed in different critical points.

3.2.1. Input

Strain gauge(S5), Thermocouple(S6), Proximity sensors (S7,S8,S24), Push button (PB3,PBS,PB5)

3.2.2. Output

Forming machine(FM), Cutting machine(CM), Hydraulic hammer(HH), Induction heater(IH), Drilling machine(DR),Threading machine(TM),Induction oven(IO), Slider (SL2), Oil pump(OP) Chain conveyor[C(1-6)].

3.2.3. Process Description

After loading the wire rod into roller, the rod is manually connected to forming machine only for the first time. Then operator starts the process by pressing the push button PB3. As soon as the operator pushes PB3 the forming machine (FM) starts. After straightening the rod when it reaches in front of the cutting machine (CM), sensor S4 senses it. Then the cutting machine waits for the operator input signal. If operator selects PB5 for nut, cutting machine starts to cut the rod into desired size to make nuts. At the same time slider SL2 is activated and materials start to fall on conveyor C1. When a desired amount of material is stacked on C1, sensor S5 is ON. As a result C1 starts moving and the metals are transferred to the induction heater (IH). Instantaneously the induction heater (IH) turns ON together with C1. When the temperature of those materials reach 1200° C, sensor S6 senses it and starts the conveyors C2,C3,C4. C2 transfers the heated pieces to the hydraulic hammer (HH). The hammering machine is started by the sensor S7. When the pieces get hexagonal shape, those are sent to the drilling machine (DM) by conveyor C3. The drilling machine is started by the sensor S8, at the same time the threading machine (TDM) and oil pump (OP) are also started. Then the finished nuts are sent to the induction over (IO) by conveyor C4. Induction oven is started by the sensor S24. After spending about 1hr in the oven, conveyor C5 starts automatically by a timer and the nuts are transferred to oil chamber. The time setting is done by PLC timer operation. At last the finished nuts are sent to galvanizing unit by conveyor C6 which is started together with C5. Push button PBS is provided to stop the process manually if required.

3.2.4. PLC program

Here the PLC is programmed using ladder logic method. The programming required to control the overall nut making process is shown in Figure 4.

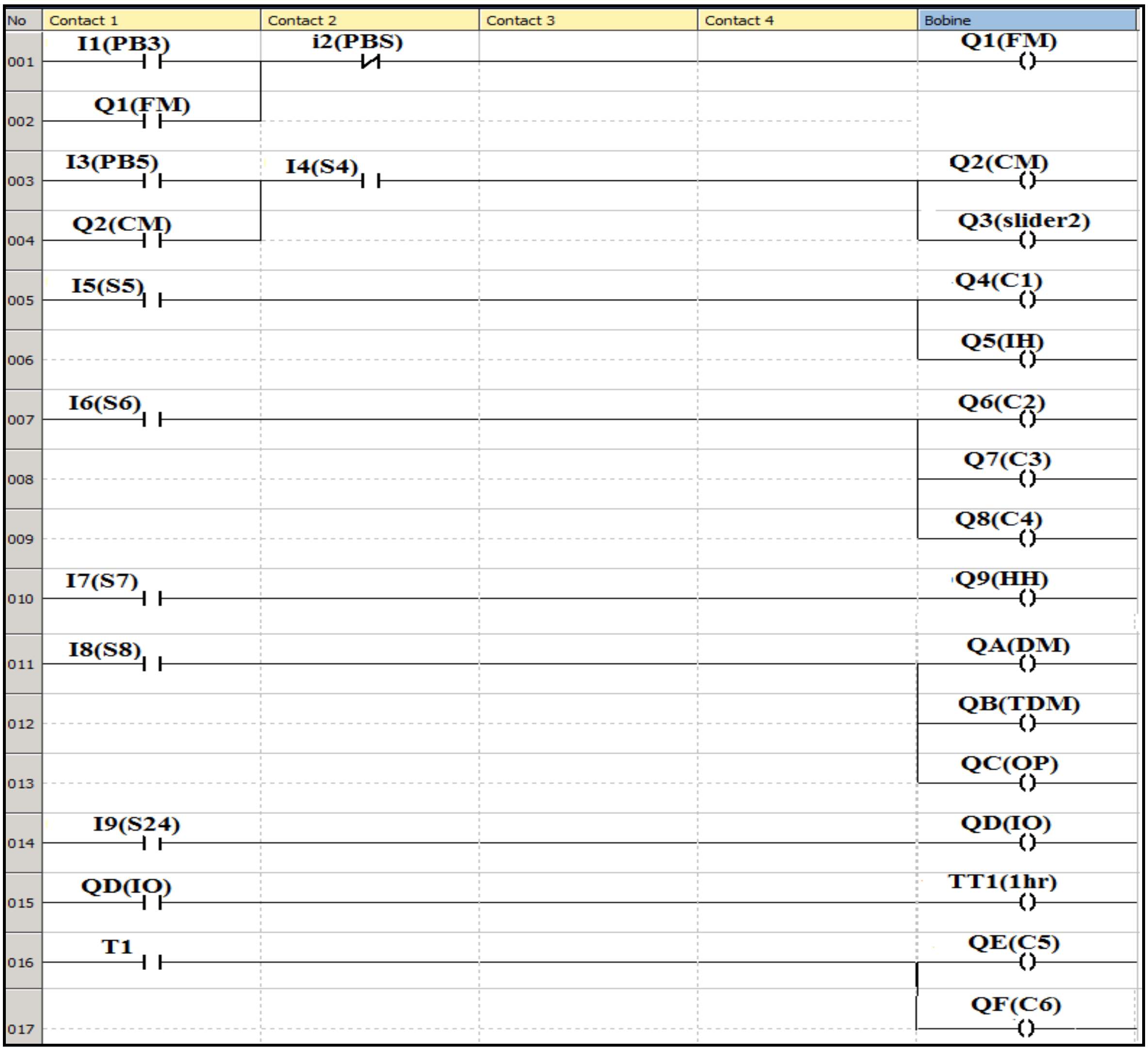

Figure 4. PLC program for nut making process.

4. BOLT MAKING PROCESS

Bolt is a piece of metal rod, whose one end is up settled and other end, is threaded. The same metal rod which is used for nut making is also used for bolt making process. The process is actually a high-speed multi-blow presses. In this process at first the straight and treated wire rod is cut into required size for bolt making. Then the materials are sent to cold heading machine which is actually a high-speed multi-blow press to make hexagonal head at one end. Actually there are series of dies in the heading machine and the unheaded metal is forced to flow into the dies to change its shape. After that the material goes to the trimming machine for cutting the edge of the bolt. At last the bolts are fed to the threading rolling machine for making dreads [4, 6]. Then the finished bolts are sent to the galvanizing unit. In each of those process controlled lubrication is used to minimize wear and tear and for cooling. Various conveyor and sensor are used between intermediate stage to transfer the material and to control the operation respectively. The overall process is shown in the section3 of Figure 1.

4.1. Process flow diagram

The process flow of bolt making process is shown in the Figure 5 [5].

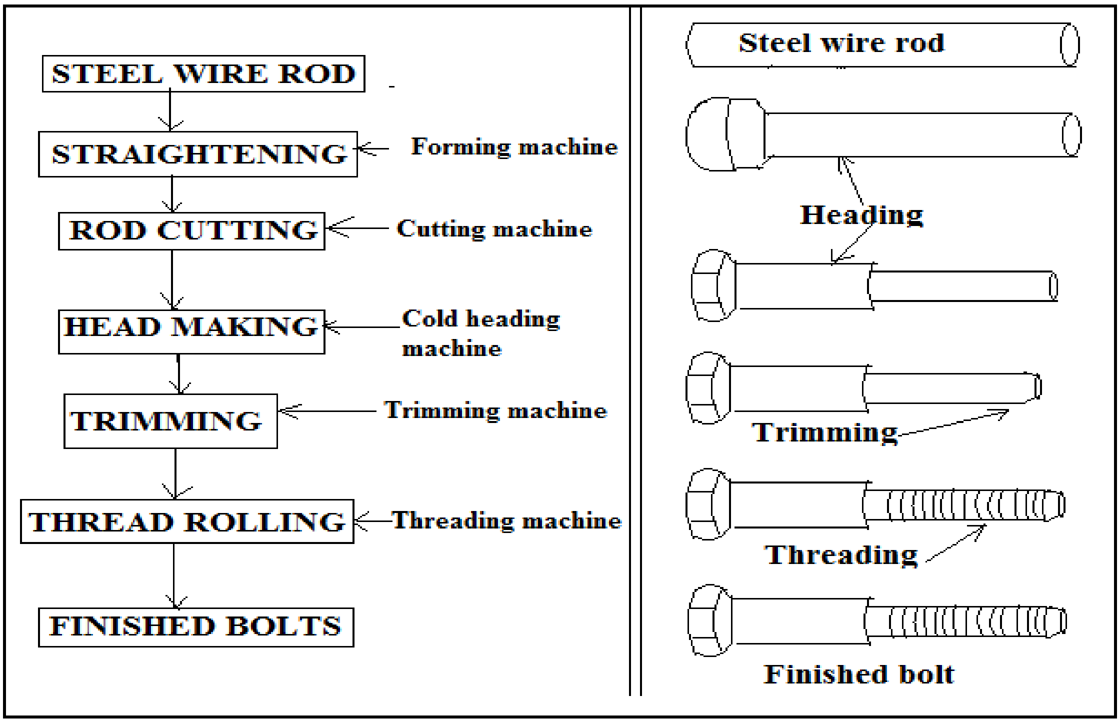

Figure 5. Process flow diagram of bolt making.

4.2. Automation of bolt making process

To make this process fully automatic a PLC unit is used. PLC takes real time decision depending upon the various field level input signals from various sensors placed in different critical points and sends the decision to the output devices.

4.2.1. Input

Strain gauge (S9), Proximity sensors (S10,S11,S12.S24), Push button (PB4), Forming machine(FM)

4.2.2. Output

Cutting machine(CM),Cold Heading Machine (HM), Trimming machine (TRM), Threading Machine (THM), Chain conveyors [C(5-10)], Slider (SL1), Oil pump(OP).

4.2.3. Process Description

In this automation process the state of the forming machine acts as an input signal. If it is running and the operator presses push button PB4 then the cutting machine starts cutting the rod into desired size to make bolts. At the same time slider SL1 is activated and materials start to fall on conveyor C6. When a desired amount of material is stacked on C7, sensor S9 is ON. As a result C6 starts rolling and the metal is transferred to the cold heading machine (HM). After that the rest process is very fast and instantaneous so a very little amount of time is required. For this reason, the PLC is so programmed that the conveyors (C6,C7,C8,C9) can start rolling together with the heading machine(HM). The heading machine is started by the sensor S10. When the heading process is completed the materials are transferred to the trimming machine (TRM) by the conveyor C8. S11 sense the incoming material and starts the trimming machine. After completion of trimming the bolts are transferred to the threading machine by conveyor C9. The threading machine(THM) is started by the sensor S12. An oil pump (OP) also starts together with the threading machine. Then the finished bolts are sent to the induction over (IO) by conveyor C10. The induction oven is started by the sensor S24. After spending about 1hr in the oven, conveyor C5 starts automatically by a timer and the nuts are transferred to the oil chamber. The time setting is done by PLC timer operation. At last the finished bolts are sent to the galvanizing unit by the conveyor C6 which is started together with C5.

4.2.4. PLC program

The programming required to control the overall bolt making process is shown in Figure 6.

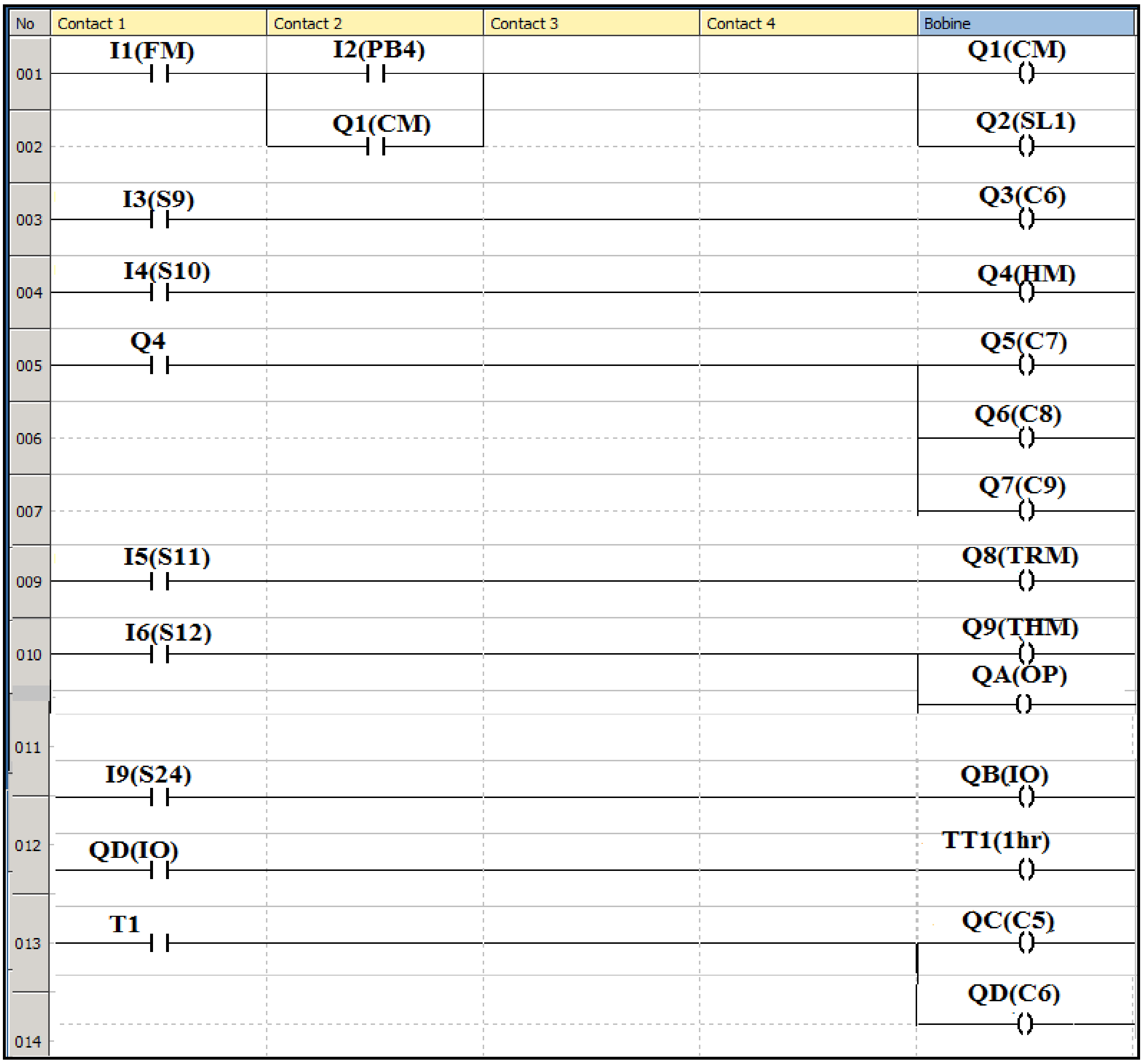

Figure 6. PLC program for bolt making process.

5. NUTS &BOLTS GALVANIZING PROCESS

The galvanizing process produces a durable, abrasion resistant coating of metallic zinc upon steel surface. Even where damage or a minor discontinuity occurs in the coating, zinc's sacrificial action protects the structures. Here the hot dip galvanizing process is used [7,8]. One of the most important advantages of hot dip galvanizing process is the formation of strong bonding between steel and its Zink coating. The overall process consists of five different stages. Those are caustic cleaning, fluxing, galvanizing, water quenching and final inspection. Water rinsing is done at the end of both caustic cleaning and fluxing process.

5.1. Caustic cleaning

In this stage the materials are dipped into a caustic (alkaline) solution which removes organic contaminants including dirt, water-based paint markings, grease, and oil.

5.2. Fluxing

Flux solution is usually consisting of Zinc chloride and ammonium chloride. It increases the wettability of the steel surface to liquid zinc.

5.3. Galvanizing

In this operation the materials are dipped into a bath consist of 98% pure molten zinc at 460°C.

5.4. Water quenching

After galvanizing process the materials are cooled in a clean water chamber, called water quenching. It also increases the smoothness of the material's surface.

5.5. Final inspection

At last the gauge of the zinc coating upon the material's surface is measured using an "Elko meter" [9]. And the approved nuts and bolts are sent to the packaging section.

The overall process is done with the help of hoistcrane2 and to control it eight proximity sensors, four limit switches are used. The overall process is shown in section 4 of the fig1.

5.6. Automation of hoist crane2 control

To control the hoist crane a PLC unit is used. It takes the required decision depends upon the various field level input signals. Then the decision is sent to the field as output signals from the PLC.

5.6.1. Input

Proximity sensors S(13-20), Limit switches (LS3, LS4, LSX, LSY), Push Button (PB6, PB7)

5.6.2. Output

Forward Motor (FM1), Reverse Motor (RM1), Up Motor(UM1), Down Motor(DM1)

5.6.3. Process Description

In case of hoist crain2 control system there are vertical and horizontal paths for the crane movement. To control the vertical moment there are two limit switches LSX, LSY and to control the horizontal movement there are also two limit switches LS3 and LS4. In this section there are four pits and one inspection section. So to stop the hoist just above those pits and to despatch the finished materials in the inspection section, four proximity sensors S13, S14, S15,S16 are used. After loading the cage of the hoist crane with finished nuts and bolts, an operator starts the entire process by pressing a push button PB6. As soon as the operator presses the press button PB6 the forward Motor (FM1) starts running. The cage moves towards the caustic chamber and LSX is reset. S13 senses the incoming crane and stops the forward motor(FM1) just above the chamber. LSX remains in reset condition. Then Down Motor (DM1) starts and the cage moves downward. When the cage dipped into the caustic solution, the down motor stopped by the limit switch LSY. After a time delay, required for cleaning the upper motor (UM1) starts and it runs until LSX is ON. Now S13 is ON, LSX is ON so the forward Motor starts again and the cage moves towards the second pit i.e. flux container. S14 senses the incoming crane and stops the forward motor FM1. Then the above cycle is repeated three times for the fluxing, galvanizing and water quenching process as shown in the section4 of fig1 but the time setting of the PLC timer is different. At last when the crane reached the point D, LS4 stops the forward motor. Then the down motor starts automatically by a timer. After that the finished nuts or bolts are unloaded manually on the inspection floor. After some time delay, required for unloading the up motor (UM1) starts automatically. At last when LS4 and LAX is on the reverse motor(RM1) starts and the cage moves towards the initial point C. When the empty cage reached the point C, the output of LS3 is on which stops the reverse motor RM1. Push button PB7 is provided to stop the process manually.

5.6.4. PLC program

The PLC programming required to control the hoist crane2 is shown in Figure 7.

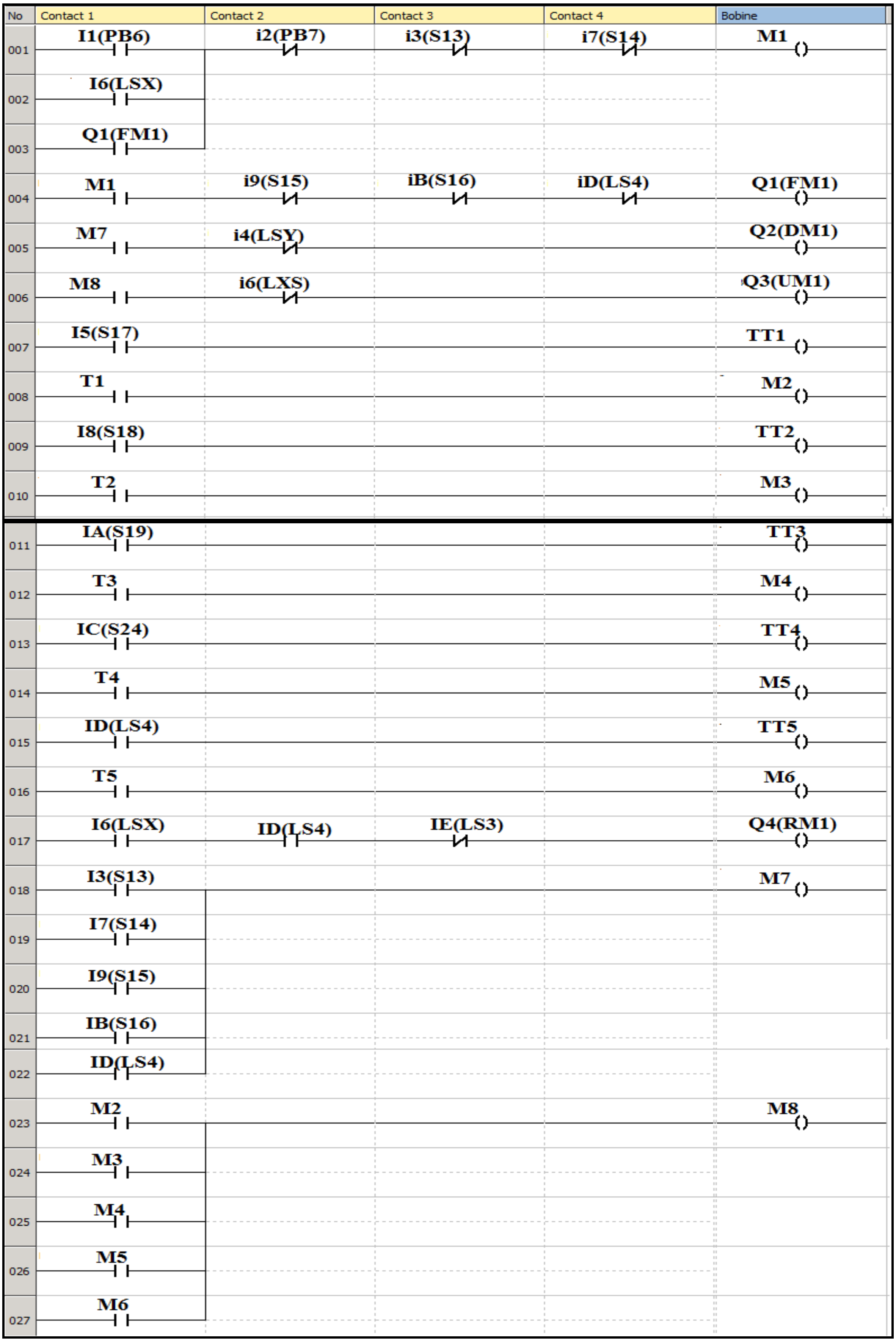

Figure 7. PLC program for hoist2 control

6. PLANT LIGHTING CONTROL SYSTEM

Lighting control system in a plant plays an important role in the reduction of energy consumption of the lighting without impeding comfort goals. Here the overall plant consists of four different sections. Those are pre manufacturing treatment section, nut making section, bolt making section and galvanizing section. All the lighting loads, used in those sections are controlled by this control system. The lights of any particular section put up automatically if works are present in this particular section [10]. Otherwise the lights remain OFF. The reverse happened when the works leave this section. A block diagram of this system is shown in the Figure 8.

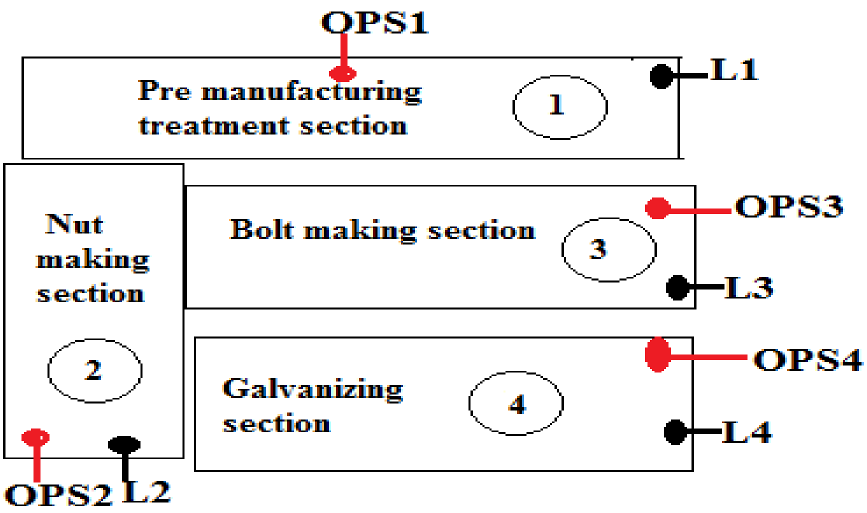

Figure 8. Block diagram of plant lighting system.

6.1. Automation of plant lighting system

To control the section lighting a PLC unit is used. It takes the signals from various occupancy sensors, placed in each and every section and sends the decision to the lighting loads.

6.1.1. Input

Four occupancy sensors(OPS1,OPS2,OPS3,OPS4)

6.1.2. Output

Section lights (L1,L2,L3,L4)

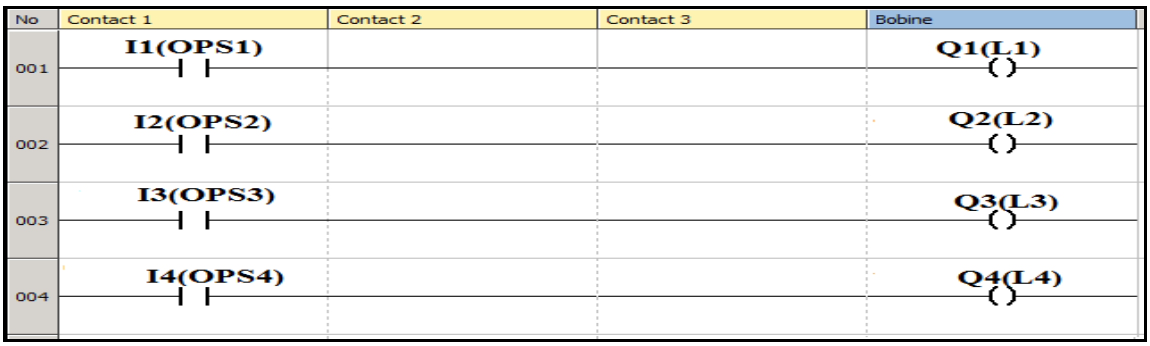

Figure 9. PLC program for plant lighting control system.

6.1.3. Process Description

The occupancy sensor can senses the presence of human in its working range. This simple principle is applied here. If anybody enters in the first section the occupancy sensor OPS1 senses it and turns ON the lights (L1) of this section. When no one present in the section the output of the occupancy sensor becomes zero and lights (L1) turns OFF automatically. The same things happens in case of the other three sections.

6.1.4. PLC program

The PLC programming required to control the overall plant lighting system is shown in Figure 9.

7. CONCLUSION

The galvanizing process is one of the most important units of SME cluster. Bureau of Energy Efficiency (BEE) has already taken various initiatives i.e. energy audit and preparation of Details Project Report (DPR) to reduce the energy consumption for this most unorganized sector in various states of India [11]. In this paper a different perspective of energy saving by virtue of automation is stated. Automation provides some form of monitoring capabilities, either through indicating lamps that's show the status of inputs and outputs that can display the program execution status also .There is also a provision of programmable troubleshooting which reduce downtime. The automation process has flexibility in programming and control techniques. Thus it provides minimum maintenance and small physical size of the galvanizing plant. In this case the automation also provides an accident free environment to the workers and prevents them from coming in direct contact with the various noxious gases that are emitted during the various galvanizing process.

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REFERENCES

[1] Charlotte Evans, March 9,1922,revised March 30,1992, An Anecdotal History of the Galvanizing Industry (Commissioned by the American galvanizers Association),pages (3-4).
[2] Programmable Logic Controllers and Industrial Automation an Introduction.A text book by Madhuchanda Mitra and Samarjit Sen Gupta,pages(1-51).
[3] Dutta Arindam, Chowdhury Ankush, karforma, Dr. Neogi Subhasis, "Automation of Coal Handling Plant", Pro.of conf. on control communication and power Engineering 2010,pages (147-149)
[4] M.S. And High Tensile Nuts And Bolts, prepared by Small Industries Service Institute Industrial Estate, Kokar,Ranchi - 834 001 (Jharkhand).
[5] 8th Edition, Helpful Hints,pages(1-5).
[6] Version 2 ME, IIT Kharagpur, Module 7, Screw threads and Gear Manufacturing Methods, Lesson 31,Production of screw threads by Machining, Rolling and Grinding.
[7] A Guide to Specifying and Inspecting Hot-Dip Galvanized Reinforcing Steel, American Galvanizers Association 6881 South Holly Circle, Suite 108 Centennial, CO 80112 USA 1-800-HOT-SPEC.www.galvanizeit.org.
[8] Hot dip galvanizing –Process, applications, properties. http://www.galvanizingasia.com/pdfs/page9-25.pdf
[9] Dr. Thomas J. Langill,2006,Corrosion Protection, Basic corrosion theory and protection methods.
[10] Chapter 6: Lighting control systems http://lightinglab.fi/IEAAnnex45/guidebook/6_lighting%20control.pdf

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