Chapter 9

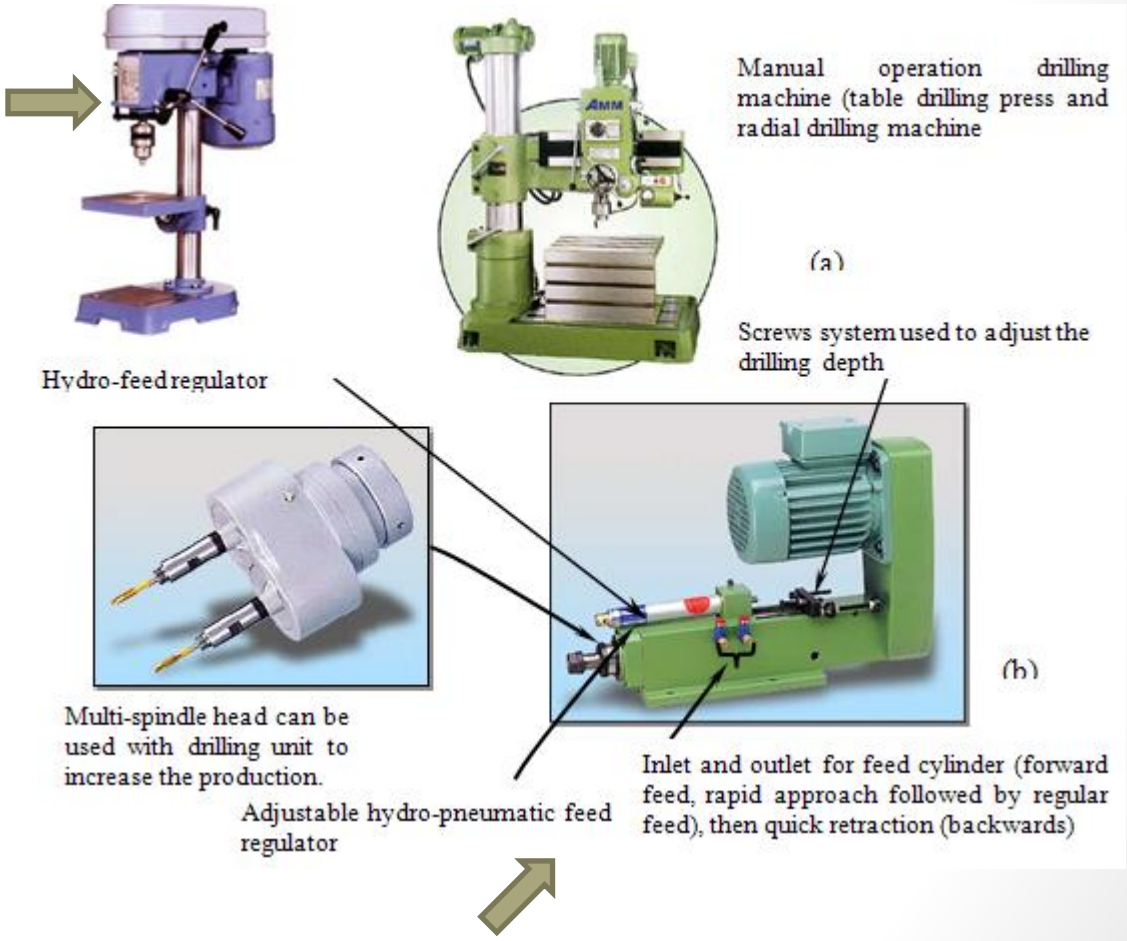
Illustrated Industrial Automation Applications

9.1 Machine tool automation problem (drilling process automation).
9.2 Metal forming process (forming a simple clip using multiple-slide pressing machine).
9.3 Process assembly automation.
9.4 Volumetric filling automation system (chemical/food Industries)

9.1 Machine tool automation problem (Drilling Process Automation)

Conventional Drilling Process.

In production lines, drilling units are used where mass production is required. Multi-spindle head sometimes is used to increase the production rate, see Fig. 9.1b.
Furthermore, pneumatic or hydraulic power fixture is used to clamp the work piece and holding drilling bushes to reduce the labor cost, see Fig. 9.2.

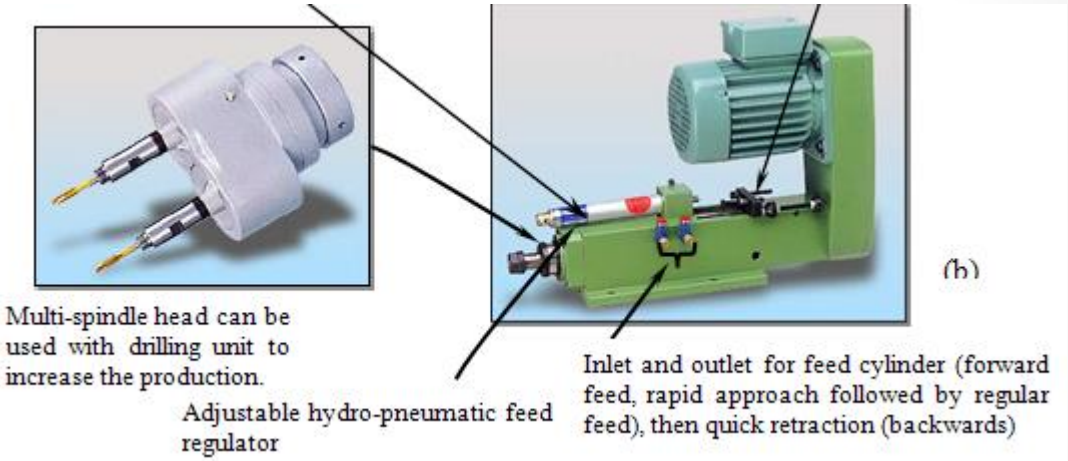


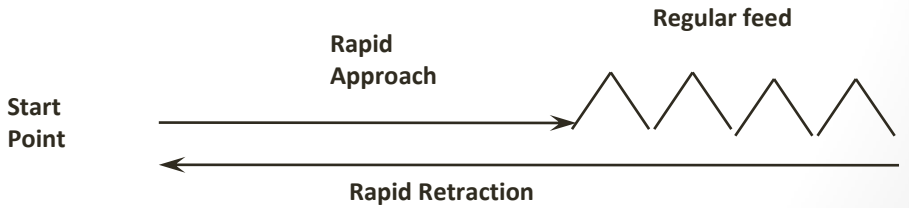
Automated Drilling Process

9.1 Machine tool automation problem (drilling process automation)

In hole production, drilling operations Three steps using the drilling unit.

1. **Rapid approaching** of the drilling bit is carried out using pneumatic (or hydraulic power for larger drilling capacity) double acting feed cylinder and 5/2 (or 5/3) solenoid valves.
2. **The regulated feed** is accomplished using adjustable hydro-pneumatic feed devices, which also adjusted longitudinally to the required drilling depth.
3. **Rapid retraction** is carried **out** using the feed cylinder by reversing the direction of airflow through the 5/2 or 5/3 solenoid direction valves





9.1 Machine tool automation problem (drilling process automation)

Machine Actuators and Feed-back sensors:

•Two contact limit switches, or reed switches: **Two extreme positions of the feed cylinder.**

•Single phase (or three-phase motor): **Spindle drive**

•Powered drilling fixture: **Clamp and guide the drilling bits through drilling bushes**.
(Using pneumatic double acting cylinder and through the 5/2 or 5/3 solenoid valve)

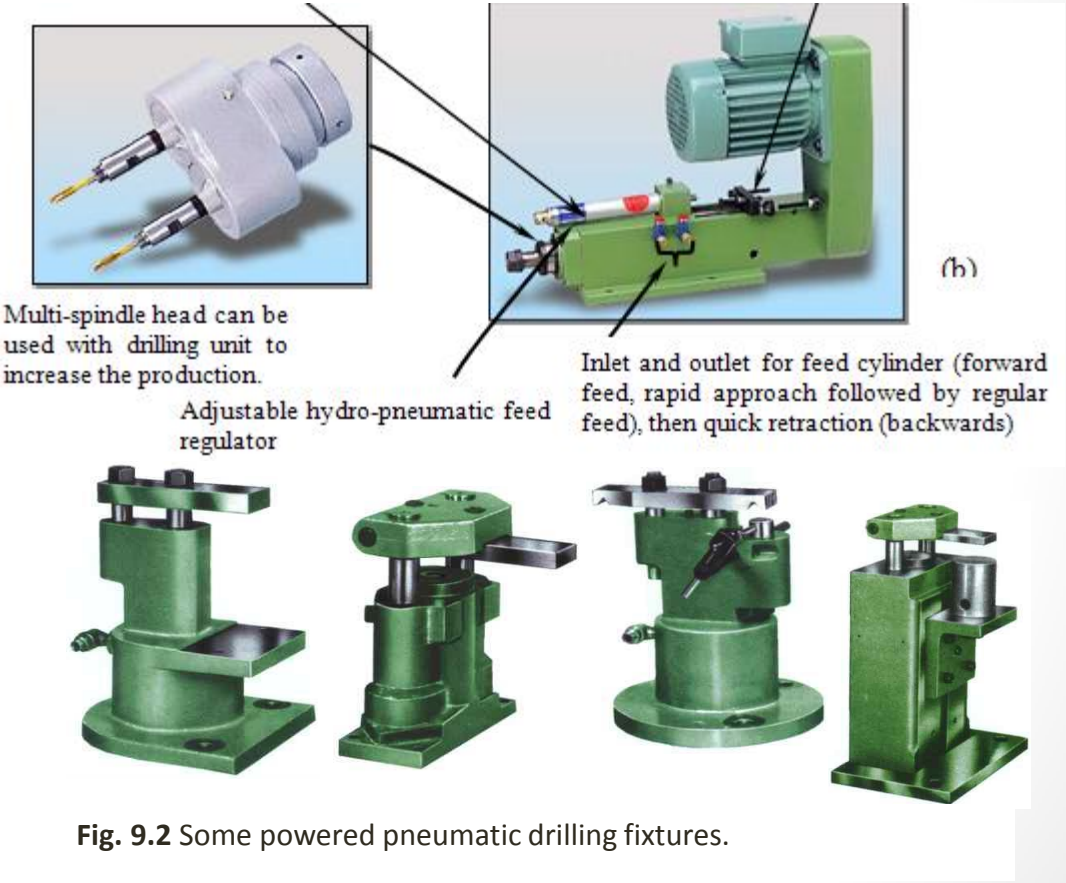


Fig. 9.2 Some powered pneumatic drilling fixtures.

Where:

9.1 Machine tool automation problem (drilling process automation)

Machine switching elements and actuators:

Fig. 9.3 Suggested user-panel control and limit contact-switches. (limit switch, push-button switch and selector switch)

Push-button and selector contact switches will be used for machine-user control panel.
Reed or limit switches will be used to monitor the extreme positions of the feed cylinder and clamping fixture-cylinder.

Suggested machine actuator and machine cycle

Two machine cycles will be used; automatic and manual cycles. Manual cycle will be used during machine setup (i.e. during adjustment of drilling depth). The automatic cycle will be used to carry out the production run. The machine cycle will be written as follows:

$$START, M+, B+, A+, A-, M-, B-.$$

M+; *Spindle Motor On*

B+; *Clamp the work piece*

A+ *;Feed cylinder forward toward work piece*

M- *; Motor Off*

B- *; Unclamp the work piece*

A- *; Feed cylinder retract from work piece*

Where:

9.1 Machine tool automation problem (drilling process automation)

Table 9.1 Suggested switching elements and its functions for drilling control problem.

Switching element	Symbol	Type	Its function
Start switch	*START*	Push bottom contact switch	Pressed by the operator to start the automatic machine cycle.
Emergency stop switch	*STOP*	Push bottom contact switch	Pressed by operator for emergency condition
Manual/Automatic selector switch	*Man/Auto*	Two position selector switch with two contacts (has mechanical memory)	Selected by operator to switch between automatic and manual cycles
Forward position of the feed cylinder	*.a+*	Reed or limit contact switch	To monitor drilling depth and used to adjust the drilling depth
Backward position of the feed cylinder	*.a-*	Reed or limit contact switch	Used to monitor the backward position of the feed cylinder
Monitor clamping switch	*.b+*	Reed or limit contact switch	Used to monitor the clamping condition of the work piece
Monitor unclamping switch	*.b-*	Reed or limit contact switch	Used to monitor the unclamping condition of the work piece
Manual feed switch	*Man a+ / Man a-*	Three position selector switch with two contacts and neutral position (with mechanical memory)	Used for manual feeding the drilling unit (forward and backward), used during machine setup
Manual clamping/unclamping the workspace switch	*Man b+ / Man b-*	Three position selector switch with two contacts and spring return to neutral position (no memory)	Used for manual clamping/unclamping the work piece during machine setup
Manual motor on/off	*Man M+*	Two position selector switch one contact (with mechanical memory)	Used for manual switching on/off the spindle motor

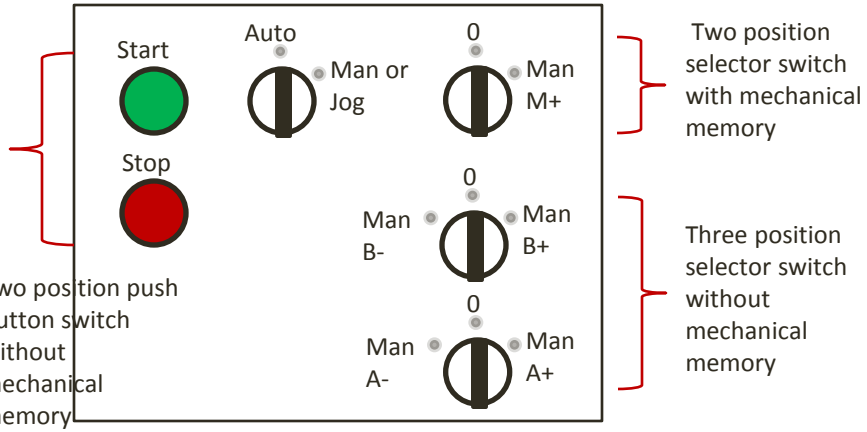
Where:

Development of *RLL* for the given machine sequence:

The machine sequence can be grouped using CASCAD method and given as follows

$$START, M+, B+, A+, A-, M-, B-.$$

$$\cdots \; Group \;\; 1 \;\Big|\; \ldots \; Group \;\; 2$$



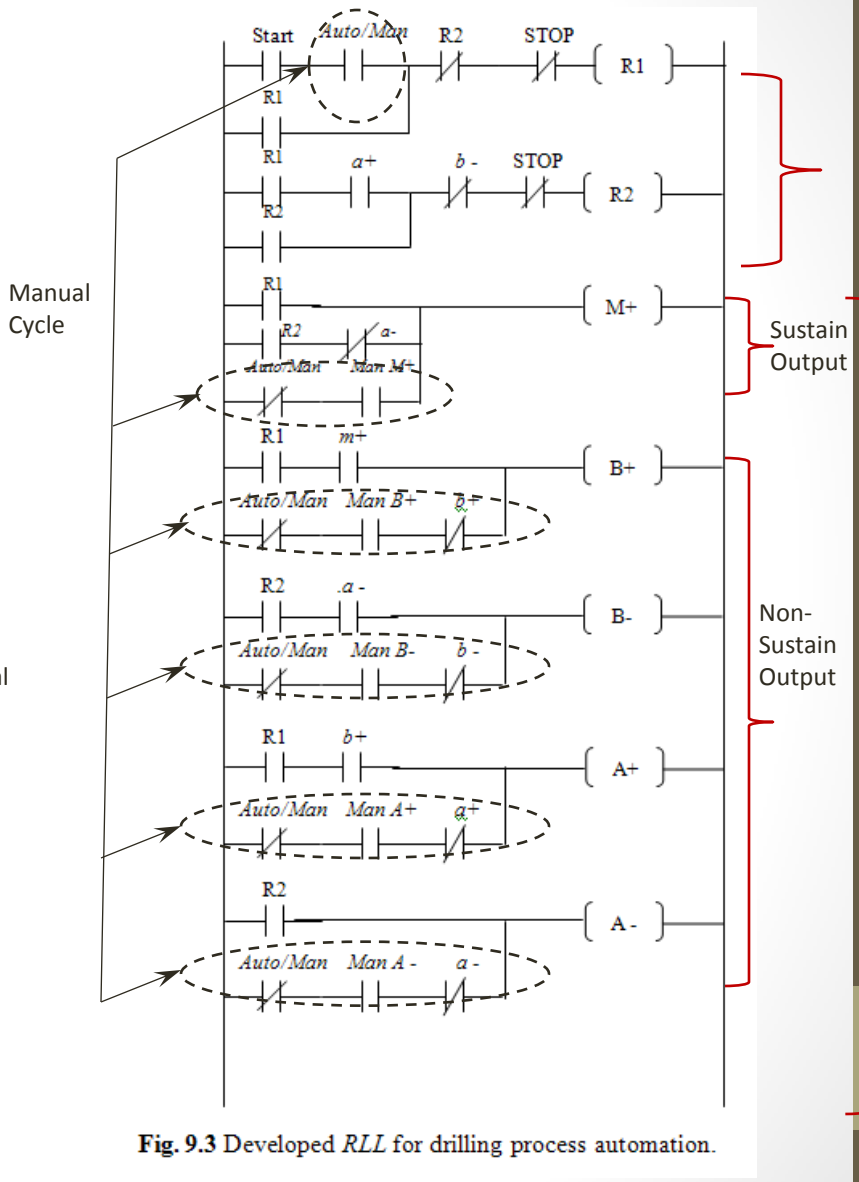


Fig. 9.3 Developed *RLL* for drilling process automation.

Where:

9.3 Process assembly automation : Insulation Paper Cutting Machine

Machine Function
The insulation paper is supplied as roll strip to machine rack where pulled out using feeding mechanism longitudinally. At the end of feeding stroke, cutting plad mechanism is used to cut the paper to the specified paper length. As protection for machine structure, the machine will not operate if no paper stock on the paper moving mechanism through an optical sensor SW1.

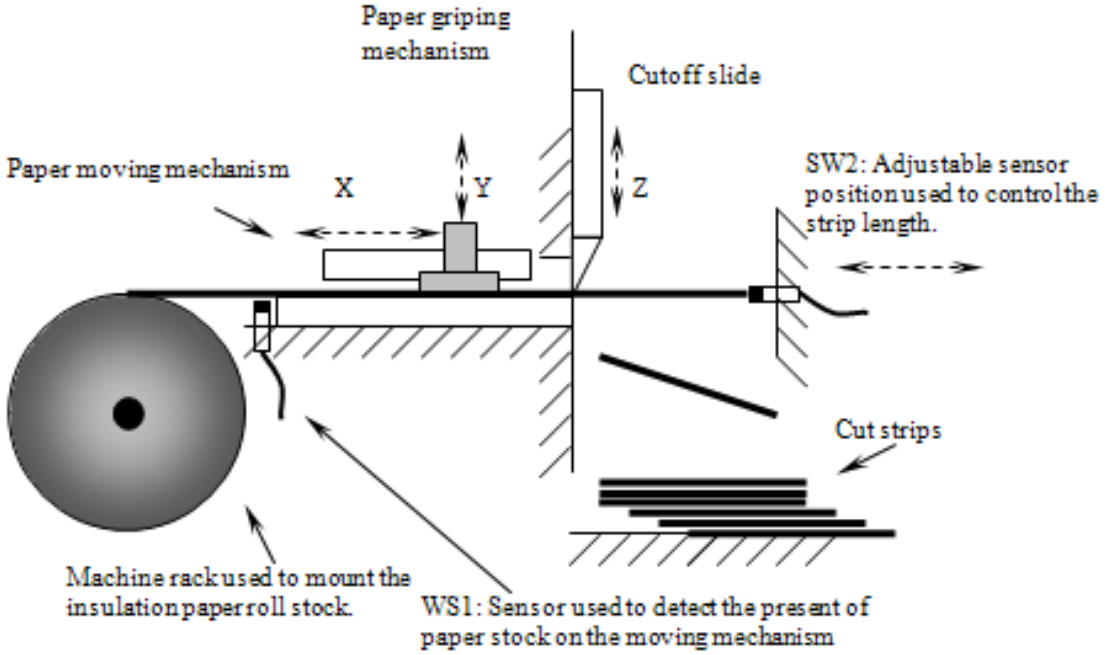


Fig. 9.7 Paper cutting assembly machine.

Where:

9.3 Process assembly automation : Insulation Paper Cutting Machine

Summery of machine cycle is given as follows:

1. Griping paper stock : Pneumatic cylinder Y+.
2. Forward movement of paper stock: moving mechanism through pneumatic cylinder X+, where 5/3 directional valve is used to actuate cylinder X.
3. Optical sensor SW2: detect the position of paper strip when reach the specified length.
4. Cutoff mechanism : cutoff slide using pneumatic cylinder Z+.
5. Simultaneously cutoff slide will retract to its original position (Z-).
6. Releasing paper stock by retracting griping cylinder (Y-).
7. Back movement for stock moving mechanism using cylinder (X-).
8. End.
9. Repeat when needed

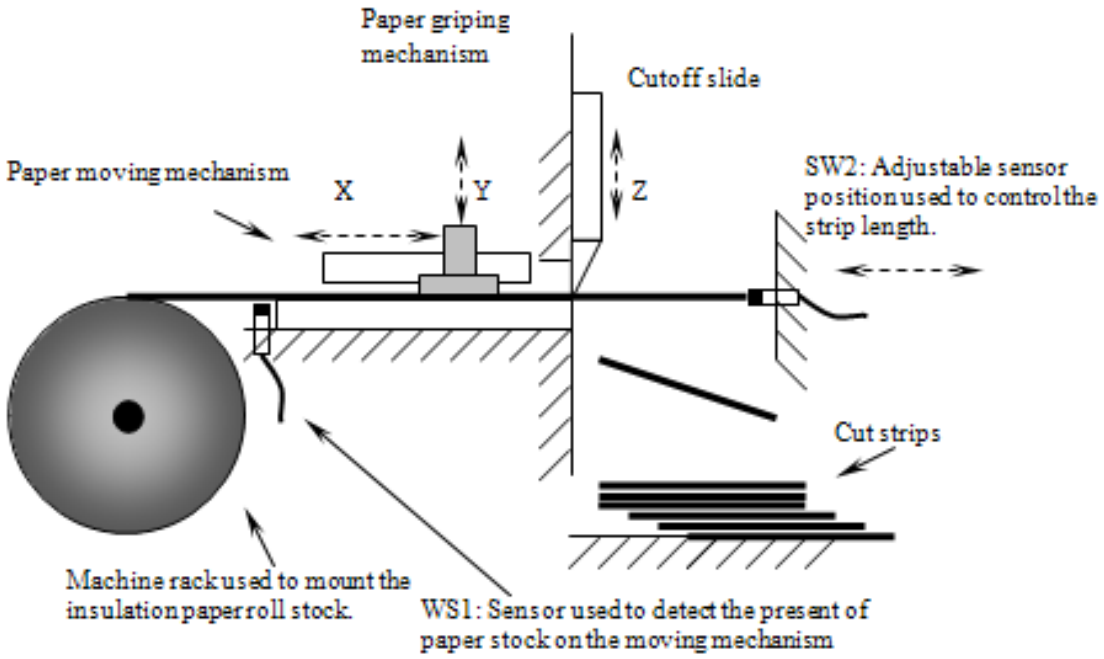


Fig. 9.7 Paper cutting assembly machine.

Where:

9.3 Process assembly automation : Insulation Paper Cutting Machine

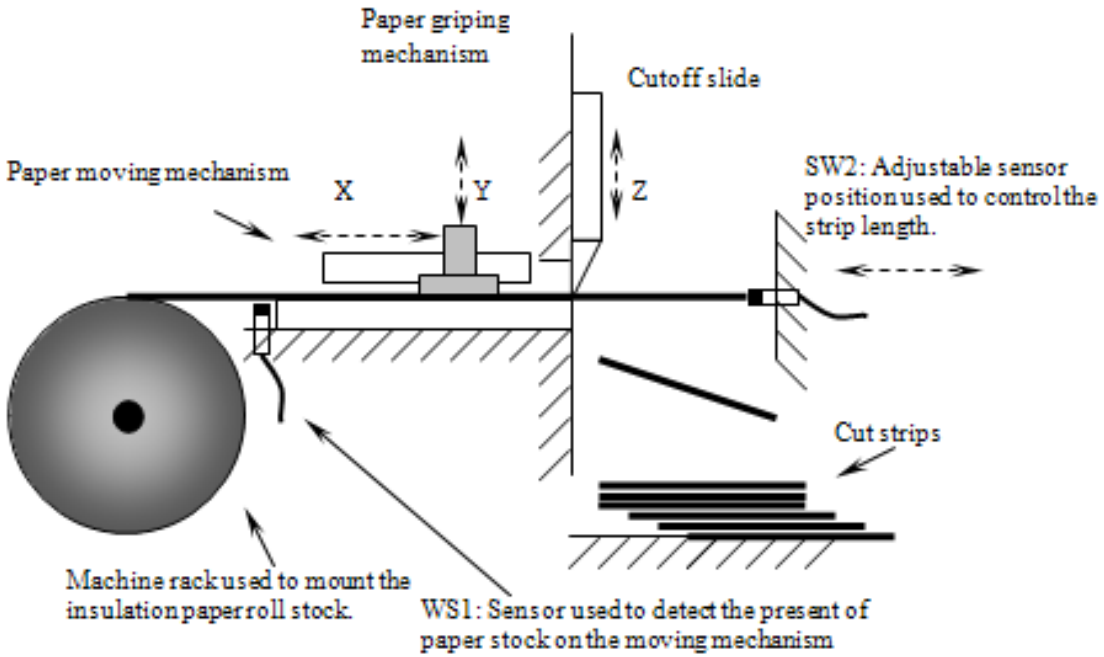
These cutting processes can be repeated for agiven number of cutting stripes. Machine cycle can be written as follows:

$$START, Y^+, X^+, Z^+, Z^-, Y^-, X^-.$$

$$START, Y^+, X^+, Z^+, Z^-, Y^-, X^-.$$

$$G1 \quad | \quad G2$$

RLL for cutting single paper stripe is given as follows:



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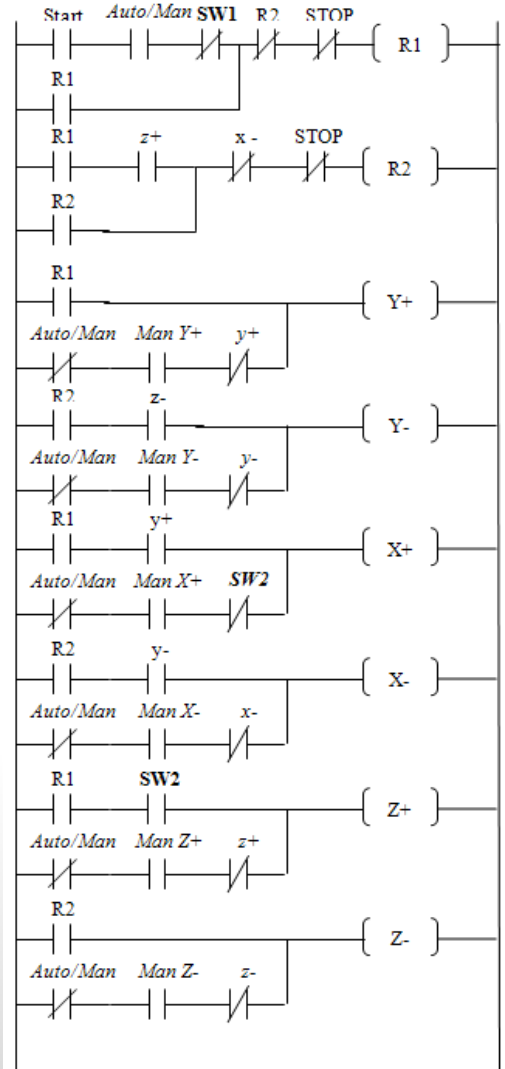


SW1 is used here to disable the machine operation in no paper stock is exist.

SW2 switch is used here to provide actual feed back signal on reaching the exact strip length.

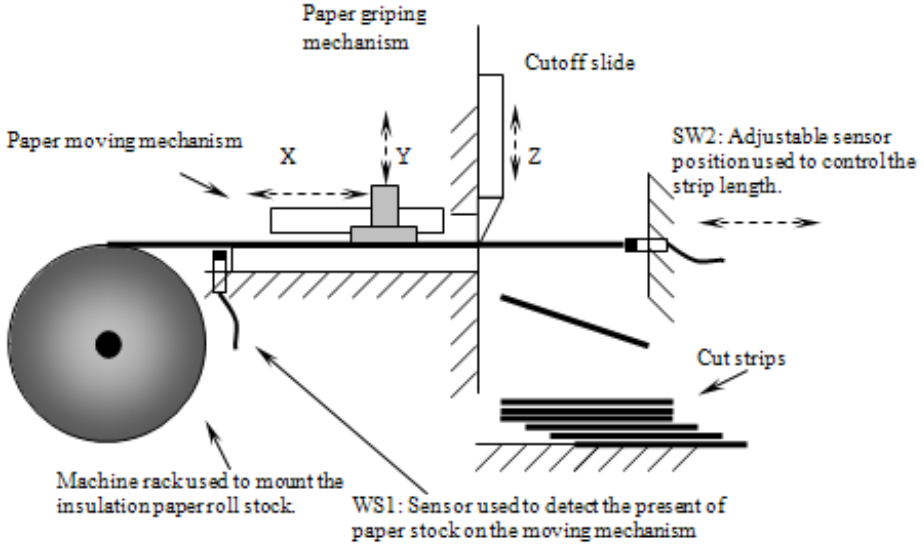
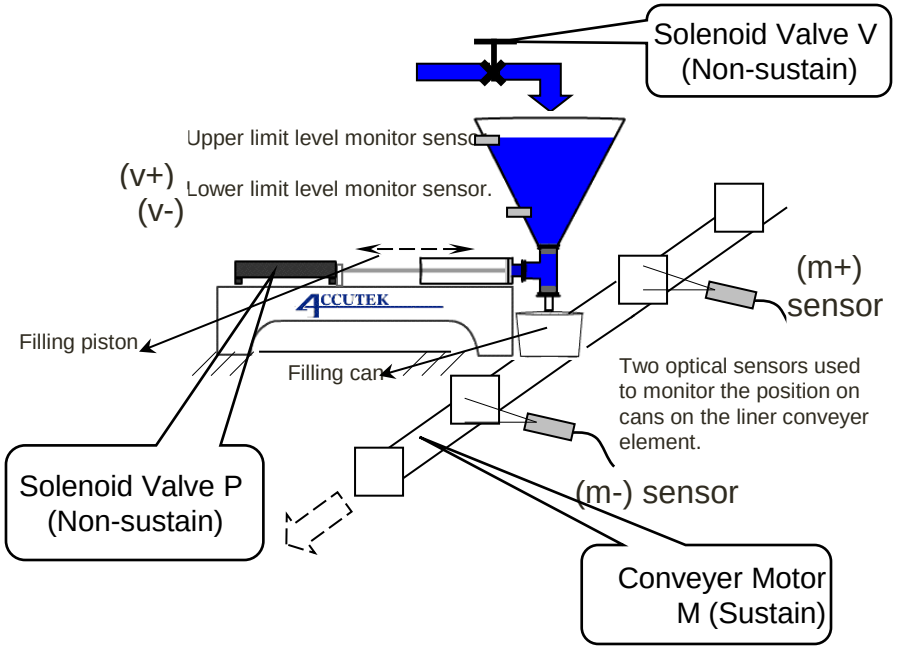


Fig. 9.7 Paper cutting assembly machine.

9.4 Volumetric filling automation process

Machine actuators and sensors are given as follows:

- Pneumatic cylinder used to move the filling piston.
- Solenoid valve, open and closed to fill in the hopper. Two approximate sensors used to monitor upper and lower hopper levels.
- AC induction motors used to move the conveyer and two optical sensors used to monitor conveyer position.



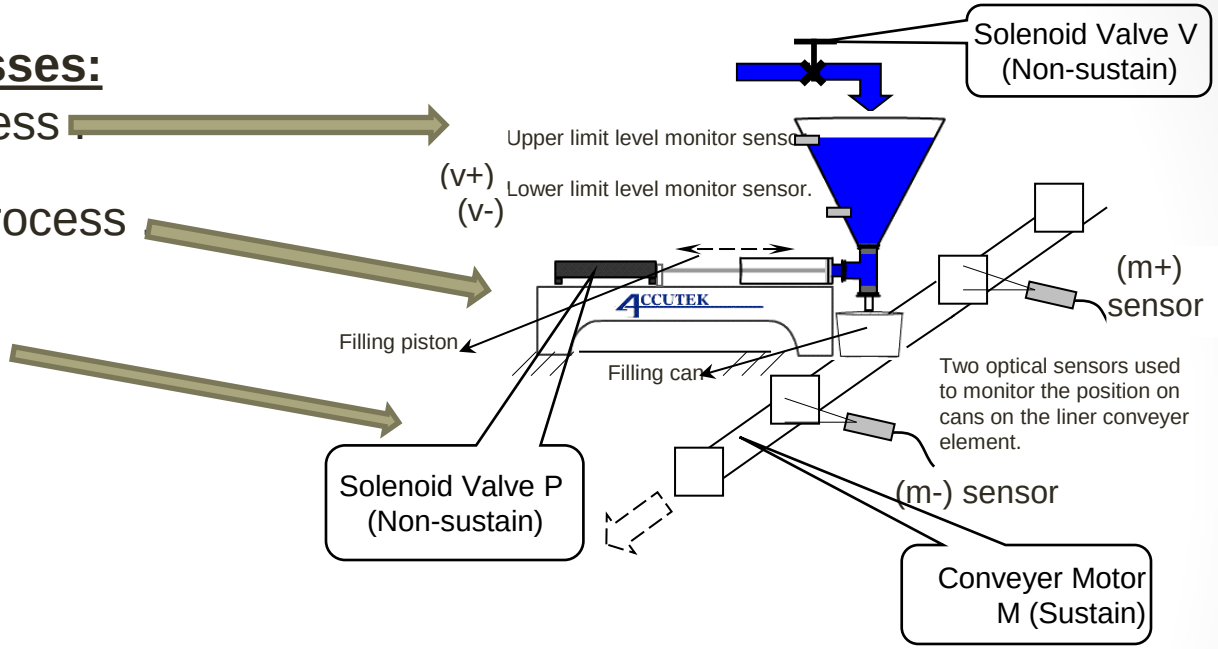
9.4 Volumetric filling automation process

9.4.1Machine Processes:

3)Hooper Filling Process .

1)Volumetric Pump Process

2)Conveyor Process.



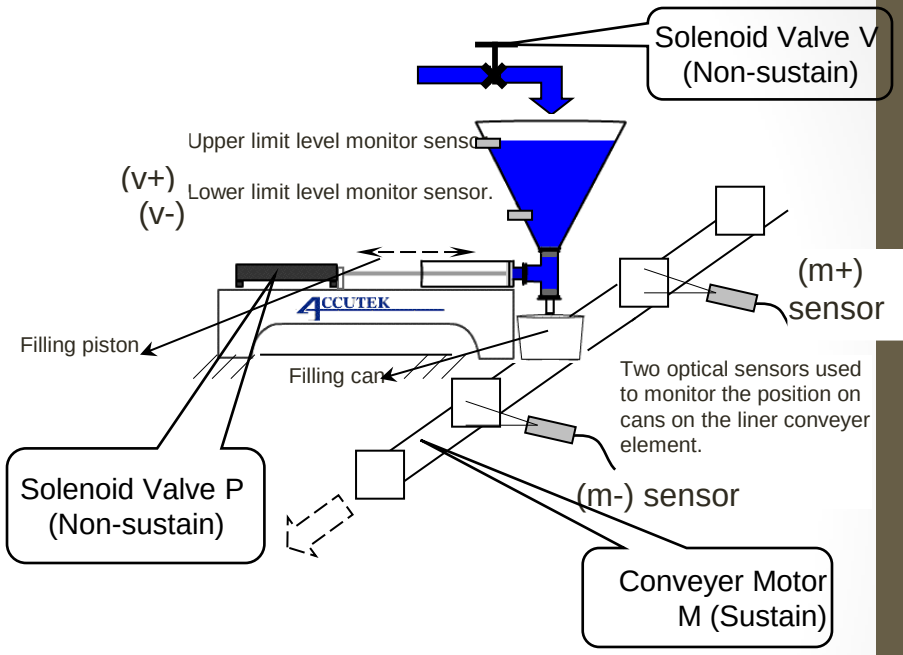
9.4 Volumetric filling automation process

9.4.3Actuators, control signals and switching elements

•Volumetric displacement pump: driven using double acting cylinders and having 5x3 solenoid directional valve as switching element with *NON-SUSTAIN* control signals. **(Symbolic address P⁺ (pump discharge state), P⁻ (pump in suction state)**

•Conveyor :driven using three phase induction gear motor having ONE electromechanical relay as witching element with SUSTAIN control signal. **(Symbolic address M+ (motor on state), M- (motor off state).**

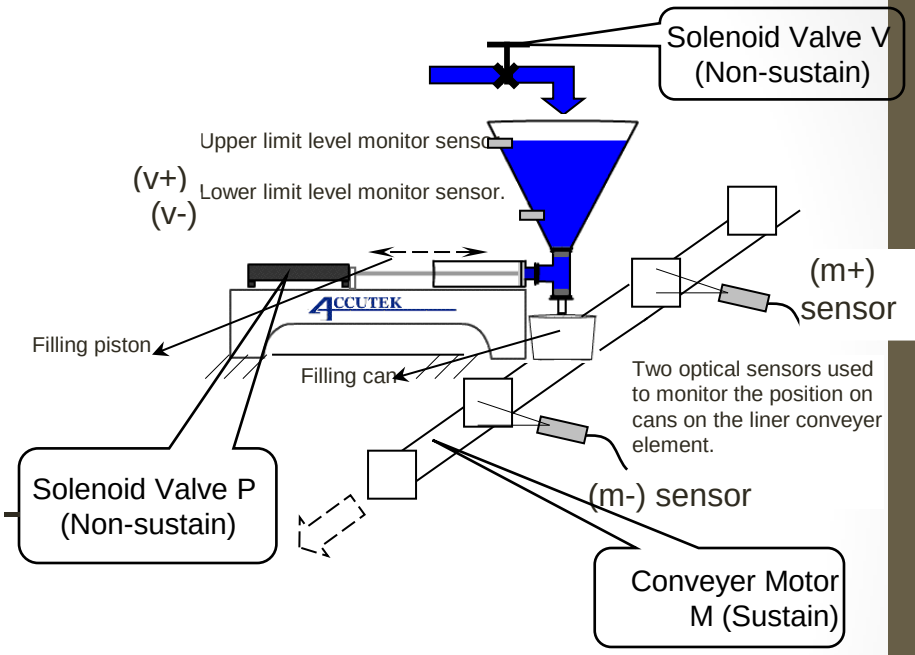
•Hooper storage: Solenoid directional valve having two solenoids to fill in the Hooper having **NON-SUSTAIN control signals. (Symbolic address V+ (valve open state), V- (valve close state))**



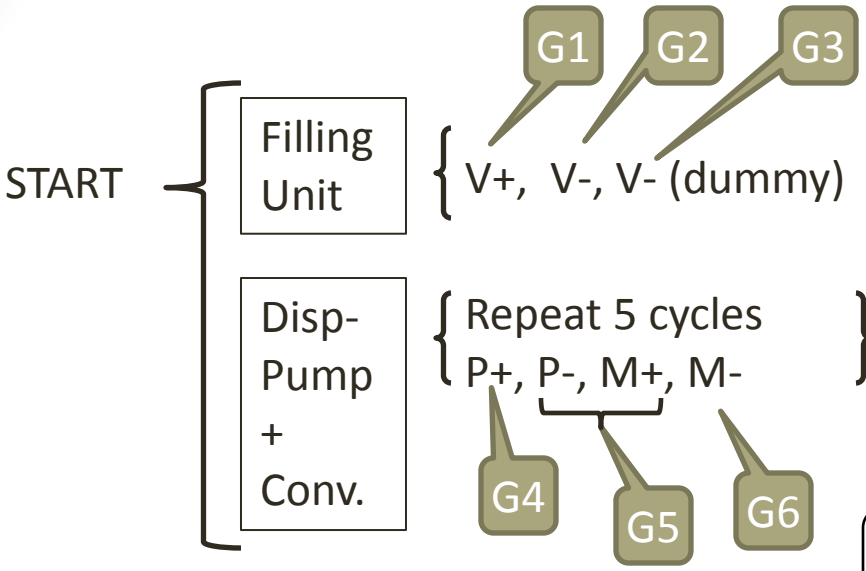
9.4 Volumetric filling automation process

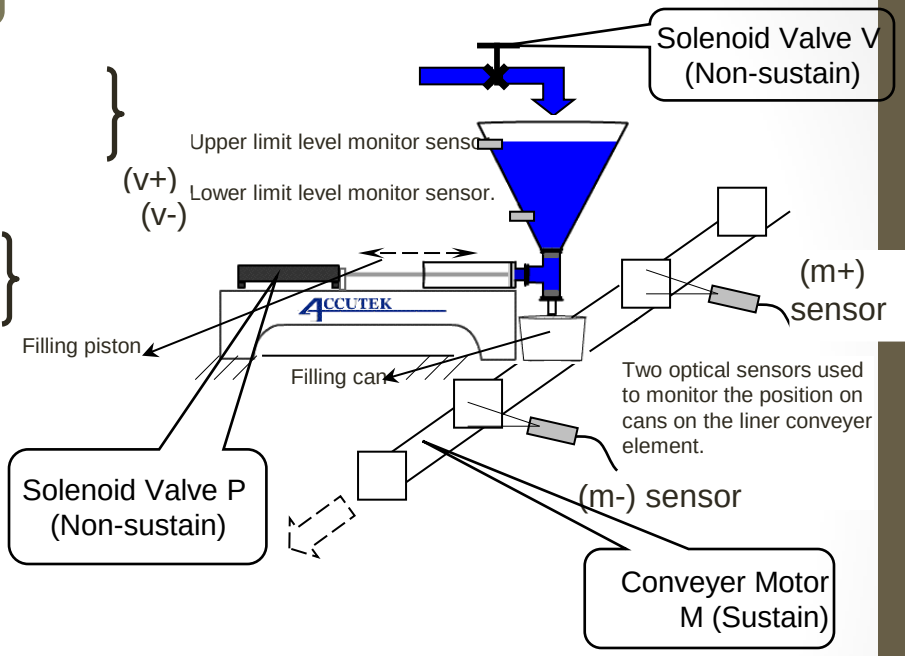
9.4.4 Feedback signals:

- Volumetric Pumps : Two magnetic reed switches at discharge and suction piston strokes **(Symbolic address p+, p-)**
- Conveyor motor : Two photo-detectors (reflection from target type) **(Symbolic address m+, m-)**.
- Hooper unit: Two capacitive proximity on top and bottom on Hooper (**Symbolic address v+ ,v-)**



9.4 Volumetric filling automation process



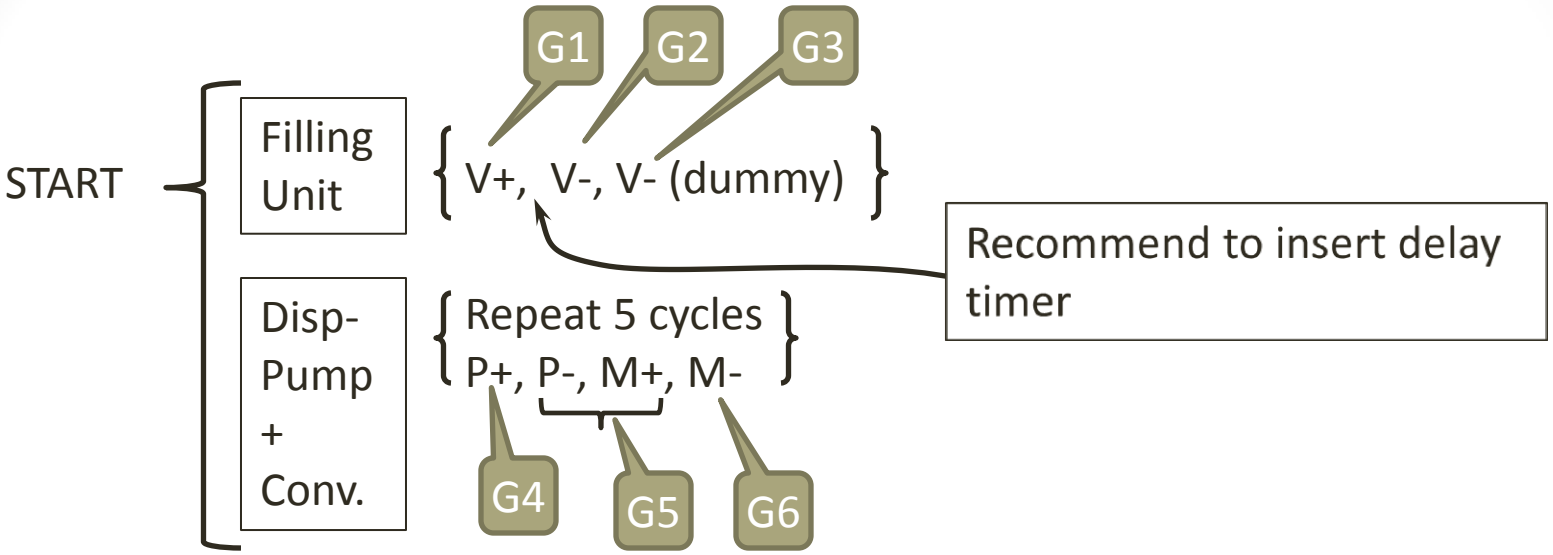


9.4.2Control Strategy :

•The Hooper Filling Process will be effected as long the two processes (volumetric pump + conveyor) is enabled. (Parallel process)

•Volumetric pump and conveyor will run together in series. (Single path).

9.4 Volumetric filling automation process



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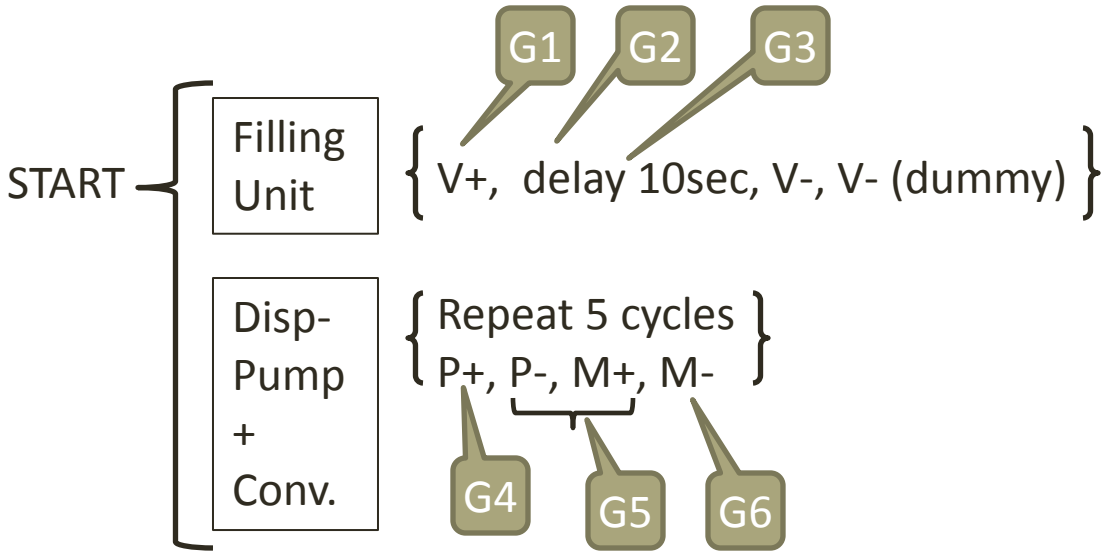

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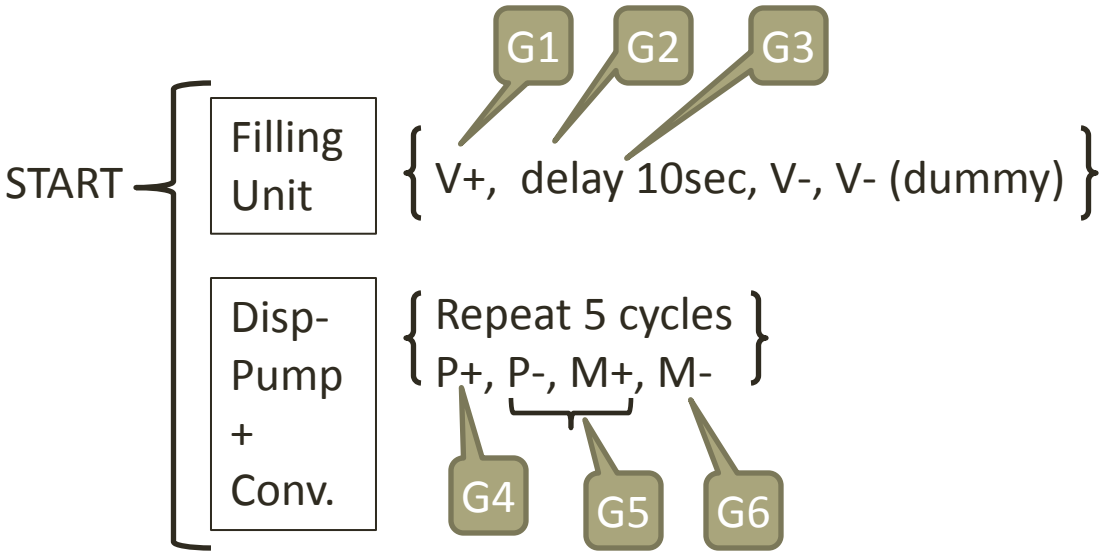
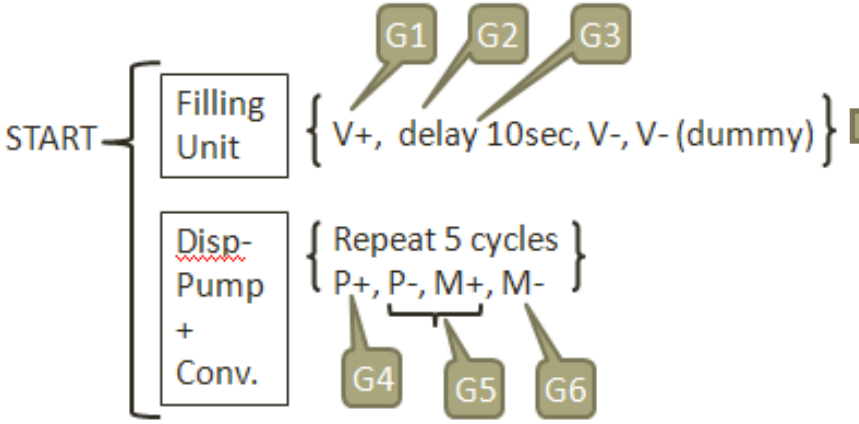
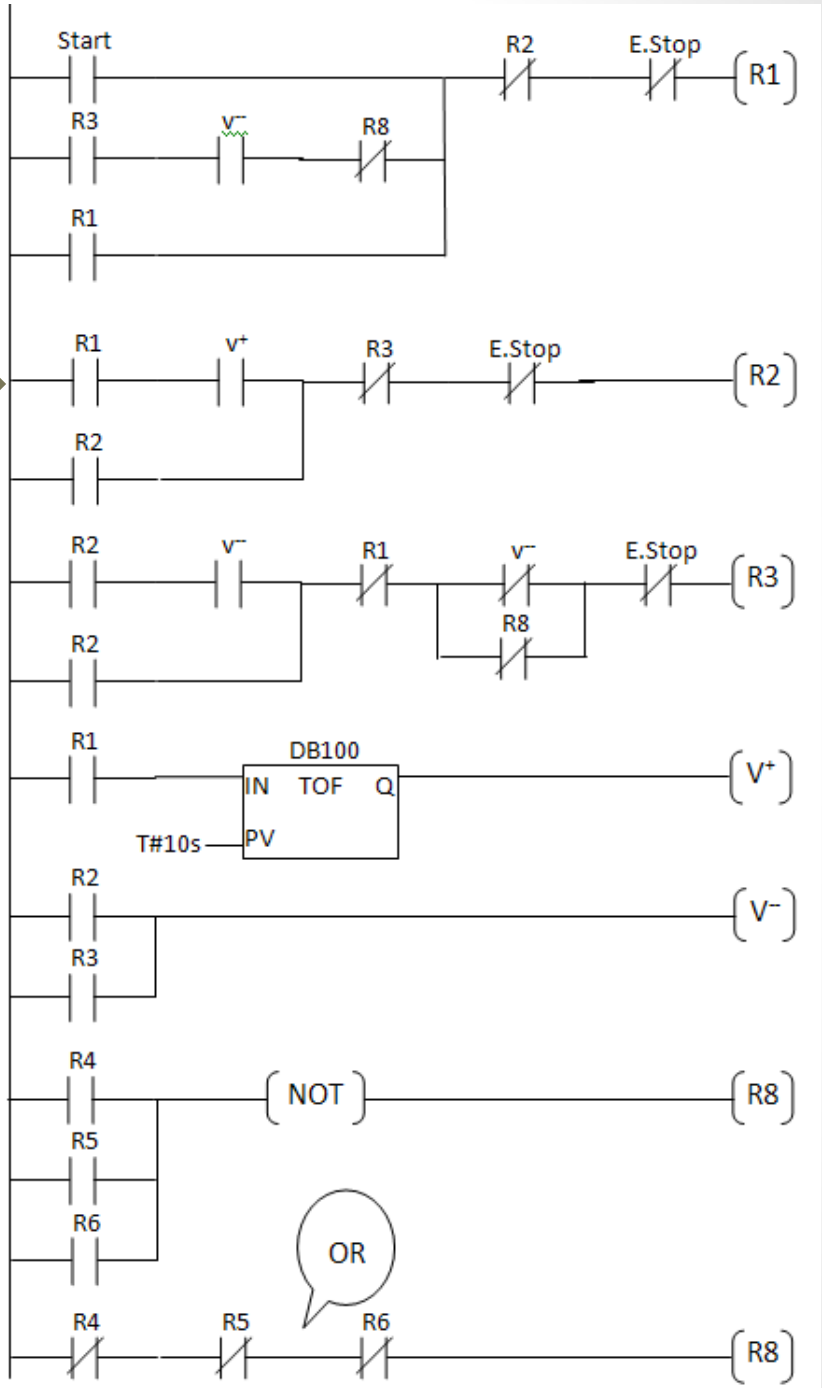


Filling Unit RLL

9.4 Volumetric filling automation process





Displacement Pump + Conveyor Unit RLL

9.4 Volumetric filling automation process