VIRTUAL LABORATORY PUMP SYSTEMS EXPERIMENT

ME 492 Senior Project Spring 2021

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Mechanical Engineering

ABSTRACT

Pump systems virtual laboratories will be designed for use in fluid mechanics class experiments. Virtual laboratory design consists of three different pump systems which are single pump system, series pump system, and parallel pump system. Thanks to that system, users can do the pump experiments with different flow rate values. At the end of the experiment, students will be able to understand the scope of the subject.

Pump systems can be integrated into the internet interface using software that can be given an opportunity to design a virtual lab. The softwares has been used to design virtual labs. In this context; We used the softwares of JavaScript, HTML, and CSS.

Figure 1. JavaScript-HTML-CSS softwires

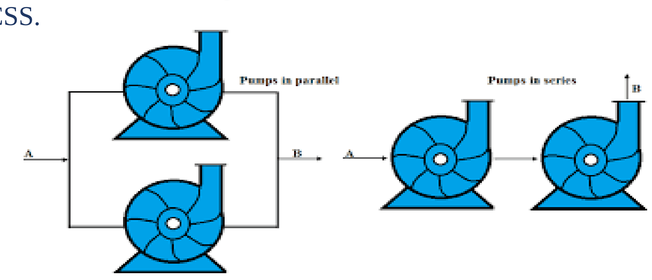


Figure 2. Pump Systems

METHODOLOGY

- **Pump Systems and Theory**

Inlet pressure can be found via Bernoulli equation. If the correlation between the tank and the inlet of the pump is established and if replaced in the Bernoulli equation, Pin can be found.

$$P_{tank} + \frac{1}{2}\rho V_{tank}^2 + \rho g h_{tank} = P_{in} + \frac{1}{2}\rho V_{in}^2 + \rho g h_{in}$$

Eqn1. Bernoulli Equation

In this kind of experiment, there can be a friction loss however, friction was neglected because the diameter of the pipe used in this experiment was quite small

We have implemented that formula for each Q (Flow Rate) values via Excel. We obtained 0.025 Pin values for each of these Flow Rates.

- **Animation For Experiments**

While making animation, html, CSS, and java were used in combination, then transferred to JavaScript.HTML provides the basic structure of sites, which is enhanced and modified by other technologies like CSS and JavaScript.CSS is used to control presentation, formatting, and layout. JavaScript is used to control the behavior of different elements.

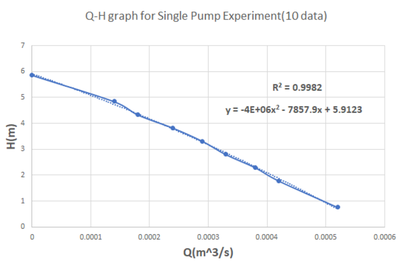
Figure 3– Animation of The Pump Experiment

- **Experiment**

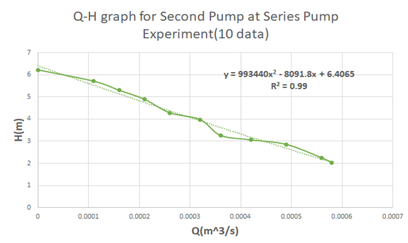
Pump System Virtual Laboratory works with real data which are measured in TED University Fluid Mechanics Laboratory. The experiment was repeated according to the university's lab sheet. Mehmet SARIKAYA did the experiment with the course assistant. A data pool was created thanks to the experiments carried out in the real laboratory.

- **Preliminary Design**

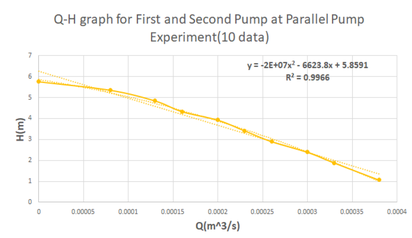
Experiments were done with 10 different flow rate values for each pump system in the university's Fluid mechanics laboratory. However, these values were not enough for the virtual laboratory. That is why thanks to 10 data from the experiment Q-H graph of each pump was drawn. Virtual laboratory work with 100 flow rate values and outlet pressures were calculated with Q-H graph equation.



VALVE OPENING DEGREE(%)	FLOW RATE(m^3/s)	HEAD(m)	ΔP(bar)	POUT(bar)	Power(W)	η(%)
1	0	5.9126	0.58002606	0.60502606	0	0
2	0.0000104	5.83043272	0.57196545	0.59696545	0.594844068	0.540767
3	0.0000156	5.7890246	0.567903313	0.592903313	0.885929169	0.80539
4	0.0000208	5.74740016	0.563819956	0.588819956	1.172745508	1.066132
5	0.0000026	5.7055594	0.559715377	0.584715377	1.455259981	1.322964
6	0.0000312	5.66350232	0.555589578	0.580589578	1.733439482	1.575854
7	0.0000364	5.62122892	0.551442557	0.576442557	2.007250908	1.824774
8	0.0000416	5.5787392	0.547274316	0.572274316	2.276661153	2.069692
9	0.0000468	5.53603316	0.543084853	0.568084853	2.541637112	2.310579
10	0.000052	5.4931108	0.538874169	0.563874169	2.802145681	2.547405
11	0.0000572	5.44997232	0.534642265	0.559642265	3.058153756	2.78014
12	0.0000624	5.40661712	0.530389139	0.555389139	3.30962823	3.008753
13	0.0000676	5.3630458	0.526114793	0.551114793	3.556536001	3.233215
14	0.0000728	5.31925816	0.521819225	0.546819225	3.798843962	3.453495
15	0.000078	5.2752542	0.517502437	0.542502437	4.036519009	3.669563
16	0.0000832	5.23103392	0.513164428	0.538164428	4.269528037	3.881389
17	0.0000884	5.18659732	0.508805197	0.533805197	4.497837942	4.088944
18	0.0000936	5.1419444	0.504424746	0.529424746	4.721415619	4.292196
19	0.0000988	5.09707516	0.500023073	0.525023073	4.940227963	4.491116
20	0.000104	5.0519896	0.49560018	0.52060018	5.15424187	4.685674



VALVE OPENING DEGREE(%)	FLOW RATE(m^3/s)	HEAD(m)	ΔP(bar)	Pout(bar)	Power(W)	η(%)
0	0	5.96	0.584676	0.609676	0	0
1	0.0000058	5.91057472	0.57982738	0.60482738	0.33629988	0.305727
2	0.0000116	5.8609476	0.57489896	0.59989896	0.666952393	0.60832
3	0.0000174	5.81111864	0.570070739	0.595070739	0.991923085	0.901748
4	0.0000232	5.76108784	0.565162717	0.590162717	1.311177504	1.19198
5	0.000029	5.7108552	0.560234895	0.585234895	1.624681196	1.476983
6	0.0000348	5.66042072	0.555287273	0.580287273	1.932399709	1.756727
7	0.0000406	5.6097844	0.55031985	0.57531985	2.23429859	2.031181
8	0.0000464	5.55894624	0.545332626	0.570332626	2.530343385	2.300312
9	0.0000522	5.50790624	0.540325602	0.565325602	2.820499643	2.564091
10	0.000058	5.4566644	0.535298778	0.560298778	3.1047329	2.822484
11	0.0000638	5.40522072	0.530252153	0.555252153	3.383008734	3.075462
12	0.0000696	5.3535752	0.525185727	0.550185727	3.655292661	3.322993
13	0.0000754	5.30172784	0.520099501	0.545099501	3.921550238	3.565046
14	0.0000812	5.24967864	0.514993475	0.539993475	4.181747014	3.801588
15	0.000087	5.1974276	0.509867648	0.534867648	4.435848534	4.03259
16	0.0000928	5.14497472	0.50472202	0.52972202	4.683820346	4.258018
17	0.0000986	5.09232	0.499556592	0.524556592	4.925627997	4.477844
18	0.0001044	5.03946344	0.494371363	0.519371363	5.161237035	4.692034
19	0.0001102	4.98640504	0.489166334	0.514166334	5.390613005	4.900557
20	0.000116	4.9331448	0.483941505	0.508941505	5.613721457	5.103383



VALVE OPENING DEGREE(%)	FLOW RATE(m^3/S)	HEAD(m)	ΔP(bar)	Pout(bar)	Power(W)	η(%)
0	0	5.8966	0.57845646	0.60345646	0	0
1	0.0000038	5.86801146	0.575651924	0.600651924	0.218747731	0.19886
2	0.0000076	5.83913412	0.572819057	0.597819057	0.435342483	0.39577
3	0.0000114	5.80996798	0.569957859	0.594957859	0.649751959	0.59068
4	0.0000152	5.78051304	0.567068329	0.592068329	0.86194386	0.78359
5	0.000019	5.7507693	0.564150468	0.589150468	1.07188589	0.97444
6	0.0000228	5.72073676	0.561204276	0.586204276	1.27954575	1.16322
7	0.0000266	5.69041542	0.558229753	0.583229753	1.484891142	1.3499
8	0.0000304	5.65980528	0.555226898	0.580226898	1.68788977	1.53445
9	0.0000342	5.62890634	0.552195712	0.57195712	1.888509335	1.71683
10	0.000038	5.5977186	0.549136195	0.574136195	2.08671754	1.89702
11	0.0000418	5.56624206	0.546048346	0.571048346	2.282482087	2.07498
12	0.0000456	5.53447672	0.542932166	0.567932166	2.475770678	2.2507
13	0.0000494	5.50242258	0.539787655	0.564787655	2.666551016	2.42414
14	0.0000532	5.47007964	0.536614813	0.561614813	2.854790803	2.59526
15	0.000057	5.4374479	0.533413639	0.558413639	3.040457742	2.76405
16	0.0000608	5.40452736	0.530184134	0.555184134	3.223539535	2.93047
17	0.0000646	5.37131802	0.526926298	0.551926298	3.403943884	3.09449
18	0.0000684	5.33781988	0.52364013	0.54864013	3.581698491	3.25609
19	0.0000722	5.30403294	0.520325631	0.545325631	3.756751059	3.41523
20	0.000076	5.2699572	0.516982801	0.541982801	3.92906929	3.57188

DISCUSSION

Pump virtual lab includes 100 data to calculate exact efficiency and power of pumps, but these are associated with outlet pressure, flow rate, valve opening degree and inlet pressure. Inlet pressure is constant so that inlet pressure can not affect the whole pump experiments. Flow rate is input value since most of equations are related to flow rate because of that flow rate value is accepted input value. As a result of that, valve opening degree and outlet pressure of pumps are output value for whole experiment.

Pump virtual lab code is designed according to real data of conventional lab, but conventional data provide to get 10 data and range of these data are wide because of that pump virtual lab must obtain more data with short range so that Q-H graph is sketched for 10 data by using Microsoft Excel.

INTERFACE OF THE PROGRAM

Figure 4. Home Page of Pump Experiments Virtual Lab

Home page provide to sign in the virtual lab experiments. Home page includes whole experiments separately. Single, Series and Parallel Pump Experiments have buttons to access simulation, procedure, test and theory. Theory sub-button provide to Access theory of experiment. Each experiment different theory parts. Simulation sub-button provide to Access simulation of experiment. Each experiment different simulation parts.

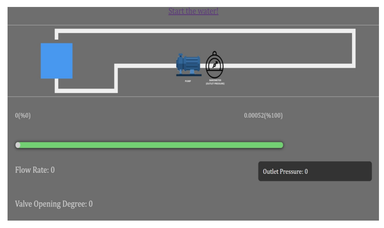


Figure 5. Single Pump Experiment of Virtual Lab

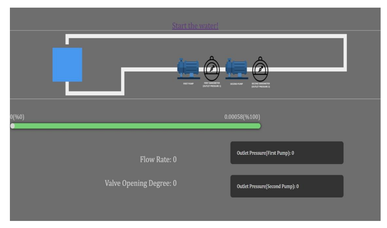


Figure 6. Series Pump Experiment of Virtual Lab

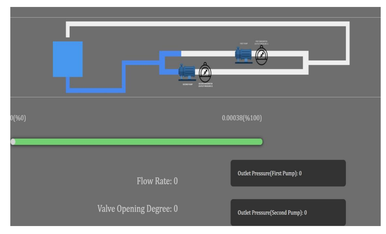


Figure 7. Parallel Pump Experiment of Virtual Lab

Simulation of pump systems includes experiment setup. Experiment setup consist of an animation. Animation is started after clicking the button and water flow follows the path that is consisted of pipes. Animation finish after water flows complete path of systems. "reset "button is shown when the flow animation finished. "reset "button provides to restart the flow animation. Flow rate slider provides to set flow rate value and valve opening degree of pump systems. Outlet pressure value can change according to flow rate value.

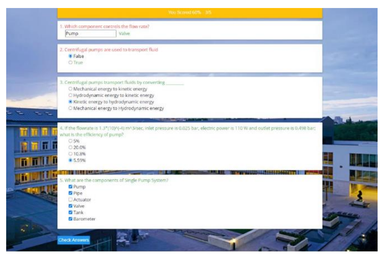


Figure 8. Test Questions of Pump Virtual Lab System

Test sub-button provide to Access questions about experiment. Each experiment different test parts. Each test part consists of 4 or 5 questions. Types of question are multiple choice, true-false and open-ended. Answers to questions are checked using "Check Answer "button. System can calculate grades of users automatically and show at the top of questions.

CONCLUSION

In conclusion, according to the university lab sheet pump system experiment was repeated. Thanks to data that came from these experiments, a virtual lab was designed for a single pump system, series pump system, and parallel pump system. Virtual lab sheet of each experiment added to the system. According to the lab sheet head loss in the entrance and through pipes was neglected. As a result of this inlet pressure was constant. ΔH was the difference between outlet pressure and inlet pressure. The output of the system is valve opening degree and outlet pressure.

In a single pump system experiment, series pump experiment and parallel pump experiment was done with 10 different flow rate values. Outlet pressure values of these flow rates were recorded. The Q-H graph of the single pump was drawn with these 10 values, first pump and second pump Q-H graphs of the series pump system were drawn with these 10 values and the Q-H graph of the pumps was the same for parallel pump system and drawn with these 10 values. The Virtual Lab has been designed with 100 different flow rate values thanks to these Q-H graphs. Users can do the same process for each pump system experiments with 100 different flow rates.

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