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Performance Analysis of Load Cell–Based Carbon and Oil Weighing System

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***Abstract*— This paper presents a detailed design, assembly, and experimental performance evaluation of a programmable logic controller (PLC)-based carbon and oil weighing system developed for industrial automation applications. Precise weighing of carbon powders, granules, and industrial oils is a critical requirement in industries such as metallurgy, rubber compounding, battery manufacturing, and chemical processing, where even small deviations in material quantity can adversely affect product quality, process efficiency, and cost. The proposed system integrates strain-gauge-based load cells for high-accuracy weight measurement, a PLC for real-time control and decision-making, and pneumatic mechanisms for controlled and repeatable material discharge.**

Experimental trials were carried out on two independent carbon weighing bins (BIN A and BINB) and a single oil weighing unit over a wide range of set values. Key performance parameters such as set weight, actual measured weight, time required for weighing, and flow rate were systematically recorded and analyzed. The experimental results indicate a strong linear correlation between set and actual weights for both carbon and oil weighing systems, with all deviations remaining within acceptable industrial tolerance limits. The average carbon flow rate was found to be approximately 0.0415 kg/s, while the oil weighing system demonstrated stable operation with an average flow rate of 0.578 L/min.
The study validates the reliability, repeatability, and accuracy of the developed weighing system and highlights its suitability for continuous industrial operation. The results confirm that PLC- based automation combined with load-cell sensing significantly reduces human intervention, minimizes material wastage, and improves overall process consistency.

***Index Terms*—Carbon and Oil Weighing System,Load Cell Measurement Principle, PLC Control Logic, Pneumatic Discharge Mechanism.**

I. INTRODUCTION

Accurate material weighing is a critical requirement in modern industrial processes, particularly in applications involving carbon powder, granules, and industrial oils. Industries such as metallurgy, rubber compounding, battery manufacturing, and chemical processing demand precise control over material proportions to ensure consistent product quality and process reliability. Manual weighing methods are prone to human error, time consumption, and inconsistency, which can lead to material wastage and increased rejection rates.

To overcome these limitations, automated weighing systems employing load cells and programmable logic controllers (PLCs) are widely adopted. Load-cell-based weighing systems provide high accuracy, fast response, and repeatability, while PLCs enable automation, process control, and integration with pneumatic and electrical subsystems. This paper focuses on the performance analysis of an automated carbon and oil weighing system assembled and tested under industrial conditions. The objective of this study is to evaluate the accuracy, flow characteristics, and repeatability of the system through experimental trials and to validate its suitability for industrial deployment.

II. SYSTEM DESCRIPTION

A. Overall System Architecture

The carbon and oil weighing system consists of a mechanical structure, hopper assembly, load cells, feeding mechanism, PLC-based control panel, and pneumatic discharge system. The integration of these subsystems enables controlled feeding, precise weighing, and automatic discharge of material.

B. Load Cell Measurement Principle

The system uses strain-gauge-based load cells arranged in a Wheatstone bridge configuration. When a load is applied, the strain gauge undergoes deformation, resulting in a proportional change in electrical resistance. This change produces a millivolt-level output signal, which is amplified and converted into a digital weight value by a weight indicator or PLC analog input module.

C. PLC Control Logic

The PLC controls the complete weighing cycle, including material feeding, weight monitoring, and discharge. The control logic follows a closed loop feedback mechanism where real-time load cell signals are continuously monitored. The PLC switches from fast feeding to fine feeding as the measured weight approaches the set value and stops feeding precisely at the desired setpoint.

D. Pneumatic Discharge Mechanism

A pneumatic system comprising solenoid valves, air cylinders, and an FRL (Filter–Regulator– Lubricator) unit is used for material discharge. After the weighing process is completed, the PLC actuates the pneumatic cylinder to open the discharge gate, allowing the material to flow into the next process stage.

III. EXPERIMENTAL SETUP

Experimental trials were conducted on two carbon weighing bins (BIN A and BIN B) and one oil weighing unit. The tests were performed for various set weight values to evaluate system accuracy, flow rate, and repeatability.

A. Carbon Weighing Trials

Carbon weighing tests were conducted for set weights ranging from 500 g to 6000 g. For each set weight, the actual measured weight, time required, and flow rate (g/s) were recorded.

B. Oil Weighing Trials

Oil weighing tests were performed for set volumes ranging from 500 ml to 10,000 ml. The actual oil volume, total filling time, and corresponding flow rate (L/min) were measured.

IV. OBSERVATIONS AND ANALYSIS

1) Carbon Weighing Machine BIN A

SR NO	SET WEIGHT (GM)	ACTUAL WEIGHT (GM)	TIME	TOLERANCE (50 GM)	GM/S

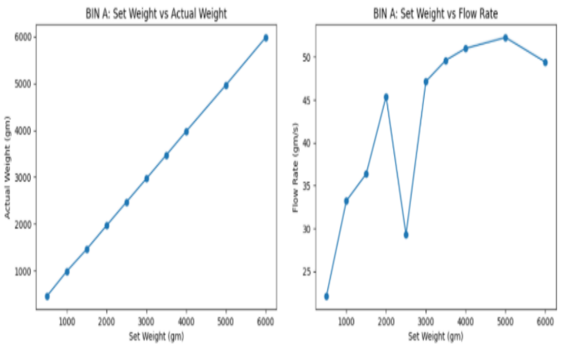
1	500	464	21	50	22.09
2	1000	996	30	50	33.2
3	1500	1465	40:33	50	36.35
4	2000	1970	43:40	50	45.39
5	2500	2472	50:35	50	29.26
6	3000	2970	1:02:53	50	47.14
7	3500	3473	1:10:35	50	49.61
8	4000	3978	1:18:08	50	51
9	5000	4966	1:34:62	50	52.27
10	6000	5980	2:00:57	50	49.42

Average (gm/sec) = 41.573 gm/sec

Average (Kg/sec) = 0.0415 kg/sec

For 1 kg, time required as per average

Time = Total mass / average = 1000gm/41.57gm/sec = 24.0558 sec



2) Carbon Weighing Machine BIN B

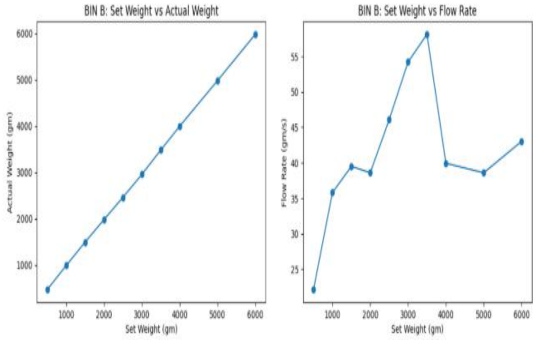
SR NO	SET WEIGHT (GM)	ACTUAL WEIGHT (GM)	TIME	TOLERANCE (50 GM)	GM/S
1	500	470	21:27	50	22.16
2	1000	988	27:67	50	35.79
3	1500	1493	37:88	50	39.49
4	2000	1980	51:37	50	38.59
5	2500	2460	53:45	50	46.06
6	3000	2953	54:54	50	54.18
7	3500	3480	59:95	50	58.09
8	4000	3993	1:39:57	50	39.93
9	5000	4977	2:08:95	50	38.58
10	6000	5978	2:18:88	50	43.00

Average (gm/sec) = 41.587 gm/sec

Average (Kg/sec) = 0.0415 kg/sec

For 1 kg, time required as per average

Time = Total mass / average = 1000gm/41.58gm/sec = 24.04 sec



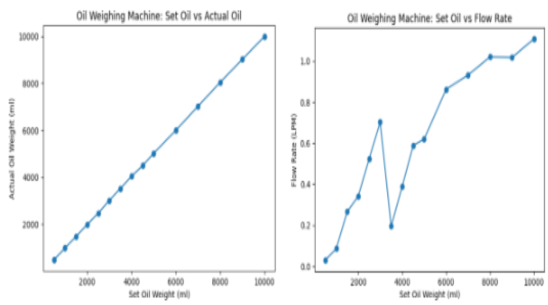
3. Oil Weighing machine

SR.NO.	SET OIL WEIGHT (ml)	ACTUAL OIL WEIGHT (ml)	TOLERANCE (ml)	FILL TANK0	DROP DOWN TIME	TOTAL TIME	LPM OF TOTAL TIME	LPM OF DROP DOWN TIME	LPM OF FILL TANK
1	500	478	50	28	15:37:19	16:15:90	0.0288	0.030	1.00
2	1000	978	50	47:49	10:26:75	11:23:29	0.085	0.093	1.22
3	1500	1475	50	52:88	6:29:74	7:25:40	0.265	0.2266	1.66
4	2000	1980	50	50:44	4:50:91	5:49:06	0.3409	0.409	2.35
5	2500	2465	50	51:52	3:42:43	4:42:98	0.524	0.664	2.87
6	3000	3010	50	50:42	3:27:27	4:17:52	0.702	0.872	3.58
7	3500	3520	50	1:31:28	16:34:68	18:07:60	0.194	0.212	2.32
8	4000	4035	50	1:22:17	9:00:27	10:23:55	0.388	0.448	2.95
9	4500	4490	50	1:18:43	6:20:62	7:38:70	0.588	0.708	3.45
10	5000	5015	50	1:10:93	6:58:83	8:06:57	0.619	0.719	4.29
11	6000	5995	50	1:21:16	5:37:12	6:57:35	0.862	1.067	4.44
12	7000	7020	50	1:18:85	6:15:43	7:32:73	0.9317	1.123	5.39
13	8000	8040	50	1:30:22	6:19:10	7:50:32	1.02	1.2727	5.35
14	9000	9020	50	1:40:38	6:45:18	8:52:31	1.017	1.336	5.41
15	10000	9995	50	1:53:44	7:8:93	9:01:20	1.108	1.400	5.30

Average LPM of Fill Tank = 3.43 L/min

Average LPM of Drop-Down Time of oil = 0.705 L/min

Average LPM of Total Time = 0.5781 L/min



V. RESULTS AND DISCUSSION

A. Carbon Weighing Performance

The experimental results show a near-linear relationship between set weight and actual weight for both BIN A and BIN B. Minor deviations were observed due to feeder response time and material settling effects; however, all deviations remained within the permissible tolerance of ±50 g. The average carbon flow rate was approximately 0.0415 kg/s, indicating stable and consistent feeding behavior.

B. Oil Weighing Performance

The oil weighing system demonstrated accurate volume control across the tested range. The flow rate increased with increasing set volume, and the average flow rate was found to be approximately 0.578 L/min.

Minor fluctuations in flow rate were attributed to valve response time and pressure variations in the pneumatic system.

C. System Reliability

Repeated trials confirmed good repeatability and stable system performance. The closed-loop PLC control effectively minimized overshoot and ensured accurate weight measurement.

VI. CONCLUSION

This paper presented the design and performance evaluation of a PLC-based carbon and oil weighing system. Experimental results confirmed that the system provides accurate, repeatable, and reliable weighing performance within industrial tolerance limits. The integration of load cells, PLC control, and pneumatic discharge mechanisms enables efficient automation and reduced human intervention. The system is suitable for industrial applications requiring precise material weighing and can be further enhanced through IoT-based monitoring and advanced control algorithms.

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