BEVERAGES PRODUCTION LNE NETWORK SCHEDULING CONTROL SYSTEM AND ALGORITHMS: AN OVERVIEW

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ABSTRACT
This paper provides an overview of the research investigation into industrial production line network scheduling control systems. Production environment like beverage industry is a dynamic setting where unforeseen events can happen at any time. These disturbances will surely have an impact on the production processes. The production line being the foundation of every manufacturing industry consists of several workstations and machines linked in series, with a common transfer mechanism and network control systems. These network control systems enhances the production performance but has an inherent time delay which will introduce the problem of resource contention, and so need scheduling system to resolve them. More so in manufacturing industries time is being allotted to all the machine operations, yet in the quest to meet up with challenges, workload grows creating job queue hence requiring scheduling criterion for efficient control of line activities. The aim of this work is to analyze the line network control system, examine sensor characteristic and locations along the line, and provide a synoptic review of production line network scheduler control system as often found in real life production environment.

Keywords: Production line, Network scheduler control system, scheduling algorithms and Sensor characteristic.

1.0 INTRODUCTION
Production environment like manufacturing industries is a dynamic setting where unforeseen events can happen at any time without prior information. These disturbances will surely have an impact on the production processes (Yu Liu et al., 2018). Production line network being the foundation of every manufacturing industry consists of several workstations and machines linked in series, with common transfer mechanism and network control systems that has inherent induced time delay in its control operations (Aniugo and Eneh, 2016; Sachi and Anwar, 2010). A major component in the network control system is the sensor and it is required that the sensor should be of high precision and accuracy so as to detects the desired physical parameter in the control systems (Maowen and Weiyun, 2022; Zhang, et al., 2017).

Practically devices on the network communicate through a communication medium. Consequently devices sharing a communication medium with timing constrain and delay due the network control operation on control devices will introduce the problem of resource contention, and therefore needs scheduling mechanisms to resolve them (Telchy, 2015). More so in manufacturing industries time is being allotted to all the machine operations, yet in the quest to meet up with challenges, workload grows creating job queue on the line. This queue if not handle appropriately will develop operation time delay which can adversely collapse the system (Yu Liu et al., 2018). Also in manufacturing industry, the resources may include machines, tools and transportation equipment, while different jobs in the production process are tasks that should be scheduled based on the allotted time. In real-life when two or more processes are simultaneously in the ready state of the processing unit, a choice has to be made which process is to run next (Dighriri, et al., 2017). This choice is an act of scheduling which is done by the operating system, and the part of operating system that does this basic task of scheduling is called scheduler and it is using a scheduling algorithm to achieve that (Georgiadis, et al., 2019). The scheduler embedded in the control device of the production line, controls all the scheduling activities of the line system.

2.0 BASIC NETWORK SCHEDULING ALGORITHMS

A queue scheduling algorithm allows an operator to select access to limited resources by selecting the next packet that will be transmitted over a node. There are many queuing scheduling algorithms that are either preemptive or non-preemptive, and each trying to find the correct balance between control, complexity and fairness. Among all these scheduling algorithms, companies have no real industrial standards, instead company refers to its own implementation as standard, meaning that there are implementation specific. Hence companies combine queuing features from generic algorithms to provide the actual functionality that will meet their customer's need (Srilatha, et al., 2018). The basic scheduling algorithms are;

2.1 First Come First Serve (FCFS)

This is the simplest non-preemptive scheduling algorithm and also called first in first out (FIFO). Here when the first job enters the system, execution starts immediately and allowed to run until job processing is completed. Meanwhile other jobs are put in the end of the queue sequentially as they come in waiting for their turn of execution. FCFS has the drawback of very important jobs waiting in the queue for very long time (Dighriri, et al., 2017).

2.2 Shortest Job First (SJF)

Shortest job first is a non-preemptive scheduling algorithm that has the policy of selecting job on the queue with shortest processing time first. Jobs with shorter processing time are executed first before job with longer processing time. So that jobs with longer processing time starve in event of network CPU having steady supply of jobs with short execution time (Akhtar, et al., 2015)

2.3 Round-Robin Scheduling Algorithms (RR)

The Round-Robin scheduling algorithm is the oldest, simplest, fairest and most widely used due to its ability in trying to put balance between control, complexity and fairness. RR is a preemptive scheduling algorithm that allow processes to be dispatched in FIFO manner but are given limited amount of CPU time called Time-slice or Quantum to run. For job processing exceeding their allotted time, the CPU is preempted for the next job on the ready queue to start, and the preempted job is placed at the back of the ready list in the queue. This preemptive nature of RR adversely creates context switches that has the ability to rundown the system (Sohrawordi, et al., 2019).

2.4 Priority Scheduling (PS)

The priority scheduling is also called priority queuing, here tasks, or jobs are first classified by the system and then placed in different priority queues for execution. The ready list on the queue contains an entry for processing in order of their priority. So that a process at the beginning of the list is of highest priority and it is run first (Biswas, et al., 2017)

3.0 NETWORK SCHEDULING CONTROL PROCESS OF DIRECT ONLINE (DOL) MOTOR STARTER IN PRODUCTION LINE SYSTEM.

The efficiency of every manufacturing production line system depend on the functionality of the various motor drive installed at different locomotive points in the production line. Electric Motors are energized and activated to run, halt or stop by signal from sensors located at strategic positions along the production line (Okeke and Eneh, 2022). This is the back bone of scheduling activities, which operates according to scheduling algorithm (scheduler) installed in the system memory. The electric motors and sensors are digitally connected to form a network. Figure 1. Shows the network scheduling control process of direct online motor starter in a beverage production line system.

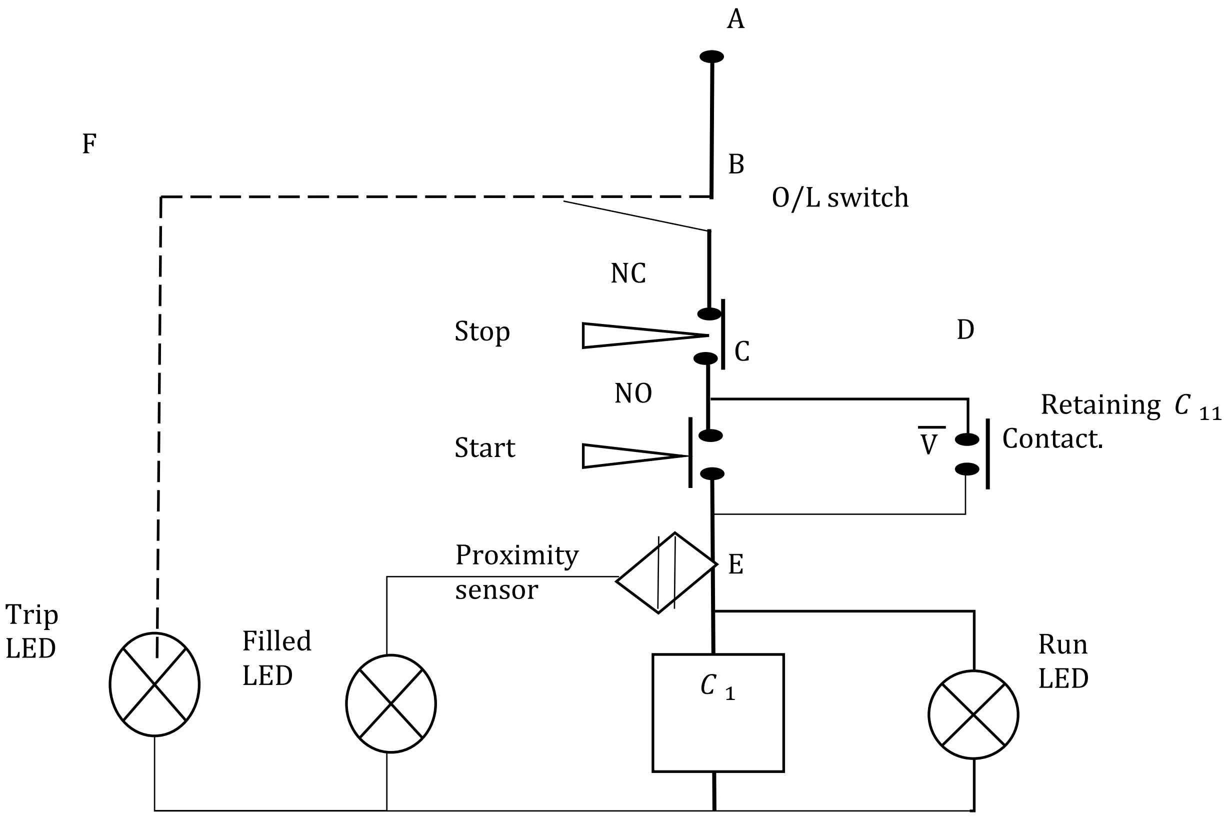

Figure 1: DOL Scheduler Control System Motor Starter Circuit.

From figure 1, the Overload (O/L) switch is a safety device that activates or cut off control voltage supply whenever its maximum current set point is exceeded. The stop button is a normally close (NC) button that breaks the control voltage supply in event of an operator wanting to stop the machine process. The start button is a normally open (NO) button that allow flow or transfer of control voltage from point of higher potential to point of lower potential. Proximity sensor is either inductive or capacitive in nature, the inductive type activates when it senses metal, and it is mounted within the conveyor to check job congestion along the production line. The Contactor (C_1) is an electromechanical switch which energises when power is supplied to its coil. LED is light emitting diode for status display to alert human on the activated operation for Trip, Filled and Run. When the panel is powered, the supply flows from terminal A to terminal C. If the overload switch is closed at point B, then the same supply proceeds to terminal D. When the start button is pressed, supply flows from terminal D to terminal E provided the proximity sensor is not activated. Then C_1 will be energized and the Run indicator will be ON for electric motor to run. But if the overload switch is activated, the supply will flow from terminal A to F and turned ON the Trip indicator to trip. The supply at terminal A to terminal E will be cut off and the machine will not run because there is a trip network signal. If the proximity sensor is activated, it will cut off supply to C_1, and turned the indicator Filled ON, this indicates that there is accumulation and therefore, items should standby or hold-on as regards to accumulating pressure. When the pressure reduces, the contactor C_1 is linked with contactor C_{11} hence energizes C_{11} to affect the return contact which returns the contact to point C. The start button is press ON thereafter for motor to commence running. This shows that the network scheduling control system in the production line, regulate the conveyor system through the help of proximity sensor to avoid bottles jams along the rails. This is because of its intelligence to pause or stop machine systems in event of unforeseen congestion in the production line.

3.1. Direct Online Motor Starter Logical Operation

The logic diagram as shown in figure 2, indicates the operation of the electric motor via a logical control from the control circuit.

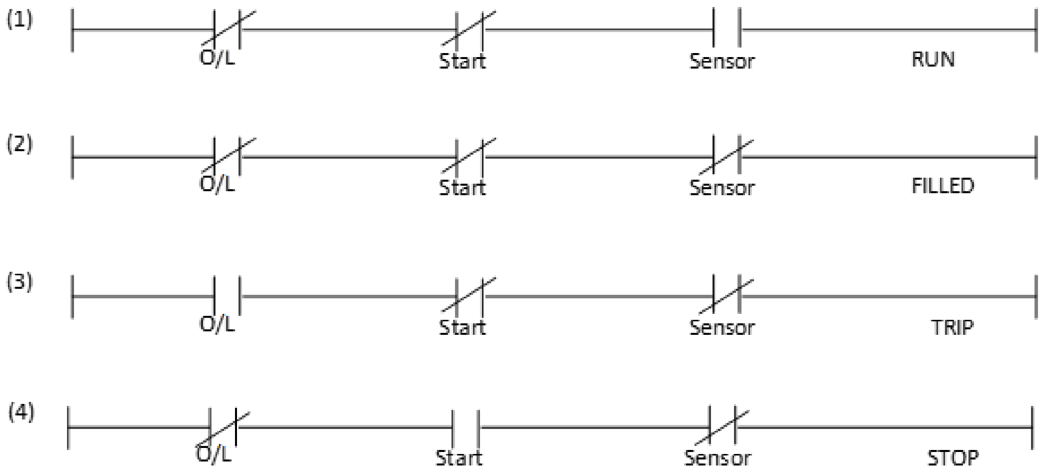

Figure 2: Direct Online Motor Starter Logical Diagram

When the overload switch (O/L) is closed, the start button is closed, and the proximity sensor not activated, the motor run to drive the system. This is shown by the Run LED indicator coming ON.

When the O/L is closed, the start button is closed, and the proximity sensor is activated, indicating pressure due to congestion, the system sends output signal for machine to hold-on. This activates the Filled LED indicator to come ON and the system will be on standby. But when the O/L is open, the start button is closed. The proximity sensor may be activated or not, the system sends output signal for machine to trip. This is because the O/L is activated and indicating voltage error. Hence the Trip LED comes ON. While when the O/L is closed, the start button is opened, and the proximity sensor is activated, the system sends output signal for machine to Stop.

4.0 NETWORK SCHEDULING CONTROL PROCESS OF CROWN ELEVATOR SYSTEM

The crown elevator section is a functional unit in a beverage production line system where the cocking of the filled bottle are driven and controlled by the network scheduling activities of the various installed sensors and motors in the system. Figure 3 shows the crown elevator scheduler control system.

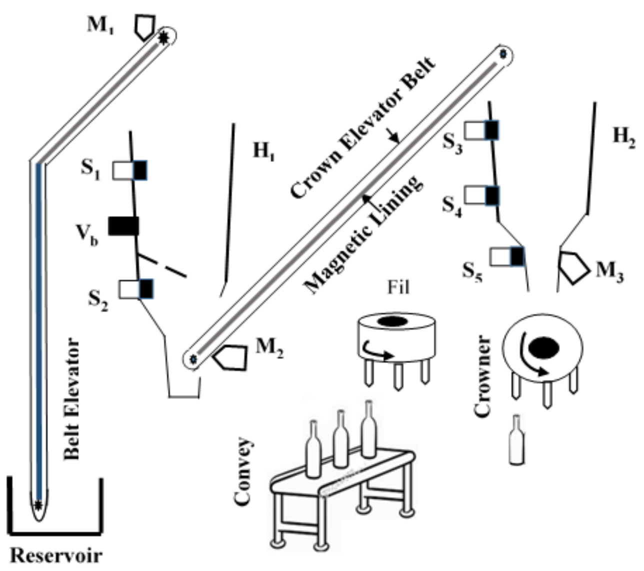

Figure 3: Crown Elevator Scheduler Control System

The crown elevator scheduler control system controls the flow of crowns from reservoir to corking of the bottles at the upper chamber, this is shown in figure 3. The belt elevator has a magnetic lining mounted in between the belt, which magnets the metallic crown corks on the belt and is carried by the belt as it revolves round the magnetic lining. By this arrangement the crowns can be moved from reservoir to lower hopper and then to upper hopper for corking of the liquid pressure filled bottles. These are made possible by the operations and control of reservoir elevator motor (M_1), lower hopper belt drive motor (M_2) and the crown cork feeder motor (M_3). These motors are linked up to sensors S_1 to S_5 with high precision and strong sensitivity to sense and activate the motors to a Run stage, Trip stage and Off stage. The conveyor that conveys the bottles from the filler section to the crown cork section is synchronized to the motor drive for a controlled movement of bottles to the destination stage.

On filling the reservoir with crowns and the selector switch selected to auto mode, M_1 is activated to run and crowns are moved from reservoir to lower hopper as shown in figure 3. The M_1 continue to run until sensor S_1 senses crown full in the lower hopper and then deactivates M_1. If the reservoir run out of crown the hooter is activated to horn for crown replenishment.

Similarly M_2 is activated to run and vibrator V_b vibrates to agitate crown towards the belt elevator for transporting crowns to upper hopper. If the upper hopper is filled with crowns, the sensor S_3 activates and disconnects machine M_2. Meanwhile motor M_3 continues to run and crowning the bottles as long as sensor S_5 is still deactivated.

Now if the lower hopper run out of crowns, sensor S_2 will be activated to indicate that lower hopper is empty, then motor M_1 will be activated again to replenish crowns to the lower hopper. While on event of reduction of crowns at the upper hopper, the sensor S_4 activates for M_2 motor drive to start operation and replenish the crown until sensor S_3 senses crown. An on-delay time (timer) is configured to keep motor M_2 running for a while after sensor S_4 detects crown at the upper hopper. The timer latches the crown elevator motor M_2 contactor normally closed (NC) contact upon sensor S_3 detecting crown to stop motor M_2. Also if sensor S_5 detects crown unavailable, the crowner main drive will be activated to automatically stop the system to avoid missing crowns on the bottles that are continually on motion. This scheduler system with the help of signal from the network scheduler control unit, regulates the entire activities of the crown production line.

4.1 Crown Elevator System Logical Operation

The crown elevator system logical operational circuit shown in figure 4, depicts a pictorial summary of the network scheduling control process of crown elevator system.

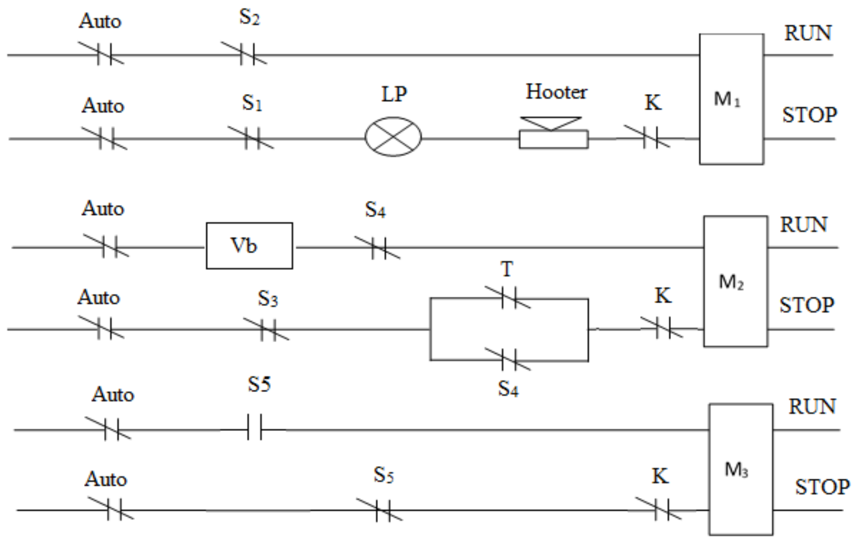

Figure 4: Crown Elevator Logical diagram

From figure 4, the crown elevator has three motors M_1, M_2 and M_3 logically connected to the sensors, so as to Run or Stop on sensor activation. The K is the main switch that trips off the entire system at empty of crowns in the upper hopper or on emergency.

Now when the auto selection key is ON and sensor two S_2 is activated, motor M_1 will run to fill in crowns in the lower hopper. But while auto is still ON and either sensor S_1 or main switch K is activated, motor M_1 will stop. Also while auto is ON and sensor S_4 is activated, the vibrator V_b comes ON and motor M_2 triggers run to fill in the upper hopper with crowns. While the system is still in operation and sensor S_3 is activated, motor M_2 will stop running. Also in refilling the upper hopper with crowns, motor M_2 is supposed to stop at S_4 sensing the crowns but a delay timer on S_4 will keep the motor M_2 running only to stop at the activation of sensor S_3. And while the system is in operation, motor M_3 keep running to cork the bottles with the crown as long as sensor S_5 is not activated. But when sensor S_5 is activated, the main switch K will be activated and motor M_3 will stop running. Note that the main switch K is a critical point activation that is inactive in the production process. It only triggers ON when sensor S_5 is activated to prevent uncork bottles from leaving the upper chamber.

5.0 CONCLUSION

An overview of beverage production line network scheduling control system and algorithms has been presented and herein stated that industrial scheduling algorithms are implementation specific. Scheduler control of direct online motor starter and its logical circuit have been highlighted for better understanding of real life operation of direct online motor system scheduling activities. It has been seen from the overview that the automatic control of crown elevator system activities completely depend on the sensitivity and accuracy of the sensor devices implemented in the production line system. Therefore there is need for routine examination, maintenance and replacement of these sensors to meet optimum functionality in industrial production line system.

NOMENCLATURE

H_1 Lower Hopper.
H_2 Upper Hopper.
Lp_1 Trip Indicator Light.
V_b Vibrator.
M_1 Reservoir Elevator Motor.
M_2 Lower Hopper Belt Drive Motor.
M_3 Crown Cork Feeder Motor.
S_1 Lower Hopper Upper Limit Proximity Sensor.
S_2 Lower Hopper Lower Limit Proximity Sensor.
S_3 Upper Hopper Upper Limit Proximity Sensor.
S_4 Upper Hopper Lower Limit Proximity Sensor.
S5 Upper Hopper Extra Lower Limit Proximity Sensor.

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