FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MECHATRONICS ENGINEERING

First Semester 2024

Fluid Mechanics Lab ENME312

Exp (8): centrifugal pump power measurements, positive displacement pumps, piston and gear pumps

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ABSTRACT

The purpose of this experiment is to study and determine the performance, characteristics, efficiency, power and factors effect on them of different types of pumps which are centrifugal, positive displacement, gear and the piston pumps depending on the pressure difference, energy conversion, dynamics of pump and the centrifugal force.

The most significant results from the experiment are the overall and volumetric efficiency electrical, mechanical and hydraulic powers for each run. The average value of overall efficiency is equal 28.9 % and the volumetric efficiency is equal to 93.4 and the relation between volume flow rate and power is approximate linear relation also the relation between hydraulic, mechanical, and the overall efficiency and flow rate is as shown in fig2 not linear relation

From the results we conclude that piston pump is better than centrifugal pump because it has larger efficiency values and the choice of pump type depend on usage, budget and system existed.

OBJECTIVES & MEASUREMENT METHOD'S

The centrifugal pump power measurements experiment aims to calculate the electrical, mechanical and hydraulic powers for the pump also is essential to determine the overall efficiency of the pump by finding the pump head. To perform this experiment the pump starts rotating at 2500 revolution per minute, it is important to balance the casing of the shaft and then all parameters which are force, voltage, current, inlet pressure, outlet pressure and the volume flow rate recorded at different volume flow rates

For the second part of this experiment which is the positive displacement pumps and the piston and gear pumps the aim is to determine the characteristics of these pumps and the effect of delivery pressure, speed and inlet pressure on their performance. The parameters need to be measured are inlet pressure, flow, shaft power and the head value all these are used to find the hydraulic power, overall efficiency, the volumetric efficiency and the theoretical flow. To perform the experiment, we run the speed of the motor at 1600 rev/min then 1800 rev/min, check that all bubbles are moved away from the flowmeter and record all parameters first by changing the delivery pressure with constant speed, second by changing the speed with constant delivery pressure, third by changing the inlet pressure with constant speed and delivery pressure.

SAMPLE CALCULATIONS

For run no.1

$$P_e = VI \tag{1}$$

Where:

- Pe: Electrical Power needed to drive the pump [W].
- V: Voltage [V].
- I: Current [A].

$$P_e = 190 \times 2.8 = 532W$$

$$P_m = \frac{2\pi NT}{60} = \frac{2\pi N(0.165F)}{60} \tag{2}$$

Where:

- $\mathbf{P_m}$: Mechanical power of the pump [W].
- $\boldsymbol{N}$: Revolution per minute [2500 RPM].
- **T**: Pump's Torque [N.m].
- $\boldsymbol{F}$: Pump's Force [N].

$$P_m = \frac{2\pi \times 2500\,(0.165 \times 8)}{60} = 345.4W$$

$$P_h = \rho g \Delta H Q \qquad (3)$$

Where:

- $\mathbf{P_h}$: hydraulic power [W].
- $\boldsymbol{\rho}$: Water density [kg/m3].
- $\boldsymbol{g}$: Acceleration due to gravity [m/s2].
- $\boldsymbol{Q}$: Volumetric flow rate [m3 /s].
- $\Delta \boldsymbol{H}$**:** Water head difference [m].

$$P_h = 1000 \times 9.81 \times 18.36 \times 0 = 0$$

$$H = 10^5 \frac{\Delta P}{\rho g} = 10^5 \frac{(P2 - P1)}{\rho g} \qquad (4)$$

Where:

- $\Delta \mathbf{P}$**:** Pressure difference [pa].
- $\boldsymbol{H}$**:** Head of the pump [m].

$$H = 10^5 \frac{(1.8 + 0.002)}{1000 \times 9.81} = 18.36m$$

- The hydraulic pump efficiency is:

$$\eta_h = \frac{P_h}{P_m} \times 100\%$$

$$= \frac{0}{345.4} \times 100\% = 0\%$$

- The mechanical pump efficiency is:

$$\eta_m = \frac{P_m}{P_e} \times 100\%$$

$$= \frac{345.4}{532} \times 100\% = 64.9\%$$

- Overall efficiency is:

$$\eta_o = \frac{P_h}{P_e} \times 100\%$$

$$= \frac{0}{532} \times 100\% = 0\%$$

PRESENTATION & RESULTS

Table (1): Data for the centrifugal pump, volumetric flow rate **Q in (L/s)** and **(m^3/s),** inlet and outlet pressure **P (bar),** voltage **(V),** current **(A),** and force **F (N).**

run	Q(L.P.S)	Q(m^3/s)	P1(bar)	P2(bar)	voltage(V)	Current(A)	F(N)
1	0	0	-0.002	1.8	190	2.8	8
2	0.6	0.0006	-0.004	1.77	190	3.4	10
3	1.2	0.0012	-0.01	1.76	190	4.1	13
4	1.8	0.0018	-0.014	1.7	190	4.6	15
5	2.4	0.0024	-0.016	1.6	190	5	18
6	3	0.003	-0.018	1.4	190	5.9	19
7	3.6	0.0036	-0.02	1.3	190	6.1	21
8	4.2	0.0042	-0.021	1	190	6.9	22.5

Table (2): calculations for the centrifugal pump, Head of the pump **H in (m),** hydraulic, electrical, and mechanical power **P (W),** hydraulic pump efficiency $\boldsymbol{\eta_h}$, mechanical pump efficiency $\boldsymbol{\eta_m}$, and the overall efficiency $\boldsymbol{\eta_o}$.

H	Ph(W)	Pe(W)	P(mech)	efficiency(h)	Efficiency(M)	Efficiency(O)
18.36901	0	532	345.4	0	64.92481203	0
18.08359	106.44	646	431.75	24.65315576	66.83436533	16.47678019
18.04281	212.4	779	561.275	37.84241236	72.05070603	27.26572529
17.47197	308.52	874	647.625	47.63867979	74.09897025	35.29977117
16.47299	387.84	950	777.15	49.90542366	81.80526316	40.82526316
14.45464	425.4	1121	820.325	51.8574955	73.1779661	37.94826048
13.45566	475.2	1159	906.675	52.41128298	78.22907679	41.00086281
10.40775	428.82	1311	971.4375	44.14282957	74.09897025	32.70938215

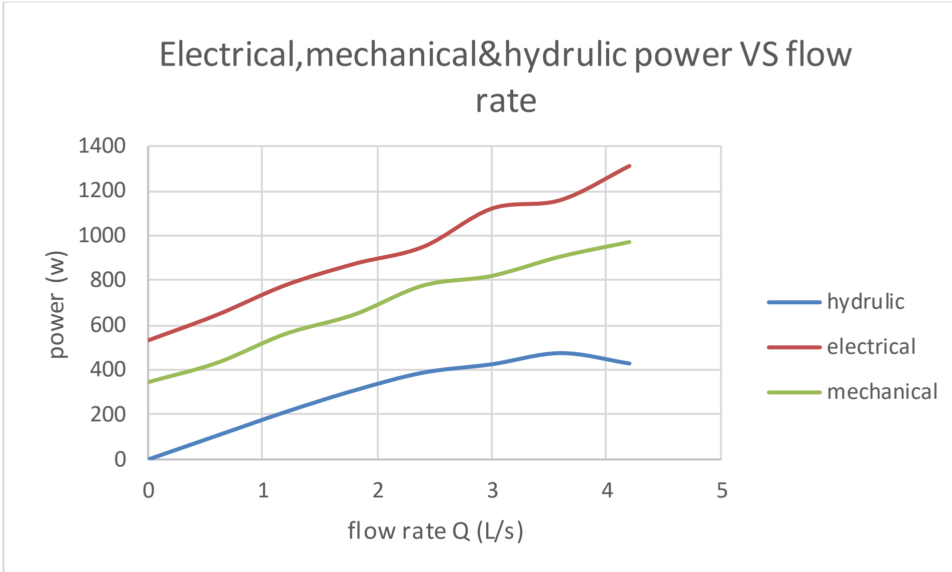


Figure (1): Electrical, mechanical & hydraulic power (w) VS. flow rate (m^3/s).

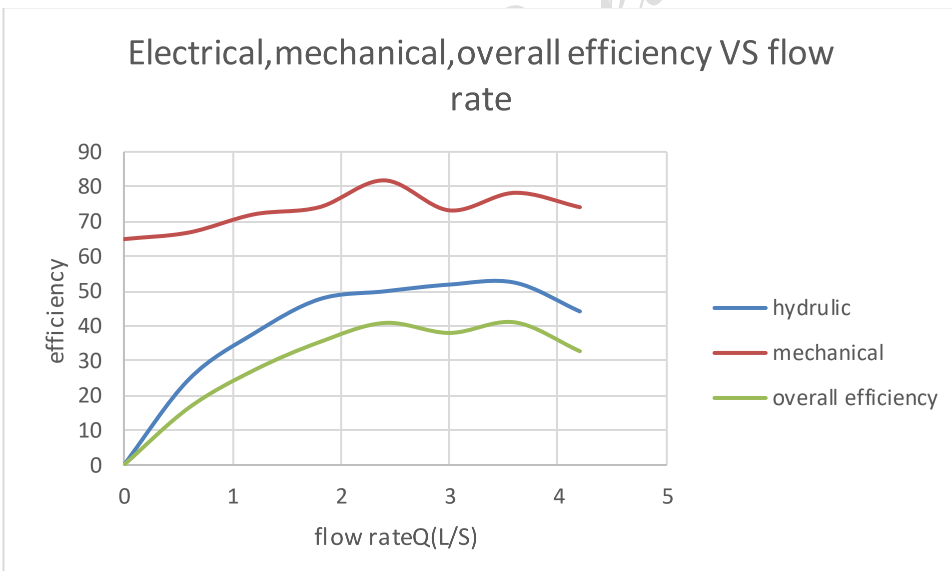


Figure (2): hydraulic, mechanical, and the overall efficiency η_o VS. flow rate (m^3/s).

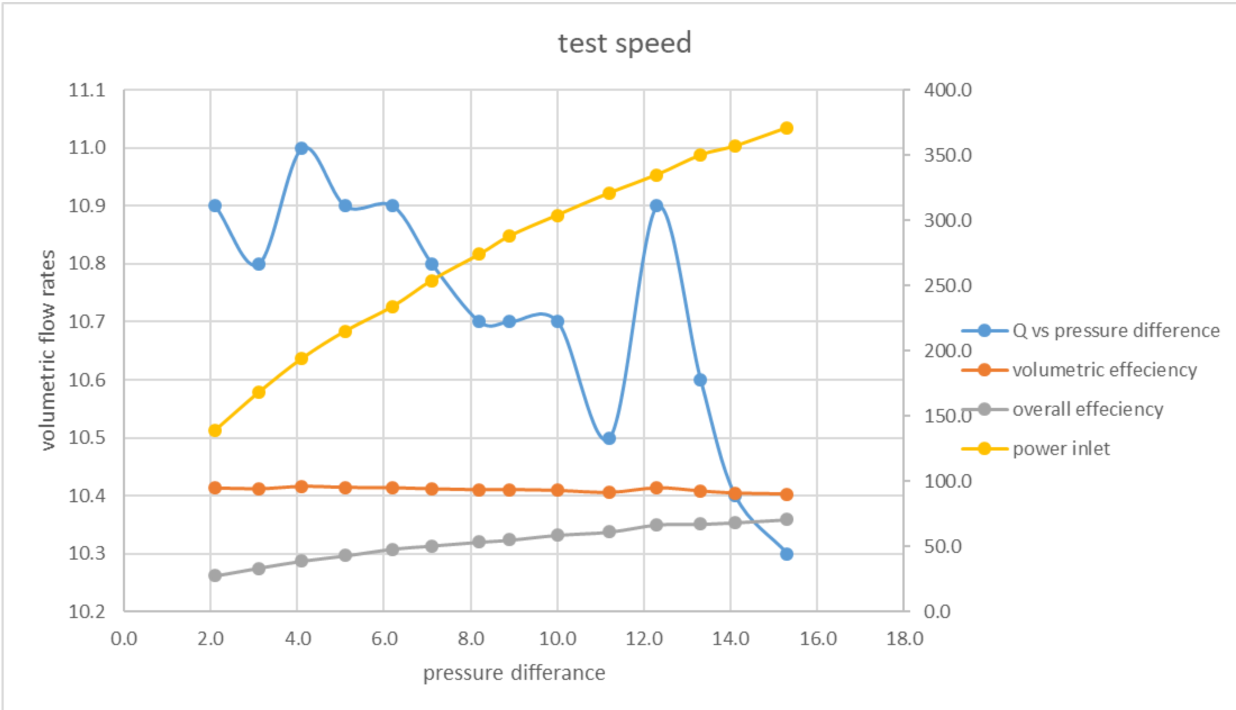


Figure (3): test speed

Figure (4): test delivery pressure

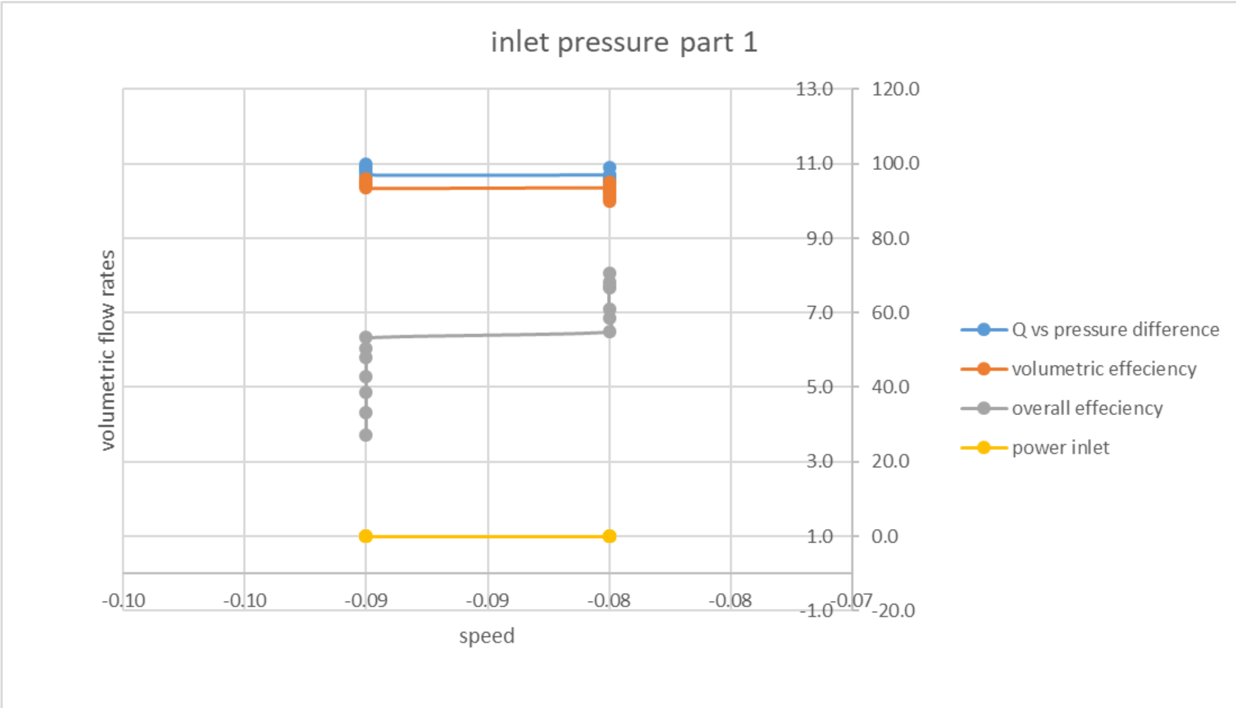


Figure (5): inlet pressure for part 1

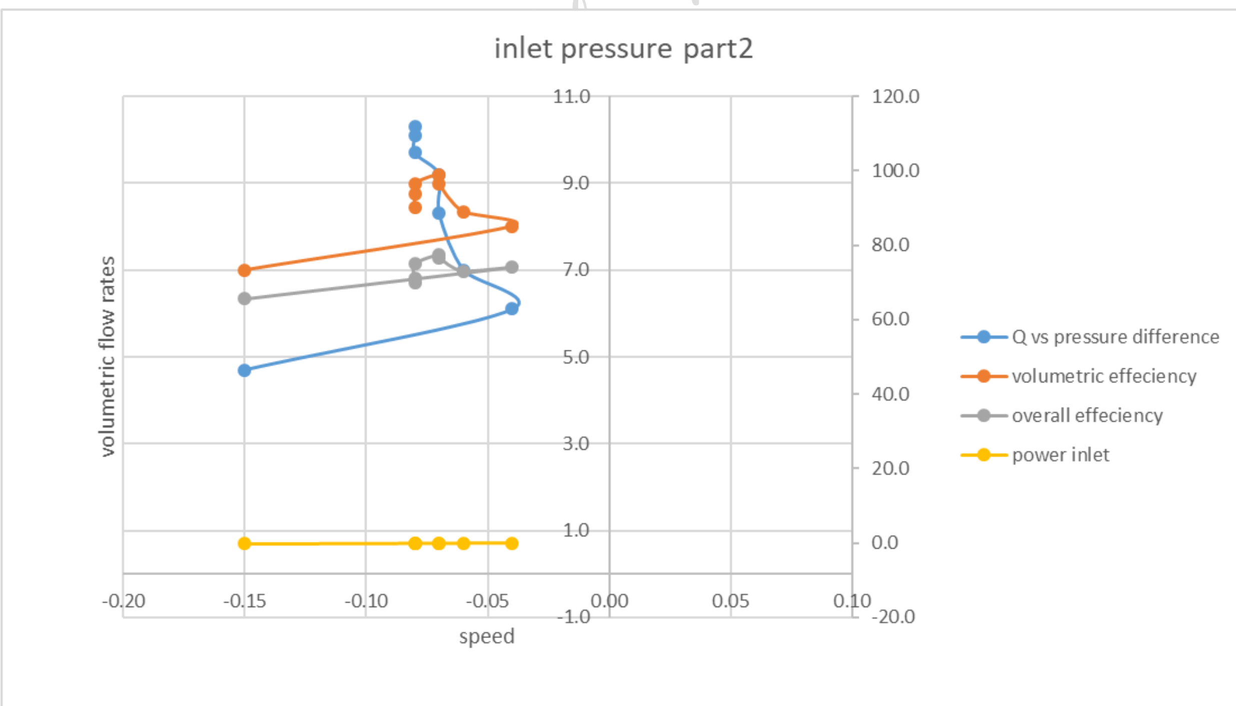


Figure (6):inlet pressure for part 2

DISCUSSION OF RESULTS

Centrifugal pumps have an average overall efficiency of(28.94),in table 2 we see hydraulic power in run 1(0) this value have negative impact on average overall efficiency .if the first run does not exist average efficiency (33.1), so this indicates its impact.

For fig 1 and 2 use to explain the calculation and data for the centrifugal pump in table 1 and 2.

For figures 3,4,5,6 the relation is not uniform and has no specific shape, for figure 5 the relation is not correct and logical.

The result showed that there difference between the measurements and there theoretical results, the reason may duo to approximate or incorrect reading, as well as the effect of the system generated by the effect, and revelation not exactly 2500rpm.

There are many methods to improve the experiment results for example we need to be more accurate while balancing the force, looking horizontally while read the values and the computer readings is not at exact required values

CONCLUSIONS

In my opinion choosing the right type of pump according to its application can improve the performance and the best type of pumps is because it has the best efficiency than others

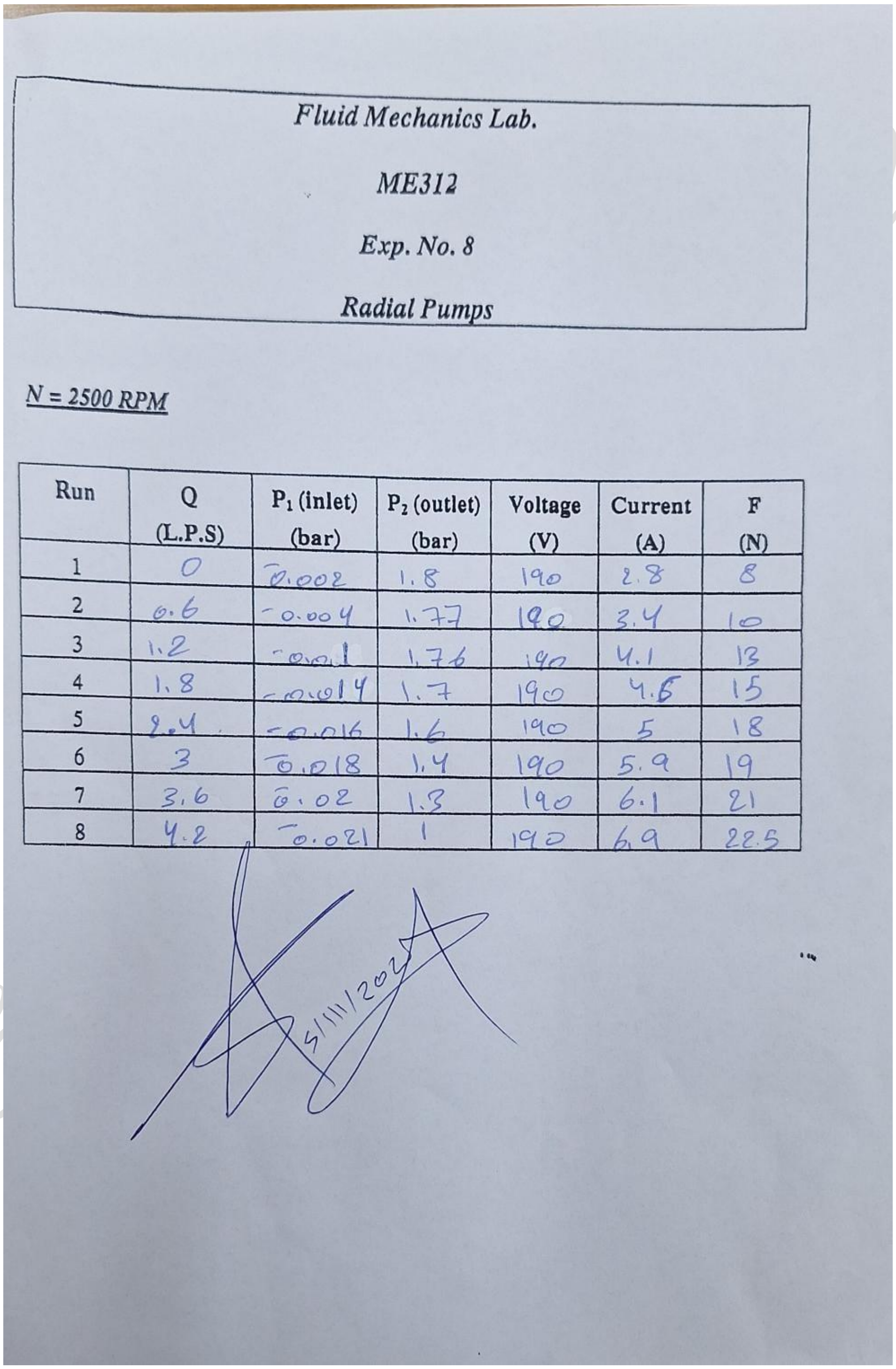
The results we got agree with the theoretical ones while the relation between Electrical, mechanical & hydraulic power and is linear relation and flow rate.

To improve the experiment results we need to

There are many applications of pumps in the real life agriculture in irrigation systems, aquaculture in fish farming to keep clean water by circulation, fire protection system and in water supply systems to distribute water to homes and businesses.

APPENDICES

- Fluid mechanics laboratory manual- ENME 312- march 2022.



Fluid Mechanics Lab.

ME312

Exp. No. 8

Radial Pumps

N = 2500 RPM

Run	Q (L.P.S)	P_1 (inlet) (bar)	P_2 (outlet) (bar)	Voltage (V)	Current (A)	F (N)
1	0	-0.002	1.8	190	2.8	8
2	0.6	-0.004	1.77	190	3.4	10
3	1.2	-0.01	1.76	190	4.1	13
4	1.8	-0.014	1.7	190	4.6	15
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6	3	-0.018	1.4	190	5.9	19
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5/11/2023

Figure(3) : original data sheet