Design of SCADA System for Oil Pipeline Control Using LabVIEW

Laith Abed Sabri
Dep. of Mechatronics Eng.
University of Baghdad
laith.sabri@yahoo.com

Subhi Aswad Mohammed
Dep. of System Engineering
University of AL-Nahrain
subhiaswad@yahoo.com

Mohammed Ibrahim Issa
Oil Pipeline Company (OPC)
Ministry of Oil
mechano84@yahoo.com

Abstract

The paper describes a design and simulation of a Supervisory Control And Data Acquisition (SCADA) system to control oil pipeline and depot plant. The aim of the process is to control oil transportation through a shared pipeline and to minimize products contamination. The study attempts to fulfill an optimal sequence of batches of refined products to satisfy the customer demands in term of: volume , maximum flow rate, optimizing the total operational cost, and reducing products contamination.

The proposed system introduces a control algorithm to perform process control system functions and for achieving the tasks and actions in specific sequences and precedence. The control algorithm performs processing of pumping station control, sharing single oil pipeline, maintaining tanks level, and depot inventory control. This paper investigate many factors which effects the length of transmix segment, which enable to offer optimum solutions to reduce products contamination.

LabVIEW software is used for performing various signals acquisition and monitoring, also for simulating and designing the control system strategy.

Keywords: SCADA System, Oil Pipeline, Labview, Slob/Transmix, Oil Depot.

1. Introduction

Scheduling the products as batches in pipelines is a complex task having many constraints. Both producer's production schedules and market demands with the operational constraints are forbidding some products to be pumped one after another, all of these are to be considered. Actual inventories available in the storage tanks at the source and the distribution terminals as well as the product batches are already in transit to the nominated destination.

SCADA systems are types of industrial control system used to collect data and to perform controlling process from a remote location. They can control water transportation systems, refineries, chemical plants, and a wide variety of manufacturing operations in the industry [1]. One advantage of a SCADA system is that the user can easily monitor the status of the overall system.

Z. Aydogmus [2] has implemented SCADA system control via Programmable Logic Controller (PLC) for a fluid level control system with fuzzy controller to achieve the parameters of the membership functions, Matlab/Simulink program has been used.

A. M. Ali [3] has presented study for scarce water resources. The research design SCADA system for managing the water pumping stations for 40 wells.

K. Parwal [4] presents an implementation of fuzzy technique based on LabVIEW for control gas system, and develop a special testing machine for testing the weak points at the pipe connections e.g. pipe bends, and intermediate connections.

The remainder of this paper is organized as follows: in section 2, a brief overview of SCADA system architecture. In section 3, present oil plant process control system architecture. Section 4 specifies oil pipeline network. In section 5, discuss batch scheduling operation, their problems of sharing pipeline and their transmix problem description. Mathematical and state space model of system are presented in section 6. Section7 describe process operations mangement and design HMI for SCADA, and the result of scada system simulation shown in section 8 . In section 9 conclusions are shown and future work is suggested.

2. SCADA System Architecture

The SCADA system consists of the following main components as shown in Figure (1). [5]

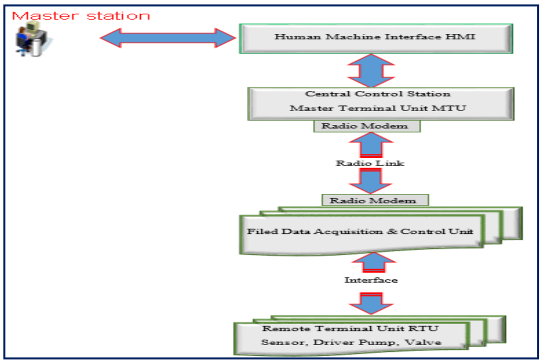

Figure (1): SCADA System Architecture

a. Remote Terminal Unit (RTU)

The RTU gathers status data from field devices, monitoring, controlling of the remote location and transmit data and control signals to a central monitoring and control station (MTU).

b. Communications and Network System

In order for the central MTU to communicate with the RTUs that are located at the distant locations a communication link must exist to transfer data from one location to another.

c. Human Machine Interface (HMI)

The SCADA operates using HMI to presents data to the operator, configure, monitor the system state and generate different control activities.

d. SCADA Software

There are several software packages used for designing HMI and SCADA. WINCC, CIMPLICITY HMI, and LOOKOUT are examples for commercial SCADA packages.

e. Master Terminal Unit (MTU)

The MTU is the centralized controller for the SCADA system. MTU initiates all communication, gathers data, stores information, and interfaces with operators. MTU processes the information received, sends it to the RTU sites, and presents it to human operators in a form that the operators can work with it.

3. Oil Plant Process Control System

Process control system for distribution of oil product, which consists of the following components:

- **Oil Field**
- **Refinery Plant**
- **Pumping Station**
- **Oil Depot Plant**
- **Pipeline Network**
- **Oil Product Distribution Terminal**

The oil plant started from filed to distribution terminal output as shown in Figure (2).

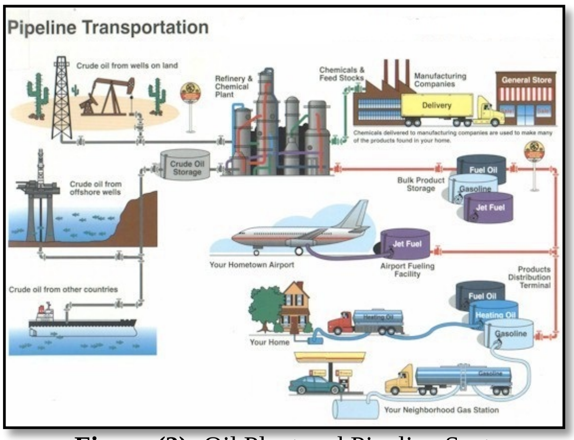

Figure (2): Oil Plant and Pipeline System

The pipeline system is divided into different segments (pipes) that connect the nodes of the distribution network. Each pipe is modeled as a fixed-size FIFO queue with a single server at the pipe extreme that permits the movement of material entities from one position to another by combining different pipes, with particular sizes and service rates [6].

When an entity enters a pipeline segment at the inlet point, it pushes the entity positioned at the other extreme out of the queue. In other words, at every pipe end, a reservoir is located that dispatches the first entity on the queue whenever a new entity enters the pipe at the inlet section. Since the system transports multiple products, the model keeps track of every pipeline fill by updating the reservoir queues at every time event.

4.Oil Pipeline Operation Batch Scheduling

The problem of interest in this research is concerned with the sequencing of batches of different refined products to be shipped via single pipeline system in order to minimize the total operational costs in a given period of time. Also satisfying the considered operational constraints of the system and the demand satisfaction of the different products at the different market zones within the corresponding delivery time.

The challenge is to achieve an optimal sequence of batches of refined products to satisfy the customer demands while optimizing the total operational cost of the system or another operational objective of interest. [6]

a. Problems of Sharing Oil Pipeline

Products transfer must satisfy the volume and maximum flow rate that are the constraints in the pipeline. There are also forbidden of specific batch sequences of products in the pipeline. The Operation of multiproduct pipelines has a unique feature, product contamination. Although pipelines provide a safe mode of transportation, product contamination is inevitable and it occurs at the interface of two miscible products.

As products are transported by only one pipeline and very large distances must be covered, it is critical mission that the correct decisions should be made.

b. Transmix Problem Description

The main problem in the single pipeline system is sharing pipeline resource for transporting oil product from the source to the storage plant (oil depot). The sequential pumping of products will leads to a mixing of different oil products called (transmix) as shown in Figure (3) .[7]

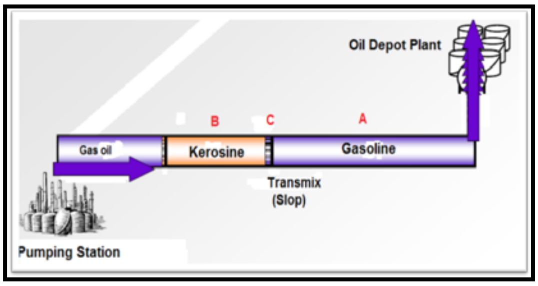

Figure (3): Transportation in Single Pipeline

The study of transmix characteristics allows defining the quality of product based on the contamination value when different products are dispatch through a single line continuous succession.

There is always a mixing at the boundary of two adjacent streams and a slug of contaminates is formed between batches of different uncontaminated products. This slug of contaminated material gradually increases in length as two streams flow along the line in the direction of the receiving points

A, B: Pure Products; C: interface length as shown in Figure (3), the contamination length is the distance between two points in the interface where sampling indicates a change in composition from 99% of one product to 99% purity of the other.

There are many effective factors which effects on the length of transmix segment:

- **i.** The distance transfer by the interface (Transmix).
- **ii.** The mean velocity of the flow in the pipeline.
- **iii.** The internal diameter of pipeline and the curvature of the pipe.
- **iv.** The Reynolds s number.
- **v.** The kinematic viscosity of the product mixture.
- **vi.** The pipe friction coefficient and the relative roughness in the pipe.

5. Mathematical Model Of Oil Pipeline System

There are three type of flow in the pipe:

i. Laminar Flow

All of the fluid velocity vectors line up in the direction of flow.

ii. Transition Flow

The flow fluctuates between laminar and turbulent flows before it becomes fully turbulent.

iii. Turbulent Flow

Takes place in flow situations with high fluid velocity and low fluid viscosity.

The Figure (4) illustrate differences between laminar and turbulent flow in a pipe. Turbulent flow is characterized by turbulence and mixing in the flow. It has point velocity vectors in all directions

Pipe flow will be laminar for a Reynolds Number (Re) less than 2100 and it will be turbulent for a (Re) greater than 4000.

For (2100 < (Re) < 4000), called the transition region, the flow may be either laminar or turbulent, depending upon factors like the entrance conditions into the pipe and the roughness of the pipe surface [8].

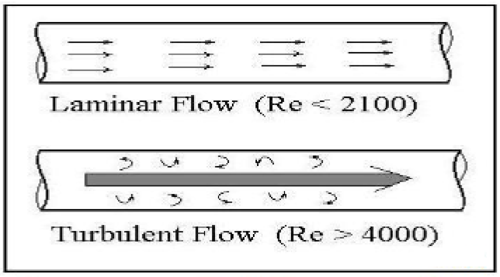

Figure (4): Types of Flow

The Reynolds Number for flow in pipes is defined as:

$$R_e = \frac{DV\rho}{\mu} \qquad (1.1)$$

Where:

- **D** is the diameter of the pipe in (m)
- **V** is the average fluid velocity in (m/s)

The definition of average velocity is:

V = Q/A

Where**:**

- **Q** is the volumetric flow rate
- **A** is the cross-sectional area of flow
- **ρ** is the density of the fluid in (kg/m^3)
- **μ** is the viscosity of the fluid in $(N.s/m^2)$

5.1 The Bernoulli Equation

The Bernoulli equation is an approximate relation between pressure, velocity, and elevation, and is valid in regions of steady, incompressible flow where net frictional forces are negligible. it has proven to be a very powerful tool in fluid mechanics[8].

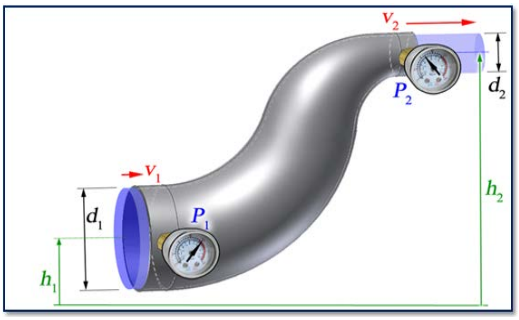

Figure (5): Bernoulli Equation

$$\frac{P}{\rho}+\frac{V^2}{2}+gz=constant \qquad (1.2)$$

This is the famous Bernoulli equation (Figure (5)), which is commonly used in fluid mechanics for flow along a streamline in in viscid regions of flow. The Bernoulli equation can also be written between any two points on the same streamline as:

$$\frac{P1}{\rho}+\frac{V^2}{2}+gz1=\frac{P2}{\rho}+\frac{V^2}{2}+gz2 \qquad (1.3)$$

Where:

- $\frac{V_2}{2}$ as kinematic energy
- **gz** as potential energy
- $\frac{P}{\rho}$ as flow energy

All per unit mass. Therefore, the Bernoulli equation can be viewed as an expression of mechanical energy balance and can be stated as follows: The sum of the kinetic, potential, and flow energies of a fluid particle is constant along a streamline during steady flow when compressibility and frictional effects are negligible.

5.2 Physical Model of Pipeline System

Mathematical models are developed that describe the relationship between different quantities of process system. It concerns with quantitative rather than a qualitative treatment of the process.

Typical oil industry consists of various processes and measurements, operated with different parameters in order to implement specific tasks. If we consider mass balance equation it is used to describe the relation between the mass input and mass output for just one of the tanks as shown in eq.1.4. [8]

(Mass flow in - Mass flow out) =

(Rate of change of liquid level volume)

$$A\frac{dh}{dt}=-Q_{out}+Q_{in} \qquad (1.4)$$

Where:

- **A** is the cross sectional area of tank (m^2)
- **V** is the volume of liquid in tank (m/s) **(V = A.H)**
- $\mathbf{Q_{in}}$ is the pump flow rate for inlet (m^3/s)
- $\mathbf{Q_{out}}$ is the flow rate outlet (m^3/s)

The overall system represent schematically in Figure (6).

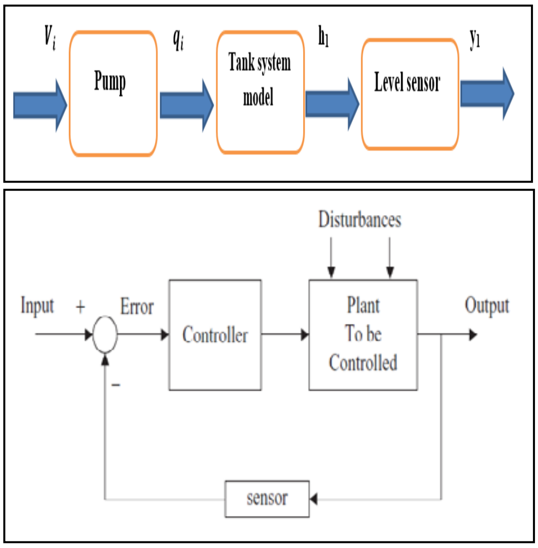

Figure (6): Schematic Diagram of The System

$$q_i=k_iv_i \qquad (1.5)$$
$$y_i=k_sh_i \qquad (1.6)$$

Where;

- $\mathbf{V_i}$ is the applied voltage to the pump motor
- $\mathbf{Q_i}$ is the input flow rate;
- $\mathbf{h_1}$ is the liquid level;
- $\mathbf{y_1}$ is the output voltage
- $\mathbf{K_i}$ is the pump characteristic;
- $\mathbf{K_s}$ is the sensor characteristic

5.3 Modeling of Storage Tank System

Initially consider the single tanks with valve A closed and valve B open. This system is a single tank process that can be drawn as shown in Figure (7).

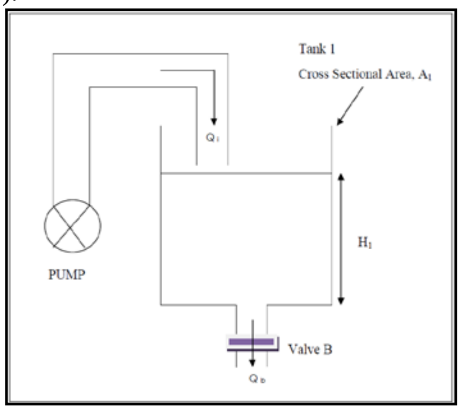

Figure (7): Tank System

The system model is described eq. 1.7, and determined by relating the flow into the tank to that leaving via valve B. Hence, [8]

(Rate of mass accumulation) =

(Rate of mass in - Rate of mass out)

$\mathbf{(Q_i - Q)_b}$ **= Rate of change of liquid volume**

$$Q_i - Q_b = \frac{dv}{dt} = A\frac{dh}{dt} \qquad (1.7)$$

If valve B is assumed to behave like a standard sharp edged orifice, then the flow through valve B will be related to the fluid level in the tank, H_1, by applying Bernoulli equation eq. 1.7,

$$\frac{P1}{\rho} + \frac{V^2}{2} + Z_1 + h_{pump} = \frac{P2}{\rho} + \frac{V^2}{2} + Z_2 + h_L \qquad (1.8)$$

Assumption of present case study:

$P_1 = P_2, \quad Z_1 = h_1, \quad V_1 = 0, Z_2 = 0$

$$h_1 + h_{pump} = \frac{V^2}{2g} + h_L$$

$$2g\,(h_1 + h_{pump} - h_l) = v_2^2$$

$$Q_{outlet} = Q_2 = a_b \times k_v \sqrt{2g(h_1 + h_{pump} - h_L)} \qquad (1.9)$$

The eq.1.9 above it is applied when the discharge form each tank occurs by head of the tank level without using pump.

a_b is the cross sectional area of the orifice.

K_V is the discharge coefficient of valve.

g is the gravitational constant = 0.98 (m/s^2). The mathematical model of the inherent valve characteristic, through the relation eq. 1.10. The Figure (8) describe this relation

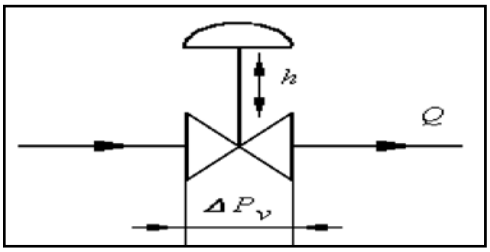

Figure (8): valve architecture

$$K_v = \frac{Q}{\sqrt{\frac{\Delta P_r}{\rho}}} \qquad (1.10)$$

Where:

- **h** is the movement of the valve plug's
- **Q** is the debit of the fluid
- **ΔPv** is the drop pressure on control valve
- **Kv** is the valve characteristic.

The mass balance and the Bernoulli's law are extended to other tanks to obtain a non-linear model, which is described by the system differential equations as follows in the equation;

$$A_{Tank}\frac{dh}{dt} = -Q_{Out} + Q_{in} \qquad (1.11)$$

$$-\frac{dhi}{dt} = \frac{a_{out} \times k_v}{A_{Tank}}\sqrt{2g\left(h_i + h_{pump} - h_L\right)} + \frac{Q_i}{A_{Tank}} \qquad (1.12)$$

Where the parameters used above are;

A_{Tank} is the cross-sectional area of tank

a_{out} is the cross-sectional area of outlet hole

$\mathbf{h_i}$ is the Product level in tank i

g is the acceleration due to gravity 9.81 m/s^2

5.4 State Space Models

A general compact form of the state-space model is [9].

$$\dot{x} = Ax + Bu \qquad (1.13)$$

$$y = Cx + Du \qquad (1.14)$$

Where **x** is the state vector and **u** is the input vector to the system. **A** is referred to as the system matrix. In case of the tank process, the system has **(h)** variables are denoted as **(x).** The two input variables, **v1** and **v2**, are denoted as **u** correspondingly. Matrix **D = 0** because its auxiliary parameter, the variables can be assembled in a matrix-vector form that corresponds to eq.1.13 and eq.1.14.

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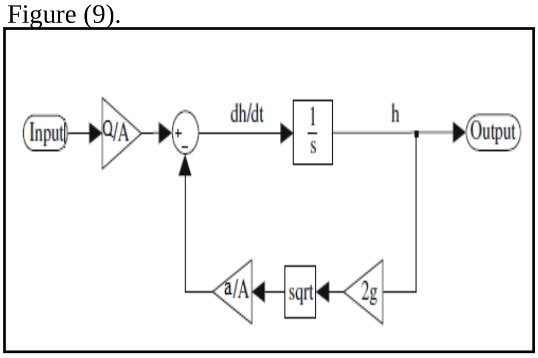

Figure (9): Closed Loop System

The non-linear model of eq.1.12 can be linearized around the chosen working point given by the level in the tanks we get:

$$\dot{x} = \begin{bmatrix} \frac{-1}{T_1} & 0 & 0 \\ 0 & \frac{-1}{T_2} & 0 \\ 0 & 0 & \frac{-1}{T_3} \end{bmatrix} X + \begin{bmatrix} \frac{1}{A_{Tank1}} \\ \frac{1}{A_{Tank2}} \\ \frac{1}{A_{Tank3}} \end{bmatrix} Q_i \qquad (1.15)$$

$$y = \begin{bmatrix} K_c & 0 & 0 \\ 0 & K_c & 0 \\ 0 & 0 & K_c \end{bmatrix} x + [0]\,D \qquad (1.16)$$

Figure (10) shows the simulation results of the oil depot theoretical model. It illustrates system specification and system performance when applying step input to the eq.1.13 and eq.1.14.

It can be observed that the system response behavior is acceptable and does not have oscillation.

6. Oil Plant Process Operations Mangement

The oil plant system operations can be partitioned into four phases as shown in Figure (11). The simulated oil plant mimics a real system problem, where three batches of different products (gasoline, kerosine and gas oil) are pumped randomly using one pipeline. [10]

i. First stage (Task no.1)

The refinery refines crude oil to multi product

ii. Second stage (Task no.2)

This stage contains two phases: the first, is the input that acts as a temporary storage, which contains three tanks each for a different oil product; the second, represents a pumping station.

iii. Third stage (Task no.3)

The oil depot plant receives oil products through a single pipeline from a pumping station. This stage consists four different pipeline paths, each path leads different products to a separate depot, and each depot contains two tanks.

iv. Fourth stage (Task no.4)

This stage represents distribution terminal to the consumer.

The system representes a simulated oil depot as a real plant. The system operations are controlled through the flowchart shown in Figure (13). Table (1) describes the actions performed in the system operation, these actions generated from the control system in order to manage the operations in task no.2 and task no.3 shown in Figure (11).

- **Detect Pure Oil Products**
- **Detect Slob Fluid**
- **Detect Depot Tanks Level**

It is required to separate differents oil products at the destination point into a set of depot tanks, considering the mnimization and isolation of the transmix (slob) into a sperate tank.

7. Design SCADA System Using LabVIEW

LabVIEW software provides an efficient tool to build SCADA process control system , perform on-line control algorithm, design HMI screen consist of all plant elements as graphical model representation and Data analysis and logging for system activity.[11]

7.1 Design HMI for SCADA System

LabVIEW Software is used to achieve the tasks and actions described in Table (1), and according to the sequences and precedence shown in the control algorithm in Figure (12). LabVIEW create HMI for SCADA system to describe the task activity execution and real time monitoring and control of the system.

LabVIEW tool is used for simulating a process of transportion the different refined liquid fules products. The oil products are transported as batch sequences with sharing a single pipeline.

Figure (13) reprsents HMI SCADA system screen designed to monitor and control oil pipline process. The simulation scenario desgind a pumping station to suctions (20000) cm^3 oil products and feeds it as batches sequences to depot tanks.

The density changes of fluid represents the main factor for classification of the product types, then accordingly it selects the specific pipeline segment that leads to a tank storag. The simulation required about (120)s .

7.2 SCADA System Program Structure

The block diagram structure using programming terminals with loop, case structure and subroutine. It contains all the internal workings and the background operations of the

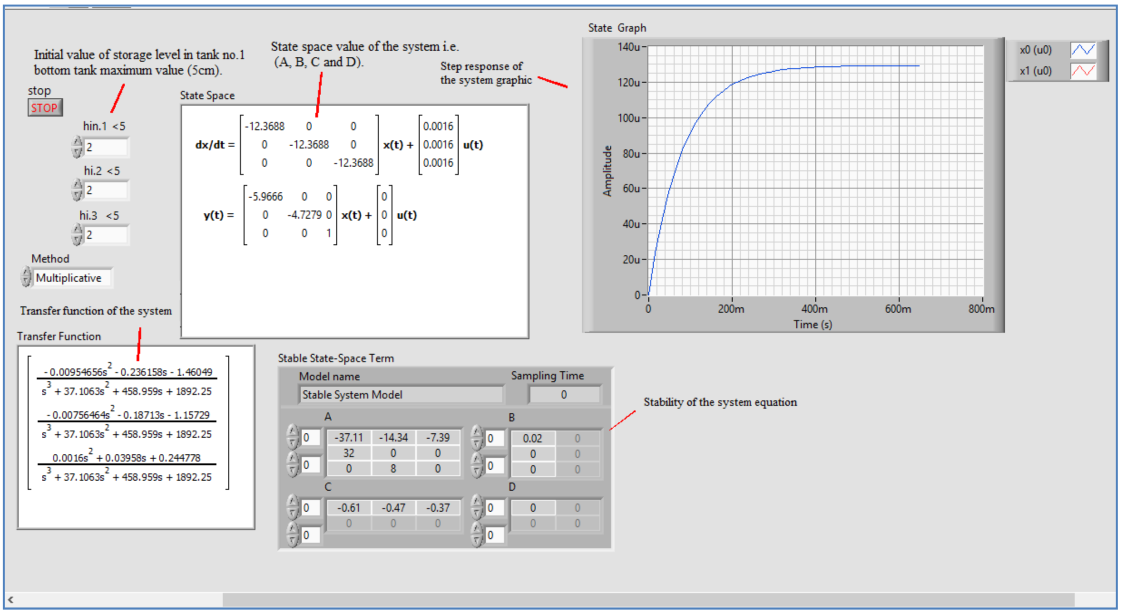

Figure (10): System Specifications and Performances

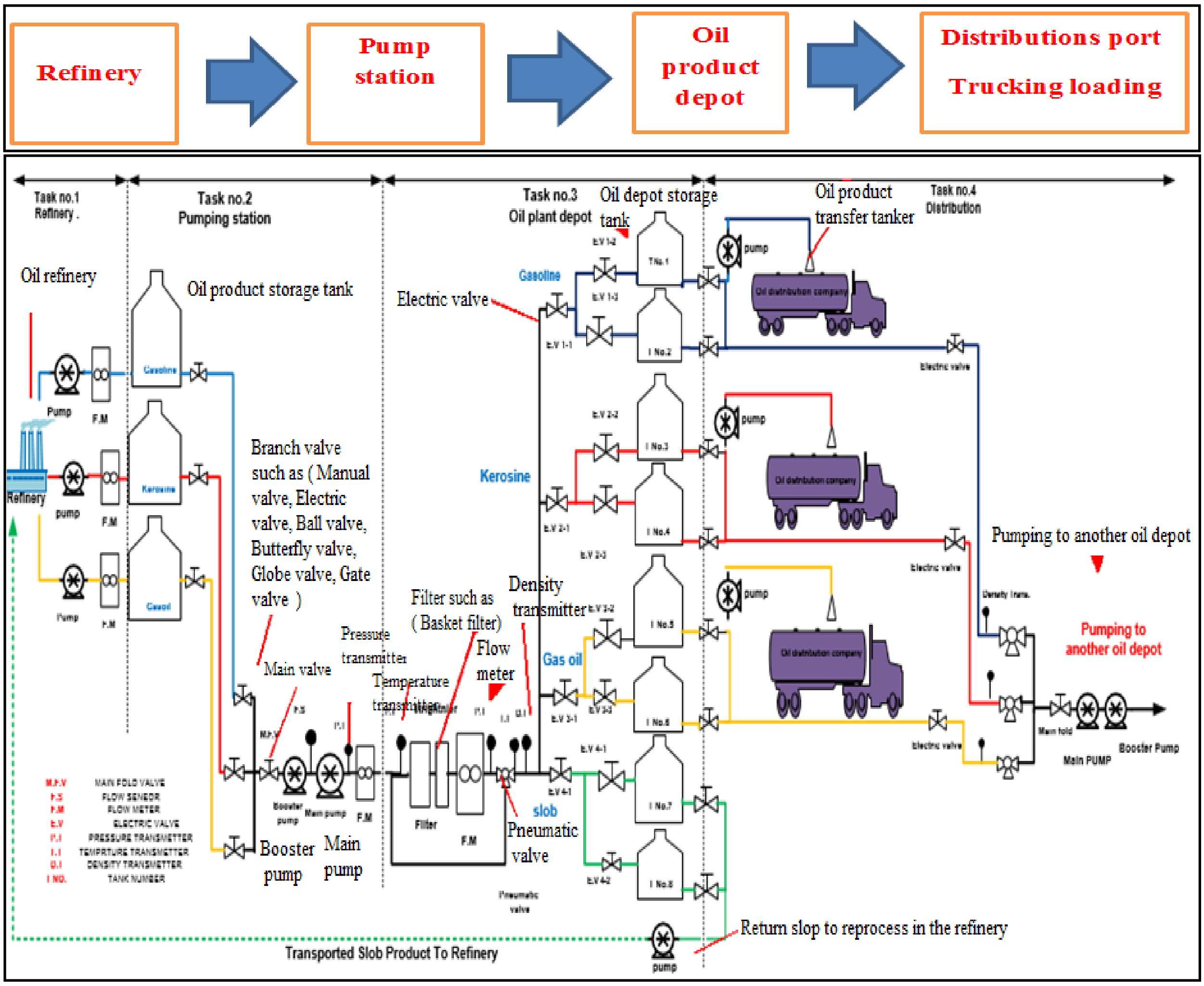

Figure (11): Oil Plant Process Operations

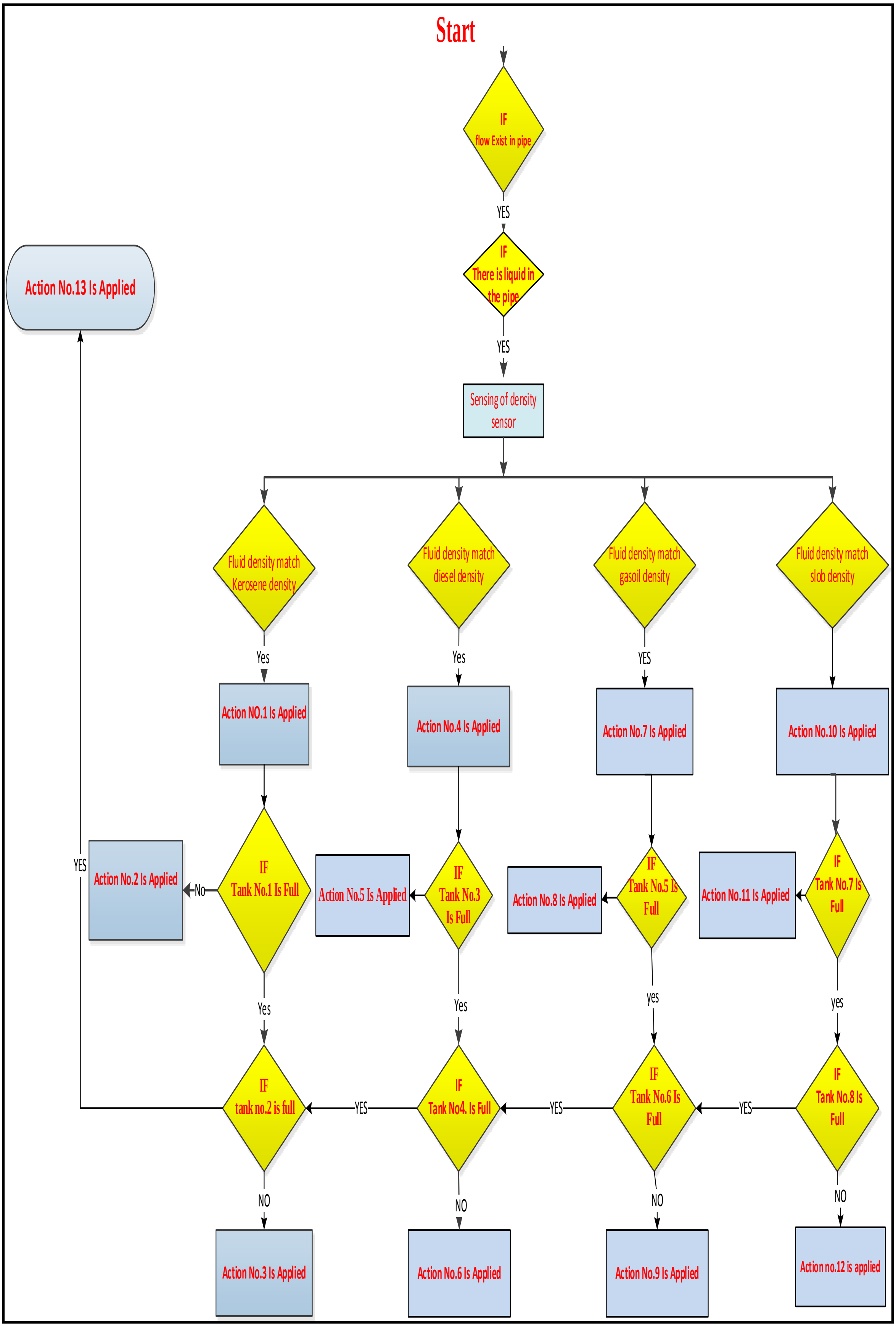

Figure (12): Tasks Execution Algorithm

Table (1): Actions to Perform the Functions algorithm in Figure (12)

NO.	ACTION			Fluid Type
	Action no.1	**Action no.2**	**Action no.3**	
1	a- Open valve no.1-1 b- Close valve no.2-1 c- Close valve no.3-1 d- Close valve no.4-1 e- Pumping with low speed (set booster pump only)	a- Open valve no.1-1 b- Open valve no.1-2 c- Close valve no.1-3 d- Pumping to tank no.1 with high speed (set booster main pumps	a- Open valve no.1-1 b- Close valve no.1-2 c- Open valve no.1-3 d- Pumping to tank no.2 with high speed (set booster main pumps	Gasoline
	Action no.4	**Action no.5**	**Action no.6**	
2	a- Open valve no.2-1 b- Close valve no.1-1 c- Close valve no.3-1 d-Close valve no.4-1 e- Pumping with low speed (set booster pump only)	a- Open valve no.2-1 b- Open valve no.2-2 c- Close valve no.2-3 d- Pumping to tank no.3 with high speed (set booster pump and main pump)	a- Open valve no.2-1 b- Close valve no.2-2 c- Open valve no.2-3 d- Pumping to tank no.4 with high speed (set booster main pumps)	Kerosene
	Action no.7	**Action no.8**	**Action no.9**	
3	a- Open valve no.3-1 b- Close valve no.1-1 c- Close valve no.2-1 d- Close valve no.4-1 e- Pumping with low speed (set booster pump only)	a- Open valve no.3-1 b- Open valve no.3-2 c- Close valve no.3-3 d-Pumping to tank no.5 with high speed (set booster main pumps)	a- Open valve no.3-1 b- Close valve no.3-2 c- Open valve no.3-3 d- pumping to tank no.6 with high speed (set booster main pumps)	Gasoil
	Action no.10	**Action no.11**	**Action no.12**	
4	a- Open valve no.4-1 b- Close valve no.1-1 c- Close valve no.2-1 d- Close valve no.3-1 e- Pumping with low speed (set booster pump only)	a. Open valve no.4-1 B .Open valve no.4-2 c- Close valve no.4-3 d- pumping to tank no.7 with high speed(set booster main pumps)	a- Open valve no.4-1 b- Close valve no.4-2 c- Open valve no.4-3 d- Pumping to tank no.8 with high speed (set booster main pumps)	Slob
	Action no.13			
5	a. Close valve no.1-1 b. Close valve no.2-1 c. Close valve no.3-1 d. Close valve no.4-1 e. Close valve no.1-2 f. Close valve no.1-3	a. Close valve no.2-2 b. Close valve no.2-3 c. Close valve no.3-2 d. Close valve no.3-3 e. Close valve no.4-2 f. Close valve no.4-3	a. Shut down the main pump b. Set alarm signal c. Send signal to the main refinery pump through the wireless d. Send SMS to the manger of operation	Emergency Condition

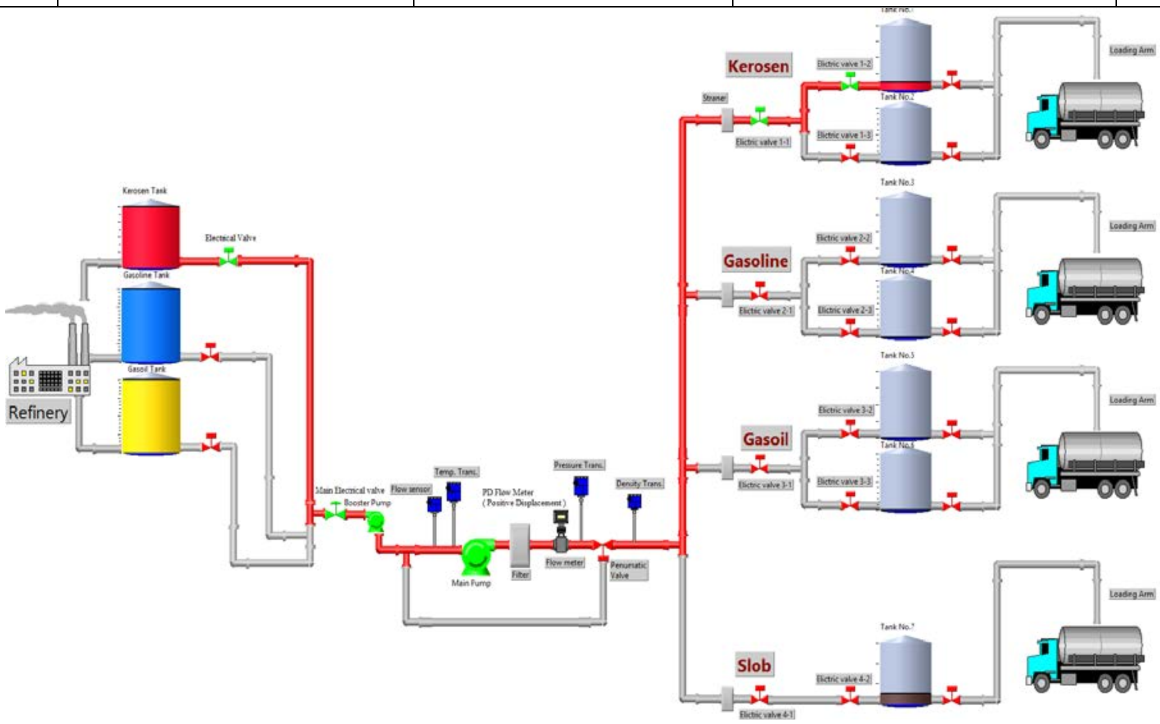

Figure (13): HMI SCADA of Real Oil Depot System

Code that are built from subroutines shown in Figure 14. When system is run, signals and values from control modules flow through the block diagram. The programming structure consists of thirteen case structure as follows:

- **a.** The first module case structure (case 0) is used to implement initialization operation, product pumping, products transportation, as shown in Figure (15).
- **b.** The second, third, and fourth, module case structure is used to fill kerosene, gasoline and gas oil product respectively, to specified tanks as shown in Figure (16).
- **c.** The fifth and ninth module case structure is used to (fill and discharge) slob to specified tank respectively.
- **d.** The sixth, seventh, and eighth modules module case structure is used to discharge kerosene, gasoline, and gas oil products respectively.

8. Simulation scenario and Result of SCADA system

The system operational follows the batch sequences scenario described in Figure (17). Figure (17a) shows a scenario of pumping batch sequences contains three types of oil products, therefore two batch cycle are performed in six pumping phases:

- **a.** Pumping phases (1 and 4) (Pump of gasoline product).
- **b.** Pumping phases (2 and 5) (Pump of kerosene product).
- **c.** Pumping phases (3 and 6) (Pump of gasoil product)

The scenario of feeding products in the pipeline has been implemented in eleven transportation phases, and each phase represents a specific fluid segment, as shown in Figure (17b):

- **d.** Transportation phases (1 and 7) (Transport of gasoline product)
- **e.** Transportation phases (3 and 9) (Transport of kerosene product)
- **f.** Transportation phases (5 and 11) (Transport of gasoil product)
- **g.** Transportation phases (2, 6, 8 and 11) (Transport of slob product).

The products (density, level in the tanks, and flow rate) are sensed and used as a feedback signal to generate a control actions in time. The perfect controls will lead to reduce contamination product (slob).

Figure (18) describe pump station action when feeding products through two cycle of a batch sequences, each batch contains (6000) cm^3 of three different products.

Each product segment in a batch takes (9) sec to be fully discharged through the shared pipeline to the oil depot. The total period time for pumping products of each batch take about (27) sec. Figure (19) illustrate the products feeding arrangement as a batch sequences in a pipeline and the slob (transmix) generation.

As shown in Figure (19), the period time between (0-28.5) sec represents the time delay for products transportation from pumping station to the oil depot tanks through pipeline network. The time duration depends on the following factors:

- The length of pipeline network
- The pipeline diameter
- Products pumping speed
- Locations of the sensors in the system

Figure (19) shows the scenario of execution a first cycle batch sequence as follow:

- **i.** **T-Phases 1, 3 and 5:** Receive three segment (1900) cm^3 of gasoline, kerosene, and gasoil during a period time between (28.5-37.5, 40.5-49.5, and 52-61) sec respectively, then loading in specified tanks.
- **ii.** **T-Phases 2,4 and 6:** Generate a segment of (155, 125, and 120) cm^3 slob during a period time between (38-40, 50-51.5, and 58.5-60) sec respectively, and discharge in tank no.7.

The scenario of execution a second cycle batch sequence was implemented during the T-phases (7, 8, 9, 10, and 11).

Figure (20) shows the appropriate control actions generated for valves system to perform gasoline loading. It is noticed that the system produces an ideal control action, because it is behaving according to the ideal simulation conditions.

Figure (21) shows the responses of the loading gasoline product for tank no.1 and tank no.2.

Tank no.1 Received (950) cm^3 of pure gasoline, while tank no.2 received (950) cm

The difference between the total product volume has been pumped and the quantity volume has been received through pipeline in the tanks is about (100) cm^3. This represents a contamination that appears as slob segment no.1 product.

When the pipeline started to receive a second product (kerosene), that will causes a contamination in the product (i.e. transmix or slob generate) because of residual gasoline in the pipeline. When the density sensor detects contamination (slob) during the periods (85-40) sec, (50-51.5) sec, (58.5-60) sec, (70-71.5) and (81.5-83.5) sec, the control system will generate a sequence of control action no.10.

The pumping of kerosene and its transportation through the pipeline to their destination tanks are performed during the following phases:

- Pumping phases (2) and (5): these are performed in the time periods (9.5-18.5) s and (39.5-48.5) s.

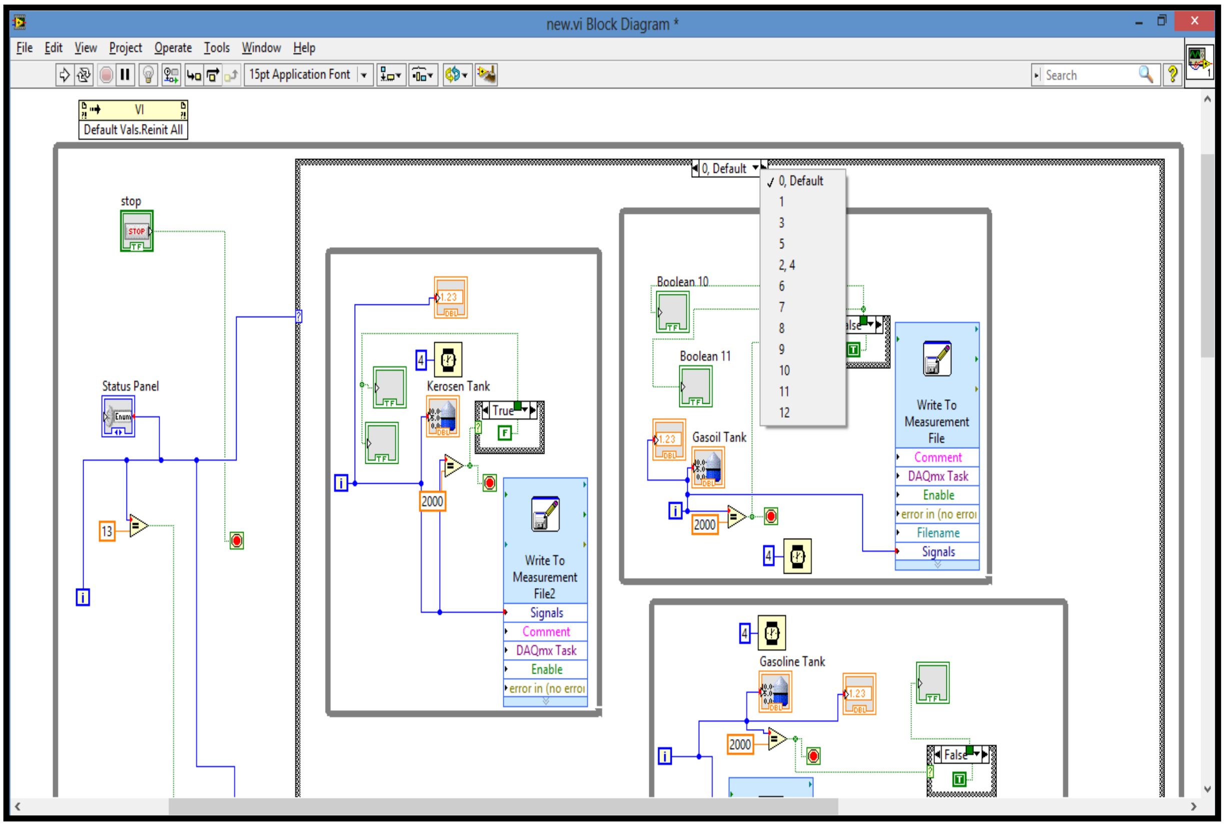

Figure (14): Block Diagram of HMI SCADA System

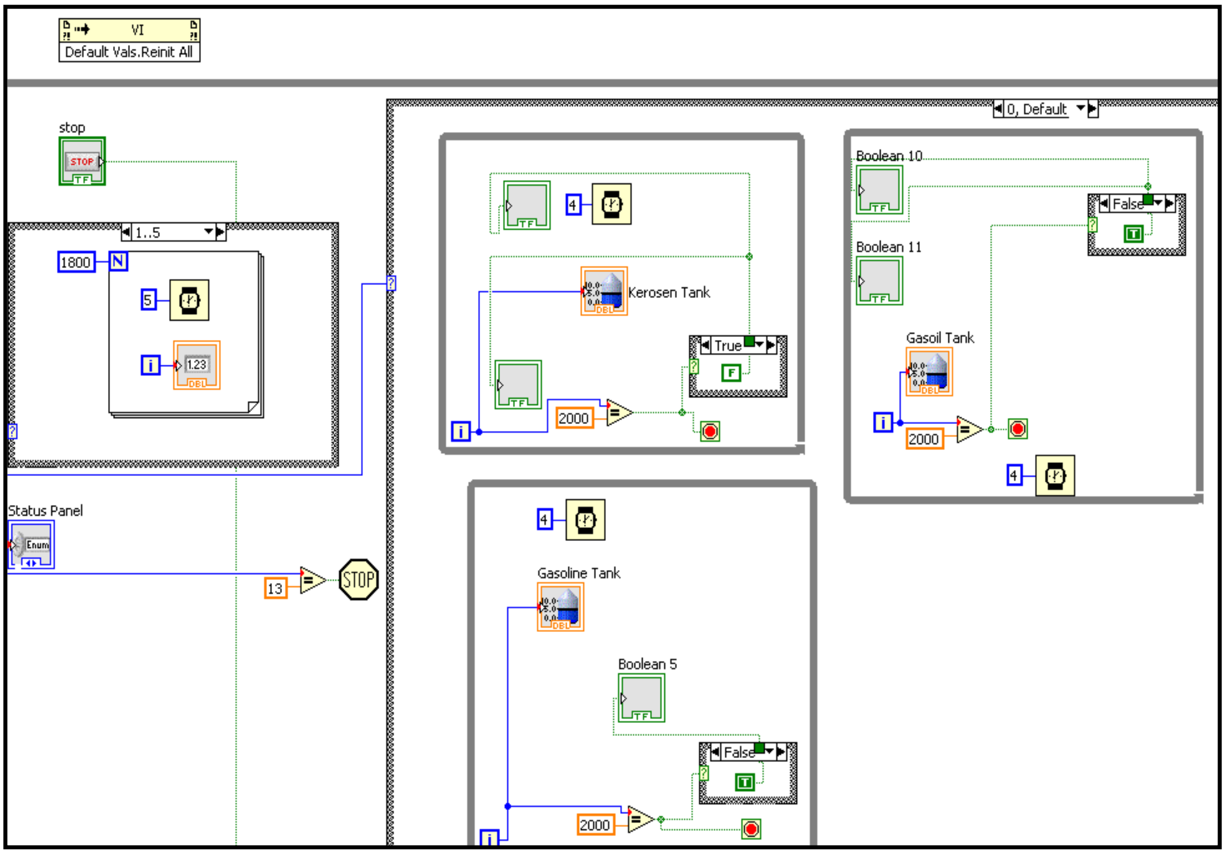

Figure (15): Module Structure to implement system Initialization

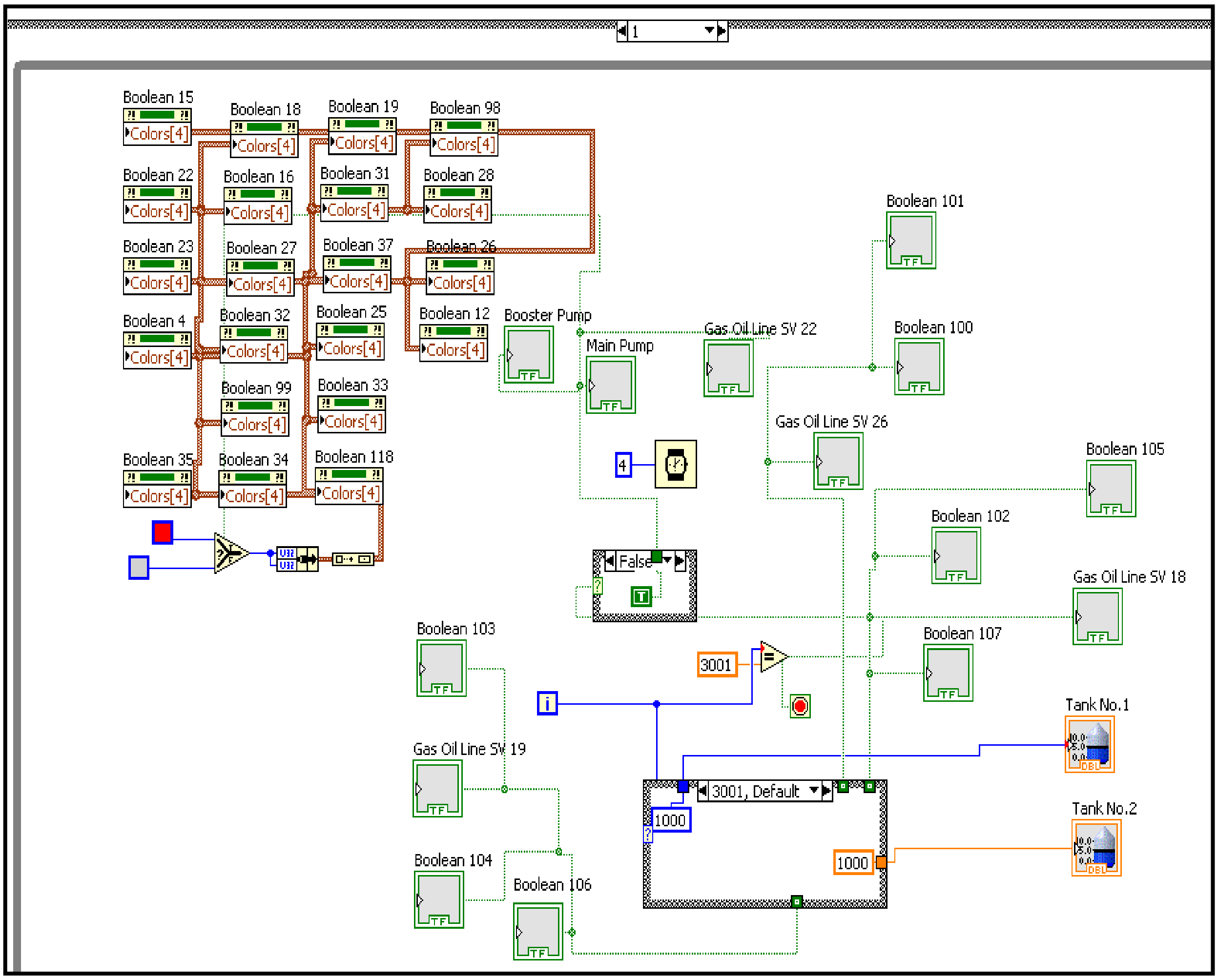

Figure (16): Module Structure to Fill in Tanks (no.1 and no.2) With Kerosene Product

(a)

P-Phase 1	Gasoline
P-Phase 2	kerosene
P-Phase 3	gasoil
P-Phase 4	Gasoline
P-Phase 5	kerosene
P-Phase 6	Gasoil

(b)

T-Phase 1	gasoline
T-Phase 2	Slob 1
T-Phase 3	kerosene
T-Phase 4	Slob 2
T-Phase 5	Gasoil
T-Phase 6	Slob 3
T-Phase 7	gasoline
T-Phase 8	Slob 4
T-Phase 9	kerosene
T-Phase 10	Slob 5
T-Phase 11	Gasoil

Figure (17) (a) Pump Station Feeding Two Cycle of Batch Sequences of Oil Products
(b). Multi-Phases of Two Cycle of Batch Sequence Products Feeding in The Pipeline

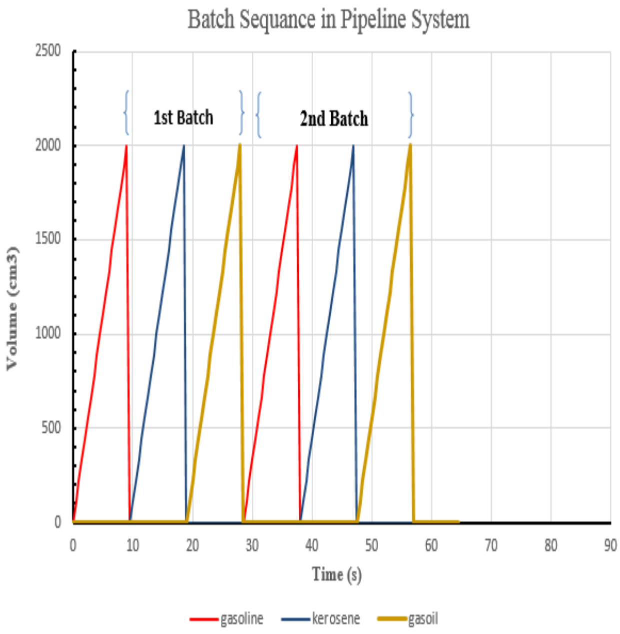

Figure (18): Pump Station Feeding of Two Cycle Batch Sequences of Products

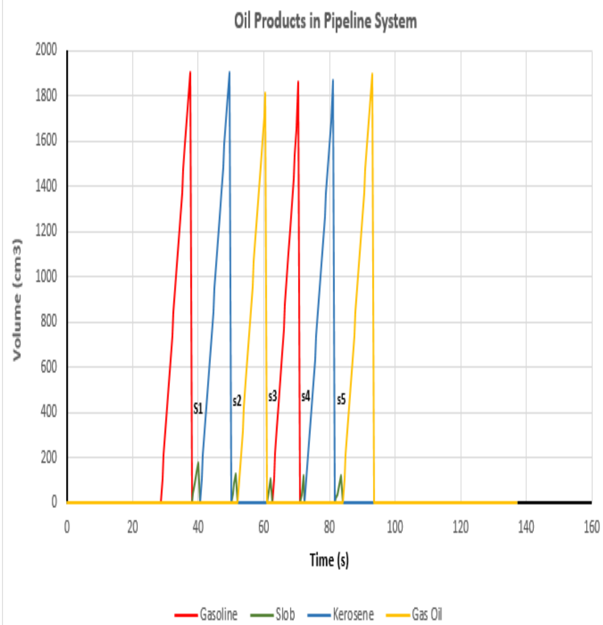

Figure (19): Products Batch Sequences With Slob Generation in Pipeline System

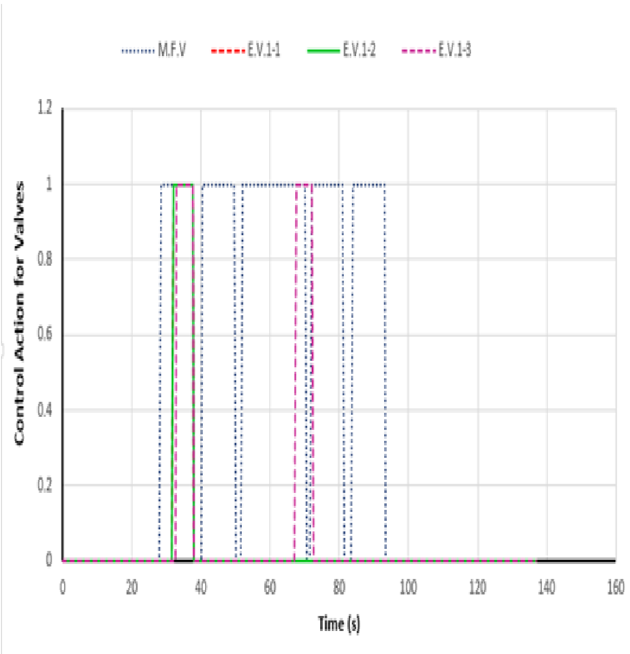

Figure (20): Control Action Generated for Valves during Loading Gasoline Product

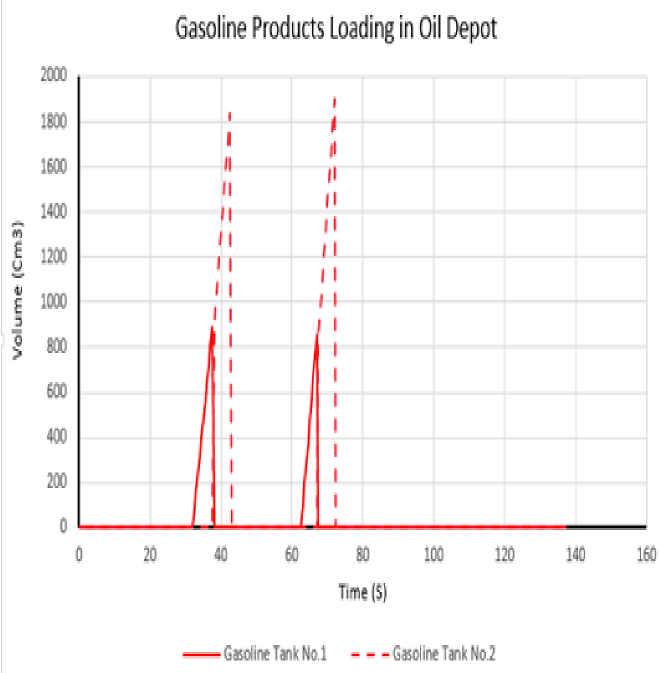

Figure (21): Response of Loading Gasoline in Specific Tanks

- Transportation phases (3) and (9): these are performed in the time periods (40.5 – 49.5) s and (72-81) s.

An appropriate control actions generated for valves system to perform kerosene loading. When the density sensor detect contamination (transmix or slob generate) set of control action generated.

The pumping of gas oil and its transportation through a pipeline to their destination tanks. These tasks are performed during the following phases. The timing sequence for gas oil in the pipeline as follow:

- Pumping phases (3) and (6): these are performed in the time periods (19-28) s and (49-58)s.
- Transportation phases (5) and (11): these are performed in the periods (52-61)s and (84-93)s

An appropriate control actions generated for valves system for loading and unloading gas oil.

The product contamination in the pipeline (transmix generate) was repeated cycle according to the products pumping and transportation as a batch sequence.

9. Conclusions

This paper proposes a framework to design and build SCADA system to control oil pipeline. The simulation develop and deploy a control algorithm, which contain sets of control action to perform system tasks and functions. The adoption of GUI can improve monitoring system operations and logging activities execution.

This research is concerned with the sequencing of batches of different refined products to be shipped via single pipeline system in order to minimize the total operational costs in a given period of time. SCADA system specified acceptable contamination in the range of (3-5%), while the manual system range about (12-15%).

The minimum amount limit of contamination (slob) segment have been generated in the pipeline depend on many factors (pipeline diameter, speed of product pumping, density of product and Reynolds number), and this slob must be generated in all condition.

The volume of contamination segment is inverted relation with respect to the volume of transmitted products volume.

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تصميم منظومة السيطرة الرقابية والتحكم والاشراف وجمع البيانات للسيطرة (SCADA)على خطوط الأنابيب النفطية باستخدام النظام (LabVIEW)

د. ليث عبد صبري
قسم هندسة الميكاترونكس
جامعة بغداد

د. صبحي أسود محمد
قسم هندسة المنظومات
جامعة النهرين

محمد أبراهيم عيسى
شركة خطوط الانابيب النفطية
وزارة النفط

الخلاصة

بسبب عدم توفر خطوط انابيب نفطية مستقلة لنقل المنتوجات النفطية المختلفة لذلك يستخدم اسلوب المشاركة في استخدام خطوط انابيب النقل واجراء عملية الضخ التعاقبي للمنتوجات عبر الانابيب على شكل دفعات.

تهدف الدراسة الى تقليل كمية الخليط والتلوث في المنتوجات النفطية بسبب المشاركة في استخدام خطوط انابيب النقل منتوجات نفطية و تحسين جودة المنتوجات النفطية اضافة الى تامين احتياجات المستهلكين في توقيتات محددة.

اعتمدت الدراسة اسلوب الدمج بين خصائص (منظومات السيطرة الرقابية والتحكم والاشراف وجمع البيانات) والنظام (LabVIEW) مما ادى الى اكتساب محاسن هاتين التقنيتين.

تضمنت الدراسة تصميم منظومة مقترحة مشابه لمنظومة حقيقية وبناء الموديل الرياضي لها وتنفيذ واختبار المنظومة باسلوب المحاكات واجراء عدد كبير من الاختبارات والتشغيل للمنظومة . يوفر النظام المقترح امكانية التشغيل الالي وتقليل نسبة التلوث بمقدار (3-5) % بالقياس الى النظام اليدوي.