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Design a New Controller for Lube Oil Blending System

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Abstract: Blending applications are important, especially in petroleum sector, and it is not only limited to oil refineries, but also used in many other applications and other processes where different ingredients are mixed according to a defined recipe. Blending in petroleum sector is accomplished by blend base oil and certain additives to produce the finished product (Mineral oils). This paper deals with Lube Oil Blending, Two techniques are used in Blending, Automatic Batch Blending (ABB) in tanks or vessels, and In Line Blending (ILB) in pipe lines. Some oil companies suffer from the disruption of the second type of blending technique due to their long periods of operation. The problem is the loss of communication between the field controller in the line blending unit and the main control system in the control room, where the recipes cannot be transmitted from the main control to the field controller. This paper presents the design of a new blending unit and a controller called "the new blend controller for ILB", where a real-time, multi-tasking operating system is utilized to operate this unit. This new technology is designed to be run either standalone, or to be integrated as part of other systems. This new controller can be integrated with the existing system to solve the problem of communication between the control unit and the main control. In addition, this unit is used in the preparation of new recipes quickly and efficiently, rather than experimenting on the real system and then that recipe's data can be transferred to the main control unit of the real system for mass production.

Keywords: Oil refineries, Mineral oils, Controller

I. INTRODUCTION

The blending of liquids and solids is an art which goes back to the early Stone Age [1]. Blending is the physical mixture of a number of different components together that the constituent parts are indistinguishable; to produce a homogenous finished product with certain desired characteristics, quality and quantity [2]. In the petroleum sector, blending to produce products of specified quality and volume is a skill that can give a supplier a valuable competitive edge [3]. The ability to guarantee delivery for the exact quantity required by the customer is the daily challenge of every modern Lube Oil Blending Plant (LOBP) [4-10]. Types of blending systems depend on the products being blended, the quality of the final product specifications [4]. In LOB factories, two systems are used [2-6]: 1. Automatic batch blending (ABB) "The perfect blending unit for small batches and complex formulations" [11]. The delivery of the product, the supplier prepares the blend by adding a number of different products together and analyzing the mix.

The process of batch blending has been in use by bunker suppliers for decades. Using this process, the supplier prepares the blend in holding tanks with several capacities. 2. In Line Blending (ILB) "The continuous mixing technology in pipe lines for large batches" [11]. In this technique for blending, the controlled, proportioning of two or more component streams to produce a final blended product of closely defined quality from the beginning to the end of the batch, thus permitting the product to be used immediately or loaded directly to the customer [4]. ILB has several important technical and economic advantages over ABB, [1-3,6,7], are Faster blending, Improved production flexibility, High level of blending accuracy and repeatability, Reduce storage requirements, and lower costs.

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Section II presents an overview of the Jiskoot ILB system as the famous system in the world for ILB technique. The proposed Model is presented in Section III. Section IV includes the whole operation steps in details. The results of experiments and the conclusion are presented in Sections V and VI.

II. OVERVIEW OF THE JISKOOT ILB SYSTEM

Jiskoot ILB system JSK-ILB is one of the famous systems in blending in the world for ILB technique, which consists of two parts, hardware part and control part which contains two elements, field controller and main controller.

Hardware Part

Fig. 1 show an ILB system which mounted on one skid, and consists of four stream lube oil blenders, and each equipped with:

1. Actuated valve complete with a manual override switch,
2. Manual isolation valve for safety and maintenance,
3. Mass flow meter to issue mass flow, temperature and contact alarm signals,
4. Flow control valve.

Each input stream comes from the certain tank from "tanks area" which contains the base oil tanks and the additive tanks. The finished product oil goes either to the market or to the storage tanks. The blender was designed to produce different grades of lubrication oils for diesel and petrol engines [12].

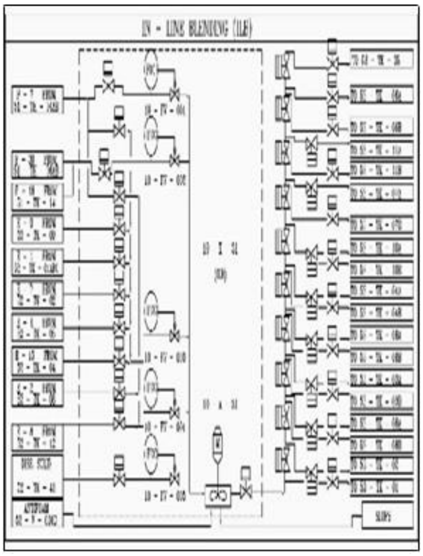

Fig. 1. JSK-ILB system (hardware network configuration).

Control Part

Field controller:

It consists of a microprocessor blending system that comprises safe area field blender controller type FR5-B [12] from JSK-ILB mounted in a 19" weatherproof enclosure rack complete with one JSK-ILB F3143 Processor Card [12], one JSKILB F3148 I/O Expansion Card [12], power supplies, solid state control relays and slots for an additional card set located on the blending skid in the field. The measurements are taken by the mass flow meter in each stream and signals are issued to the FR5-B controller, shown in Fig. 2.

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Fig. 2. JSK-ILB field controller.

Main controller:
This system was designed to interface with the Blending Plant Control (BPC), where field controller (FR5-B) transfers signals to the Distributed Control System DCS in the control room as the main control system [12]. The FR5-B communicates with the DCS with anRS232 [13-15] interface for process control and onward reporting. The problem was in transmitting the recipes of the desired product from the main controller to the field controller to be performed, so we introduce the solution for this problem to reoperation this unit. The proposed solution is called "the pilot unit" and it presented in the next section.

III. THE PROPOSED MODEL

In this section we introduce the solution for the above problem by design "the pilot unit and controller". This section is divided into two parts; the first part includes the design and fabrication of the pilot unit for the new technique imitating the hardware components currently in the field, while the second part will introduce the proposed technique for controlling this unit; as a field controller and a controller in the control room and the proposed technique of communication between them. This complete unit (the pilot and the designed controller) will be used to perform experiments and test new recipes and then apply the out coming data in the existing system in the field.

1st Part-Design of the Pilot Unit
As shown in Fig. 3, a metal stand, working as a system skid with a metal frame to hold the three motors to run the in-tanks' agitators, three cylindrical PVC vessels, two for base oils and one for the additive, each with a transparent part to show oils level during operation, mounted on load cells with analog(electrical) output to measure the weight of oils in each tank [16,17]. Cupper coils fixed in the center of tank's base to heat the oil in it. PTC (Positive Temperature Coefficient) temperature sensors fixed in each tank side to measure the temperature of oils inside. Manual valves mounted between the tanks' outlets and the automatic valves to block the flow or allow it to pass; for maintenance and safety reasons.

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Fig. 3. The proposed model.

Motorized ball valve for automatic control is used, to regulate flow at a point anywhere from fully opened to fully closed by opening, closing, or partially obstructing various passageways. PVC pipelines connecting tanks with the automatic valves and fixed to the skid by ring holders. Light hoses to connect the automatic valve with the in-line mixer inlet and not to affect the load cells. Two 24-V motor to operate the in-line mixer and the recycle pump through a coupling mounted on their shafts. The in line mixer is an Artel on cylindrical mixer contained in a PVC tube with a transparent horizontal part to show oil mixing process. It will mix the base oils with additive coming on the tanks to generate the desired finished oil. The finished product tank on the bottom shelf will contain the finished oil after being mixed from the in line mixer, it has connections to a pump for recycling oil in it for long storage time. Each tank has an ame tag attached to it to identify its components. Control panel which contain the field controller is mounted in the front of the skid.

2nd Part- Proposed Control Unit

Digital controller is achieved, where all the ingredients are metered simultaneously at accurately controlled rates using digital technology to assure that the product batch is within specifications at all times that provide accurate material balance [18,19].

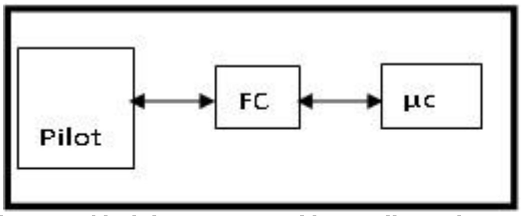

Fig. 4. Suggested control systems block diagram, FC: Field Controller, and µc: Main Controller" Laptop".

Fig. 4 shows the control process divided into two levels; Field controller which using microcontrollers µc in the field control panel and Main controller in the control room using a microprocessor based computer.

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Field controller:
The field controller mainly consists of 3 PCBs (Printed Circuit Boards) [20,21] of three microcontrollers µc_A, µc_B , and µC_C that communicate with each other and serially with a PC in the control room, as shown in Fig. 5.

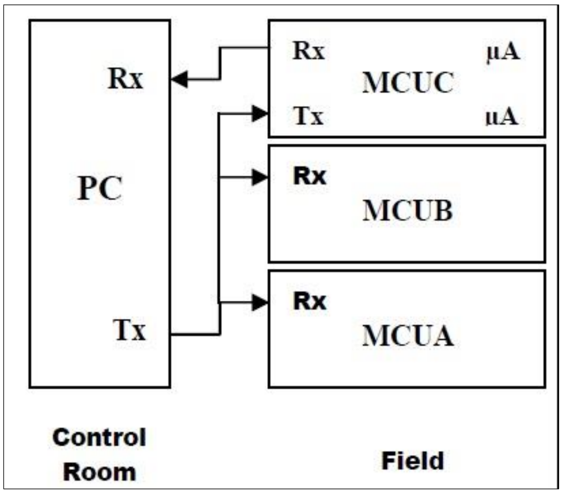

Fig. 5. Field controller schematic.

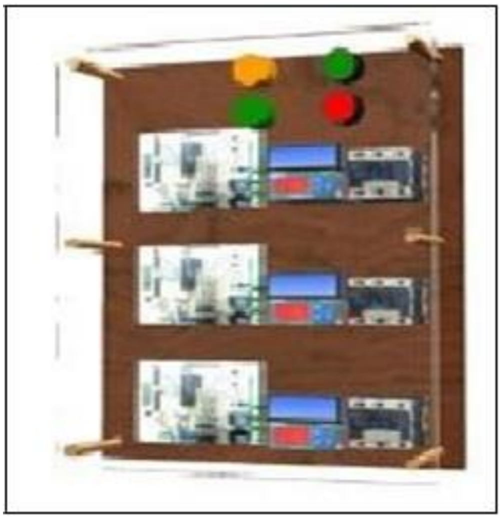

Fig. 6. Control panel schematic.

Fig. 6 shows the utilized control panel which consist of:

1. 3 LCDs one for each tank to display tank information (tank name and quantity of oil inside it).
2. 3 temperature controllers one for each tank to display the temperature of oil inside it, they can be preset to the required temperature value to stop the heaters and the in- tanks agitator when the desired temperature is reached.
3. 3 contactors one for each tank to operate its heater; as heaters consume high power (220 VAC, 13.6 A).
4. 3 control boards one for each tank that contain the microcontrollers and the conditioning circuits.

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The tasks of each microcontroller are shown in Fig. 7, [22-25]. Each microcontroller deals with its tank's load cell, valve, temperature sensor, heater, LCD and specifies a pin to notify microcontroller µc_C of its status (as a flag).

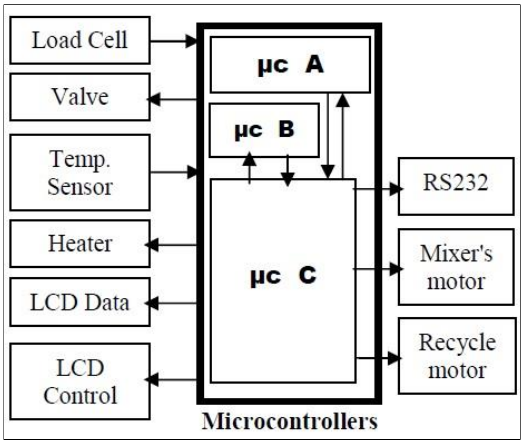

Fig. 7. Microcontrollers schematic.

Main microcontroller is µc C on board C; plus its previous tasks it does not have the notification pin, but it is responsible for more tasks such as receiving the batch frame from the PC through the RS232 cable and hearing from the other microcontrollers (µC_A and µC_B) their responses through the notification pins and send them back to the PC and operating the mainmixer and the recycle operation.

Main Controller

The main controller is a microprocessor based computer that works as SCADA system through a HMI shown in Fig. 8, programmed by a high level language (Microsoft visual C#) that communicates with the field controllers (microcontrollers) by the RS232 cable to maintain the blending process within the required parameters [26-29].

The system has the capability that allows the operator to choose the desired oil type, quantity and grade. Communicate with the field controller to perform the required batch. Show the batch progress through a progress bar, status label and changing images. Display error messages if an error (Insufficient quantity) occurred.

Fig. 8. Running program HMI.

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IV. Operational Sequence

The steps of performing a whole batch, from the selection of the desired product till being ready in the finished product tanks according to suitable program steps (for example as C Program).

A whole batch since initiation to end in the next main steps:

1. The user starts the ILB program and chooses the desired oil type and amount.
2. When the "start batch" button is pressed; a message frame containing the chosen batch data is sent serially to the field controller through the RS232 cable.
3. The three microcontrollers µc A, µc B, and µc C in the field receive the message.
4. Each microcontroller start checking the availability of the oil in their tanks.
5. The main controller sends a "heating message" to the field controller.
6. The main microcontroller will start the motor for the in line mixer and each microcontroller will open its valve to an open saved in it according to the message sent in the beginning.
7. Each microcontroller will monitor its load cell, till the stop value is reached then close its valve and notify the main microcontroller.
8. After the 3 valves are closed, the in line mixer will keep working for one more minute to assure that all the oil is pushed to the finished product tank and the mixer is empty, then the main microcontroller send a "notification message" to the main controller.
9. The main controller displays this operation on its graphical interface, progress bar and status label.
10. The recycle will keep running to a period of time according to the grade of oil in the message sent in the beginning of the program.
11. After the recycle period elapses, the main microcontroller stops the pump and sends a "notification message" to the main controller.
12. The main controller displays this operation on its graphical interface, progress bar and status label and displays a message to notify the user that the batch is finished.
13. All information of the batch is saved for the next batch.

V. Results

The tests were performed using real data given from the company chemists and engineers and on samples from the oils used in the factory. The concluding sections examine the results.

In the experiments performed two base oils (Base Oil 1(BO1) and Base Oil 2(BO2)) are used with one additive (Additive) to produce three different oil types (Oil I, Oil II, and Oil III) with three grades (A, B and C).

Table 1 shows the ideal percentage from each component in the ideal batch to produce the required final products [12].

Table 1. Ideal batch constituent oils percentages.

Oil Type	Ideal Batch		
	BO1 %	BO2 %	Additive %
Oil I	20	76.5	3.5
Oil II	30	66.5	3.5
Oil III	50	46.5	3.5

Table 2 presents the recycle time in minutes according to the preferred oil grade. Table 3 shows the average batch time

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for each finished product according to its quantity.

Table 2. Recycle timing according to batch grade.

Grade	Time (min.)
A	3:00
B	2:00
C	1:00

Table 3. Average batches timing without recycling.

Oil Type	Quantity L (Liters)	Batch Timing (min: Sec.)
Oil I	10	2:30
Oil I	15	5:30
Oil I	20	7:55
Oil II	10	2:55
Oil II	15	3:55
Oil II	20	4:00
Oil III	10	2:17
Oil III	15	2:50
Oil III	20	4:55

The next Tables (three quantities - BO1, BO2, and Additive - for three products - Oil I, Oil II, and Oil III); analyzing each batch data, showing the error in each ingredient, the total error (quantity in liters and percentage), notes (oil status, valve open) and the final adjustment to get the best result.
Each main table represents in sub-three tables a, b, and c where:-

Ideal and Actual amounts for each batch, the error for each batch and batch time and final adjustment
Table 4 Result for 10 Liters to the first product "Oil I"

Table 4. Ideal and actual amounts for each batch.

Batch	Ideal Amount			Actual Amount		
No.	BO1 (L)	BO2 (L)	Additive mL (mille liters)	BO1 (L)	BO2 (L)	Additive mL
1	7	2.5	350	6.7	2.4	325
2	7	2.5	350	7.1	2.4	300
3	7	2.5	350	7	2.4	325
4	7	2.5	350	7.2	2.3	325
5	7	2.5	350	7.1	2.5	300
6	7	2.5	350	7	2.6	325

Table 5. The error for each batch.

Batch No.	Error			Total Error	Total Error
	BO1 (L)	BO2 (L)	Additive (mL)	(L)	%
1	-0.3	-0.1	-25	-0.425	-4.25
2	0.1	-0.1	-50	-0.05	-0. 5
3	0	-0.1	-25	-0.125	-1.25
4	0.2	-0.2	-25	-0.025	-0. 25
5	0.1	0	-50	0.05	0. 5
6	0	0.1	-25	0.075	0. 75

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Table 6. Batch time and final adjustment.

Batch No.	Adjustment	Batch Time		
		BO1	BO2	Additive
1	C-open=35%	2.3	2.3	6
2	C-open =35%	2.2	2.3	4
3	C-open =70%	2.2	2.3	2
4	C-open =50%	2.2	2.2	1.4
5	C-open =45%	2	2.3	1.3
6	C-open =43%	2	2.3	1.1

From the Tables 4-6, we mention two items during progress to produce this product:

1. Note Oil in Tank C was cold for batch no. (1) Oil in Tank C was warm for batch no. (2)
2. Final Adjustments Super Diesel 50, 10Liters, and batch Time =2:30 min A-open= 90%, B-open= 30%, and C-open= 43%.

Result for 15 Liters to the first product "Oil I"

Table 7. Ideal and actual amounts for each batch.

Batch No.	Ideal Amount			Actual Amount		
	BO1 (L)	BO2 (L)	Additive (mL)	BO1 (L)	BO2 (L)	Additive (mL)
1	10.5	4	525	10.9	4.5	450
2	10.5	4	525	10.6	4.3	500
3	10.5	4	525	10.5	4.3	425
4	10.5	4	525	10.6	4	500
5	10.5	4	525	10.7	3.9	500

Table 8. The error for each batch.

Batch No.	Error			Total Error	Total Error
	BO1 (L)	BO2 (L)	Additive (mL)	(L)	%
1	0.4	0.5	-75	0.825	5.5
2	0.1	0.3	-25	0.375	2.5
3	0	0.3	0	0.3	2
4	0.1	0	-25	0.075	0.5
5	0.2	-0.1	-25	0.075	0.5

Table 9. Batch time and final adjustment.

Batch No.	Adjustment	Batch Time		
		BO1	BO2	Additive
1	C-open=35%	4:45	5:25	4:00
2	C-open =50%	4:50	5:20	1:27
3	C-open =50%	4:50	5:20	1:29
4	C-open =45%	5:00	5:25	1:03
5	C-open =40%	5:00	5:30	2:30

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From the Tables 7-9, we mention two items during progress to produce this product.

Notes

Oil in Tank C was warm for batch no. (1)

Final Adjustments

Super Diesel 50, 15 Liters and Batch Time =5:30 min A-open= 90%, B-open= 29%, and C-open= 40%. Result for 20 Liters to the first product "Oil I".

Table 10. Ideal and actual amounts for each batch.

Batch No.	Ideal Amount			Actual Amount		
	BO1 (L)	BO2 (L)	Additive (mL)	BO1 (L)	BO2 (L)	Additive (mL)
1	14	5.3	700	13.9	5.5	700
2	14	5.3	700	13.8	5.2	625
3	14	5.3	700	14	5.3	675
4	14	5.3	700	13.9	5.3	700
5	14	5.3	700	14.1	5.2	700
6	14	5.3	700	14	5.1	725
7	14	5.3	700	13. 8	5.3	700

Table 11. The error for each batch.

Batch No.	Error			Total Error	Total Error
	BO1 (L)	BO2 (L)	Additive (mL)	(L)	%
1	-0.1	0.2	0	0.1	0.5
2	-0.2	-0.1	-75	-0.375	-1.875
3	0	0	-25	-0.025	-0.125
4	-0.1	0	0	-0.1	-0.5
5	0.1	-0.1	0	0	0
6	0	-0.2	25	-0.175	-0.875
7	-0.2	0	0	-0.2	-1

Table 12. Batch time and final adjustment.

Batch No.	Adjustment	Batch Time		
		BO1	BO2	Additive
1	C-open=35%	8	5:00	5:30
2	C-open=34%	6:35	5:00	5:45
3	C-open=33%	6:45	5:40	6:05
4	C-open=33%	7:00	9:30	6:00
5	C-open=34%	7:00	6:10	5:35
6	C-open=34%	7:20	6:20	5:50
7	C-open=36%	7:20	7:45	4:40

From the Tables 10-12, we mention two items during progress to produce this product.

Notes

A-open= 90% and B-open= 35%, for batch no. (1)
A-open= 93% and B-open= 35%, for batch no. (2)
A-open= 95% and B-open= 34%, for batch no. (3)
A-open= 95% and B-open= 25%, for batch no. (4)

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A-open= 95% and B-open= 28%, for batch no. (5)
A-open= 95% and B-open= 28%, for batch no. (6)
A-open= 95% and B-open= 29%, for batch no. (7)

Final Adjustments

Super Diesel 50, 20 Liters and Batch Time =7:55 min A-open= 95%, B-open= 29%, and C-open= 36%

Result for 10 Liters to the second product "Oil II ".

Table 13. Ideal and actual amounts for each batch.

Batch No.	Ideal Amount			Actual Amount		
	BO1 (L)	BO2 (L)	Additive (mL)	BO1 (L)	BO2 (L)	Additive (mL)
1	5	4.7	350	5.2	4.7	275
2	5	4.7	350	4.9	4.8	300
3	5	4.7	350	4.9	4.9	325

Table 14. The error for each batch.

Batch No.	Error			Total Error	Total Error
	BO1 (L)	BO2 (L)	Additive (mL)	(L)	%
1	0.2	0	-75	0.125	1.25
2	-0.1	0.1	-50	-0.05	-0.5
3	-0.1	0.2	-25	0.075	0.75

Table 15. Batch time and final adjustment.

Batch No.	Adjustment	Batch Time		
		BO1	BO2	Additive
1	C-open=43%	2.3	1.2	1.2
2	C-open=43%	2.3	1.6	1.2
3	C-open=43%	2.3	2.6	1.23

From the Tables 13-15, we mention two items during progress to produce this product

Notes:

A-open= 90% and B-open= 65%, for batch no. (1)
A-open= 90% and B-open= 45%, for batch no. (2)
A-open= 90% and B-open= 37%, for batch no. (3)

Final Adjustments

Super Diesel 40, 10 Liters and Batch Time =2:55 min A-open= 90%, B-open= 37%, and C-open= 43%
Result for 15 Liters to the second product "Oil II".

Table 16. Ideal and actual amounts for each batch.

Batch No.	Ideal Amount			Actual Amount		
	BO1 (L)	BO2 (L)	Additive (mL)	BO1 (L)	BO2 (L)	Additive (mL)
1	7.5	7	525	7.2	7.1	525
2	7.5	7	525	7.5	7.2	550
3	7.5	7	525	7.5	7.1	550

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Table 17. The error for each batch.

Batch No.	Error			Total Error	Total Error
	BO1 (L)	BO2 (L)	Additive (mL)	(L)	%
1	-0.3	0.1	0	-0.2	-1.333
2	0	0.2	25	0.225	1.5
3	0	0.1	25	0.125	0.833

Table 18. Batch time and final adjustment.

Batch No.	Adjustment	Batch Time		
		BO1	BO2	Additive
1	C-open=40%	3:45	2:30	2:00
2	C-open=40%	3:45	3:30	2:10
3	C-open=40%	3:40	3:55	140

From the Tables 16-18 we mention two items during progress to produce this product.

Notes

A-open= 90% and B-open=48%, for batch no. (1) A-open= 90% and B-open= 40%, for batch no. (2) A-open= 90% and B-open= 38%, for batch no. (3)

Final Adjustments

Super Diesel 40, 15 Liters and Batch Time =3:55 min A-open= 90%, B-open= 36%, and C-open= 40%. Result for 20 Liters to the second product "Oil II".

Table 19. Ideal and actual amounts for each batch.

Batch No.	Ideal Amount			Actual Amount		
	BO1 (L)	BO2 (L)	Additive (mL)	BO1 (L)	BO2 (L)	Additive (mL)
1	10	9.3	700	10.2	9.3	700
2	10	9.3	700	9.9	9.4	725
3	10	9.3	700	10.1	9.3	700
4	10	9.3	700	10	9.5	725

Table 20. The error for each batch.

Batch No.	Error			Total Error	Total Error
	BO1 (L)	BO2 (L)	Additive (mL)	(L)	%
1	0.2	0	0	0.2	1
2	-0.1	0.1	25	0.025	0.125
3	0.1	0	0	0.1	0.5
4	0	0.2	25	0.225	1.125

Table 21. Batch time and final adjustment.

Batch No.	Adjustment	Batch Time		
		BO1	BO2	Additive
1	C-open=36%	3:45	3:05	2:00
2	C-open=36%	3:45	3:30	2:10
3	C-open=36%	3:40	3:50	1:35
4	C-open=36%	3:40	3:55	1:40

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From the Tables 19-21 we mention two items during progress to produce this product

Notes

A-open= 90% and B-open= 43%, for batch no. (1)
A-open= 90% and B-open= 40%, for batch no. (2)
A-open= 90% and B-open= 36%, for batch no. (3)
A-open= 90% and B-open= 36%, for batch no. (4)

Final Adjustments

Super Diesel 40, 20 Liters and Batch Time =4:00 min A-open= 90%, B-open= 36%, and C-open= 36% Result for 10 Liters to the third product "Oil III".

Table 22. Ideal and actual amounts for each batch.

Batch No.	Ideal Amount			Actual Amount		
	BO1 (L)	BO2 (L)	Additive (mL)	BO1 (L)	BO2 (L)	Additive (mL)
1	3	6.7	350	3	6.7	400
2	3	6.7	350	3.1	6.8	375
3	3	6.7	350	2.9	6.8	350
4	3	6.7	350	3	6.8	350
5	3	6.7	350	3.1	6.9	300
6	3	6.7	350	3	6.6	375
7	3	6.7	350	3.2	6.7	300

Table 23. The error for each batch.

Batch No.	Error			Total Error	Total Error
	BO1 (L)	BO1 (L)	Additive (mL)	(L)	%
1	0	0	50	0.05	0.5
2	0.1	0.1	25	0.23	2.25
3	-0.1	0.1	0	0	0
4	0	0.1	0	0.1	1
5	0.1	0.2	-50	0.25	2.5
6	0	-0.1	25	-0.08	-0.75
7	0.2	0	-50	0.15	1.5

Table 24. Batch time and final adjustment.

Batch No.	Adjustment	Batch Time		
		BO1	BO2	Additive
1	C-open=43%	1:50	1:40	1:10
2	C-open=43%	1:50	1:35	1:10
3	C-open=43%	1:40	2:20	1:05
4	C-open=43%	1:40	2:20	1:06
5	C-open=43%	1:40	2:17	1:06
6	C-open=43%	1:42	2:13	1:10
7	C-open=43%	1:43	2:17	1:20

From the Tables 22-24 we mention two items during progress to produce this product.

Notes

A-open= 80% and B-open= 55%, for batch no. (1)
A-open= 80% and B-open= 55%, for batch no. (2)
A-open= 70% and B-open= 48%, for batch no. (3)
A-open= 70% and B-open= 48%, for batch no. (4)

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A-open= 70% and B-open= 48%, for batch no. (5)
A-open= 70% and B-open= 48%, for batch no. (6)
A-open= 70% and B-open= 48%, for batch no. (7)

Final Adjustments

Super Diesel 30, 10 Liters and Batch Time =2:17 min A-open= 70%, B-open= 48%, and C-open= 43%
Result for 15 Liters to the third product "Oil III".

Table 25. Ideal and actual amounts for each batch.

Batch No.	Ideal Amount			Actual Amount		
	BO1 (L)	BO2 (L)	Additive (mL)	BO1 (L)	BO2 (L)	Additive (mL)
1	4.5	10	525	4	10.4	550
2	4.5	10	525	4.4	10.2	500
3	4.5	10	525	4.5	10.1	525

Table 26. The error for each batch.

Batch No.	Error			Total Error	Total Error
	BO1 (L)	BO2 (L)	Additive (mL)	(L)	%
1	-0.5	0.4	25	-0.075	-0.5
2	-0.1	0.2	-25	0.075	0.5
3	0	0.1	0	0.1	0.67

Table 27. Batch time and final adjustment.

Batch No.	Adjustment	Batch Time		
		BO1	BO2	Additive
1	C-open=40%	1:34	2:05	1:50
2	C-open=40%	2:00	2:25	2:00
3	C-open=40%	2:30	2:40	1:02

From the Tables 25-27, we mention two items during progress to produce this product.

Notes

A-open= 75% and B-open=50%, for batch no. (1) A-open= 70% and B-open=55%, for batch no. (2) A-open= 65% and B-open=58%, for batch no. (3)

Final Adjustments

Super Diesel 30, 15 Liters and Batch Time =2:50 min A-open= 65%, B-open= 58%, and C-open= 36%
Result for 20 Liters to the third product "Oil III".

Table 28. Ideal and actual amounts for each batch.

Batch No.	Ideal Amount			Actual Amount		
	BO1 (L)	BO2 (L)	Additive (mL)	BO1 (L)	BO2 (L)	Additive (mL)
1	6	13.3	700	6.1	13.4	725
2	6	13.3	700	6.1	13.2	750
3	6	13.3	700	5.9	13.5	725
4	6	13.3	700	6.2	13.1	800
5	6	13.3	700	6.1	13.3	700
6	6	13.3	700	5.9	13.5	700
7	6	13.3	700	6.1	13.3	700

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Table 29. The error for each batch.

Batch No.	Error			Total Error	Total Error
	BO1 (L)	BO2 (L)	Additive (mL)	(L)	%
1	0.1	0.1	25	0.225	1.125
2	0.1	-0.1	50	0.05	0.25
3	-0.1	0.2	25	0.125	0.625
4	0.2	-0.2	100	0.1	0.5
5	0.1	0	0	0.1	0.5
6	-0.1	0.2	0	0.1	0.5
7	0.1	0	0	0.1	0.5

Table 30. Batch time and final adjustment.

Batch No.	Adjustment	Batch Time		
		BO1	BO2	Additive
1	C-open=34%	2:40	3:20	5:35
2	C-open=34%	3:00	4:10	5:10
3	C-open=34%	3:05	4:50	4:00
4	C-open=34%	3:30	4:45	4:30
5	C-open=34%	3:30	4:45	4:35
6	C-open=34%	3:30	4:40	4:10
7	C-open=34%	4:33	4:55	4:45

From the Tables 28-30, we mention two items during progress to produce this product

Notes
A-open= 70% and B-open= 55%, for batch no. (1)
A-open= 62% and B-open= 50%, for batch no. (2)
A-open= 55% and B-open= 45%, for batch no. (3)
A-open= 50% and B-open= 45%, for batch no. (4)
A-open= 50% and B-open= 45%, for batch no. (5)
A-open= 50% and B-open= 45%, for batch no. (6)
A-open= 40% and B-open= 45%, for batch no. (7)

Final Adjustments
Super Diesel 30, 20 Liters and Batch Time =4:55 min A-open= 40%, B-open= 45%, and C-open= 36%

VI. CONCLUSION

In this paper a New Controller for ILB (NC_ILB) has been designed, tested on a pilot and verified for lube oil blending applications. The proposed technique utilizes microcontroller based field controller and microprocessor based main controller with RS232 communication protocol.

The system can provide three grades of three different lubrication oils identical to oils produced by the company, with quantity up to 20 liters in batch duration of maximum 20 minutes. It can either operate as a standalone or in conjunction with any controller type that supports the RS232 communication protocol such as dedicated SCADA system or can be integrated with a plant-wide control system like the one already exists in the field of study in order to solve the problem and upgrade the former Additives Lube Blender to provide a consistent and up to date one.

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In addition to that, the new controller with its pilot is not dedicated for lubricant oils only but it can be used in other blending applications such as Chemical industries, Pharmaceutical industries, Personal Care Industry, Foodstuffs and Beverage Industries and Pharmaceutical.

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