

3.1 Light running test

Voltage increased to the maximum (from 0) as required

	A	B	C	D	E	F	G	H	I	J	K	L
1	voltage turned up to max											
2	No.	Voltmeter	Voltmeter	Voltmeter	Ammeter	Ammeter	Ammeter	UM1	UM2	UM3	Torque Nr	Speed rpm
3	1	2	1	2	0.014	0.05	0.009	0	-47.8	0.795	0.071	0
4	2	23	1	22	0.145	0.48	0.14	6	-47.8	0.892	0.071	0
5	3	44	1	44	0.286	0.96	0.289	24	-47.8	0.898	0.071	0
6	4	66	1	65	0.426	1.41	0.425	52	-47.8	0.903	0.082	0
7	5	88	1	86	0.568	1.89	0.563	92	-47.8	0.905	0.111	0
8	6	110	1	108	0.71	2.36	0.715	144	-47.8	0.905	0.111	0
9	7	130	1	128	0.461	1.47	0.445	108	-47.8	0.908	0.121	1996
0	8	130	1	128	0.461	1.47	0.445	108	-47.8	0.908	0.121	1996
1	9	151	1	149	0.371	1.14	0.354	100	-47.8	0.909	0.121	2407
2	10	173	1	172	0.323	0.95	0.305	100	-47.8	0.91	0.141	2603
3	11	195	1	193	0.293	0.82	0.276	101	-47.8	0.91	0.134	2710
4	12	216	1	214	0.278	0.73	0.263	107	-47.8	0.91	0.131	2779
5	13	237	1	236	0.27	0.66	0.258	115	-47.8	0.91	0.131	2827
6	14	257	1	257	0.272	0.6	0.26	125	-47.8	0.91	0.131	2857
7	15	279	1	277	0.282	0.55	0.26	138	-47.8	0.912	0.131	2886
8	16	299	1	297	0.287	0.51	0.268	151	-47.8	0.912	0.131	2905
9	17	321	1	318	0.301	0.48	0.275	169	-47.8	0.913	0.131	2919
0	18	321	1	318	0.301	0.48	0.275	169	-47.8	0.913	0.131	2919
1	19	342	1	339	0.315	0.45	0.291	189	-47.8	0.913	0.131	2934
2	20	342	1	339	0.315	0.45	0.291	189	-47.8	0.913	0.131	2934
3	21	363	1	360	0.33	0.42	0.309	211	-47.8	0.912	0.131	2944
4	22	383	1	381	0.35	0.4	0.328	237	-47.8	0.912	0.131	2952
5	23	405	1	403	0.375	0.39	0.35	268	-47.8	0.912	0.131	2959
6	24	415	1	412	0.394	0.37	0.36	285	-47.8	0.913	0.131	2964

Rotor resistance decreased to 0

	reduce r to zero											
	No.	Voltmeter	Voltmeter	Voltmeter	Ammeter	Ammeter	Ammeter	UM1	UM2	UM3	Torque Nr	Speed rpm
1	1	415	1	412	0.394	0.38	0.36	285	-47.8	0.913	0.131	2965
2	2	414	1	412	0.395	0.37	0.36	285	-47.8	0.913	0.131	2965
3	3	414	1	412	0.396	0.36	0.359	285	-47.8	0.914	0.131	2965
4	4	414	1	412	0.395	0.37	0.36	285	-47.8	0.913	0.131	2965
5	5	414	1	412	0.393	0.37	0.36	285	-47.8	0.913	0.131	2965
6	6	414	1	412	0.393	0.37	0.36	285	-47.8	0.913	0.131	2965
7	7	414	1	412	0.393	0.35	0.36	285	-47.8	0.913	0.131	2965
8	8	414	1	411	0.393	0.38	0.359	284	-47.8	0.913	0.131	2965
9	9	414	1	412	0.393	0.36	0.36	284	-47.8	0.913	0.131	2965
10	10	414	1	412	0.393	0.36	0.36	284	-47.8	0.913	0.131	2965
11	11	414	1	412	0.393	0.36	0.36	284	-47.8	0.913	0.131	2965
12	12	414	1	411	0.392	0.36	0.359	284	-47.8	0.913	0.131	2965
13	13	414	1	412	0.391	0.36	0.36	284	-47.8	0.913	0.131	2965
14	14	414	1	412	0.391	0.36	0.36	284	-47.8	0.913	0.131	2965
15	15	414	1	412	0.391	0.36	0.361	284	-47.8	0.913	0.131	2965
16	16	414	1	412	0.391	0.36	0.361	284	-47.8	0.913	0.131	2965
17	17	415	1	412	0.391	0.37	0.36	284	-47.8	0.913	0.131	2965
18	18	415	1	412	0.39	0.38	0.36	284	-47.8	0.913	0.133	2965
19	19	415	1	412	0.393	0.36	0.361	285	-47.8	0.913	0.134	2965
20	20	415	1	412	0.393	0.36	0.361	285	-47.8	0.913	0.134	2965
21	21	415	1	412	0.392	0.36	0.361	285	-47.8	0.913	0.135	2965
22	22	414	1	412	0.393	0.36	0.361	285	-47.8	0.913	0.135	2965
23	23	414	1	412	0.392	0.38	0.36	284	-47.8	0.913	0.14	2964
24	24	415	1	413	0.392	0.38	0.361	285	-47.8	0.913	0.139	2965
25	25	415	1	413	0.391	0.37	0.36	284	-47.8	0.913	0.14	2965
26	26	415	1	412	0.392	0.36	0.36	285	-47.8	0.913	0.141	2965
27	27	415	1	412	0.394	0.36	0.361	286	-47.8	0.913	0.141	2965
28	28	415	1	412	0.394	0.36	0.361	286	-47.8	0.913	0.141	2965
29	29	415	1	412	0.393	0.38	0.36	285	-47.8	0.913	0.141	2965
30	30	415	1	412	0.393	0.38	0.36	285	-47.8	0.913	0.141	2965
31	31	415	1	412	0.394	0.36	0.359	285	-47.8	0.913	0.141	2965
32	32	414	1	412	0.394	0.37	0.359	284	-47.8	0.913	0.141	2964

Torque was increased gradually, not allowing the machine to reduce speed below 2000rpm.

	A	B	C	D	E	F	G	H	I	J	K	L
	reduce torque											
	No.	Voltmeter	Voltmeter	Voltmeter	Ammeter	Ammeter	Ammeter	UM1	UM2	UM3	Torque Nr	Speed rpm
	1	415	1	411	0.393	0.37	0.358	284	-47.8	0.914	0.141	2965
	2	414	1	412	0.398	0.41	0.364	288	-47.8	0.913	0.172	2964
	3	414	1	412	0.406	0.5	0.372	294	-47.8	0.913	0.207	2942
	4	414	1	411	0.422	0.62	0.39	307	-47.8	0.913	0.291	2920
	5	414	1	412	0.441	0.75	0.407	321	-47.8	0.913	0.365	2900
	6	414	1	412	0.46	0.88	0.428	336	-47.8	0.912	0.441	2880
	7	414	1	412	0.482	0.99	0.452	353	-47.8	0.912	0.516	2857
0	8	414	1	411	0.506	1.1	0.475	370	-47.8	0.912	0.591	2835
1	9	414	1	411	0.534	1.22	0.501	391	-47.8	0.912	0.664	2813
2	10	414	1	412	0.563	1.36	0.531	413	-47.8	0.911	0.744	2790
3	11	414	1	411	0.592	1.48	0.56	435	-47.8	0.911	0.819	2766
4	12	414	1	411	0.647	1.72	0.619	477	-47.8	0.911	0.961	2718
5	13	414	1	411	0.672	1.8	0.644	496	-47.8	0.911	1.018	2699
6	14	413	1	411	0.706	1.93	0.68	522	-47.8	0.91	1.092	2667
7	15	413	1	411	0.733	2.04	0.704	542	-47.8	0.91	1.155	2655
8	16	414	1	410	0.773	2.18	0.747	572	-47.8	0.91	1.242	2611
9	17	413	1	411	0.806	2.32	0.779	597	-47.8	0.91	1.312	2578
0	18	413	1	410	0.858	2.48	0.826	634	-47.8	0.91	1.399	2534
1	19	413	1	410	0.883	2.59	0.857	654	-47.8	0.91	1.459	2509
2	20	413	1	410	0.938	2.77	0.915	697	-47.8	0.91	1.575	2468
3	21	413	1	410	0.979	2.93	0.957	728	-47.8	0.91	1.658	2422
4	22	413	1	410	1.011	3.1	0.991	753	-47.8	0.91	1.754	2384
5	23	413	1	411	1.068	3.29	1.055	799	-47.8	0.909	1.85	2279
6	24	414	1	410	1.072	3.38	1.058	802	-47.8	0.909	1.887	2286
7	25	413	1	411	1.101	3.6	1.093	826	-47.8	0.909	2.005	2202
8	26	413	1	411	1.104	3.62	1.093	827	-47.8	0.909	2.009	2179

3.2 Locked rotor test

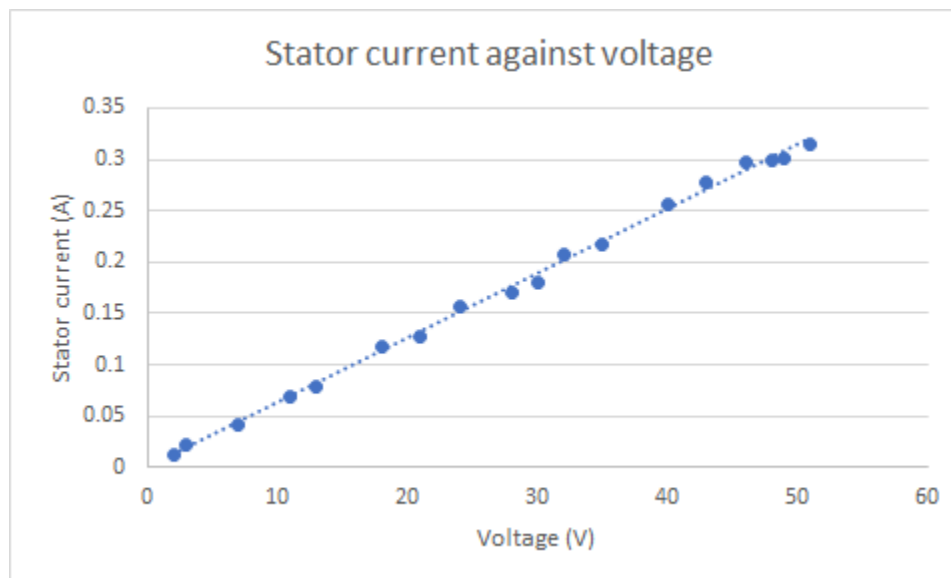
Using the allen key, the rotor was locked. The rotor resistance was set to zero and the circuit was shorted as before for 3.1 The input voltage was gradually decreased, and readings were taken, but stopping once the rated current (I_2) reached 1.0amp.

Here are the readings below.

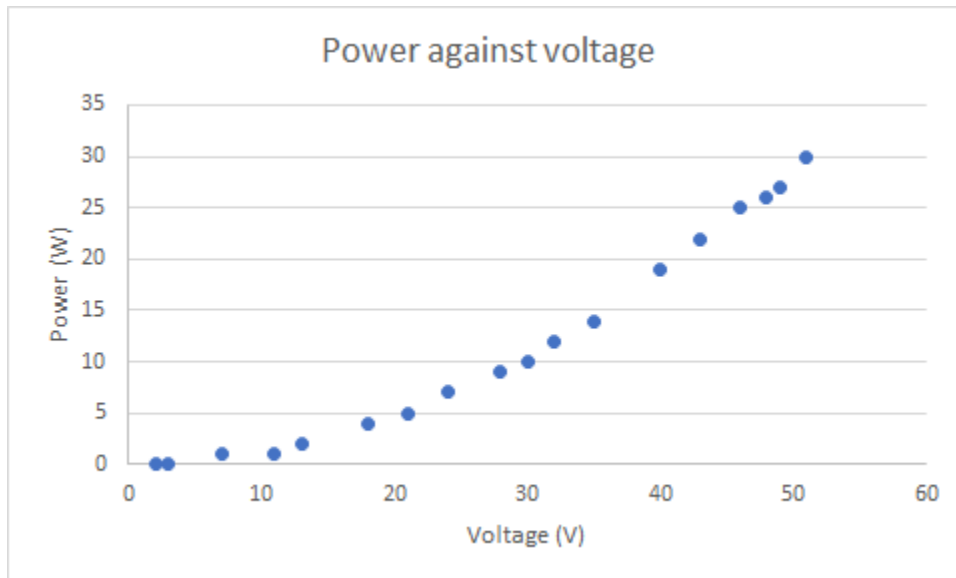
No.	Voltmeter	Voltmeter	Voltmeter	Ammeter	Ammeter	Ammeter	UM1	UM2	UM3	Torque Nr	Speed rpm
1	2	1	2	0.013	0.03	0.009	0	-47.8	0.801	0.111	0
2	3	1	2	0.022	0.06	0.015	0	-47.8	0.834	0.106	0
3	7	1	6	0.042	0.13	0.037	1	-47.8	0.86	0.103	0
4	11	1	10	0.068	0.21	0.06	1	-47.8	0.88	0.102	0
5	13	1	12	0.078	0.24	0.072	2	-47.8	0.883	0.103	0
6	18	1	17	0.118	0.34	0.106	4	-47.8	0.895	0.102	0
7	21	1	20	0.127	0.4	0.12	5	-47.8	0.892	0.103	0
8	24	1	23	0.156	0.46	0.139	7	-47.8	0.897	0.103	0
9	28	1	27	0.171	0.56	0.166	9	-47.8	0.896	0.104	0
10	30	1	29	0.181	0.58	0.174	10	-47.8	0.897	0.104	0
11	32	1	31	0.208	0.64	0.203	12	-47.8	0.898	0.105	0
12	35	1	34	0.217	0.7	0.21	14	-47.8	0.899	0.106	0
13	40	1	39	0.257	0.79	0.248	19	-47.8	0.901	0.108	0
14	43	1	42	0.278	0.85	0.274	22	-47.8	0.901	0.109	0
15	46	1	45	0.298	0.93	0.289	25	-47.8	0.902	0.11	0
16	48	1	47	0.299	0.96	0.289	26	-47.8	0.902	0.11	0
17	49	1	48	0.302	0.98	0.292	27	-47.8	0.902	0.11	0
18	51	1	50	0.315	1.02	0.308	30	-47.8	0.902	0.11	0

And the graphs created using these results:

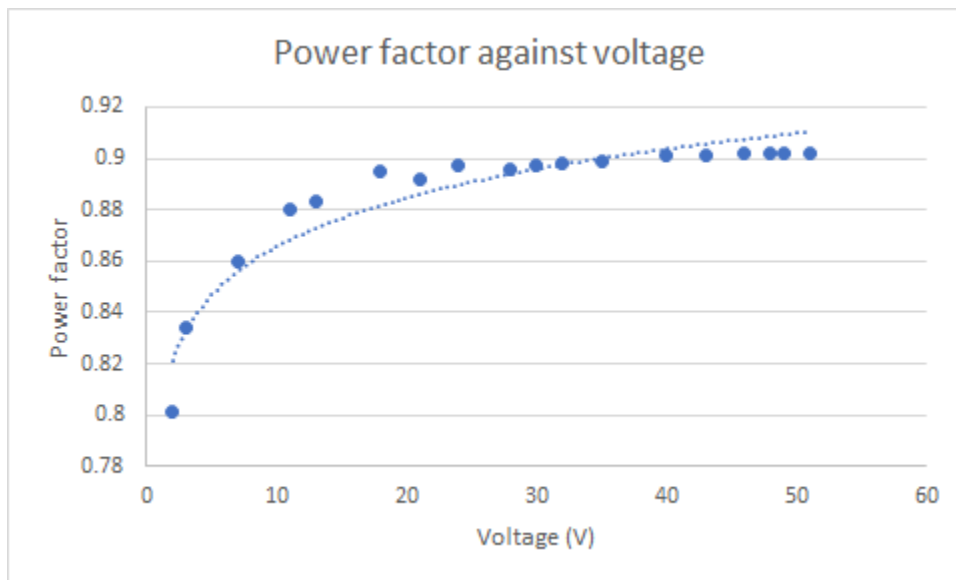
Stator current against voltage has a linear trend, the same as the light running test. Therefore, stator current is directly proportional to current.



Power against current has an exponential shape.



Power factor against current also has a slight logarithmic shape.



3.3 load test

With resistance at zero and the circuit short-circuiting, having the variable supply control around 90% gave the stator voltage of 380V. Torque was increased gradually, therefore readings at speeds between 3000-2000rpm were measured. Here are the results measured:

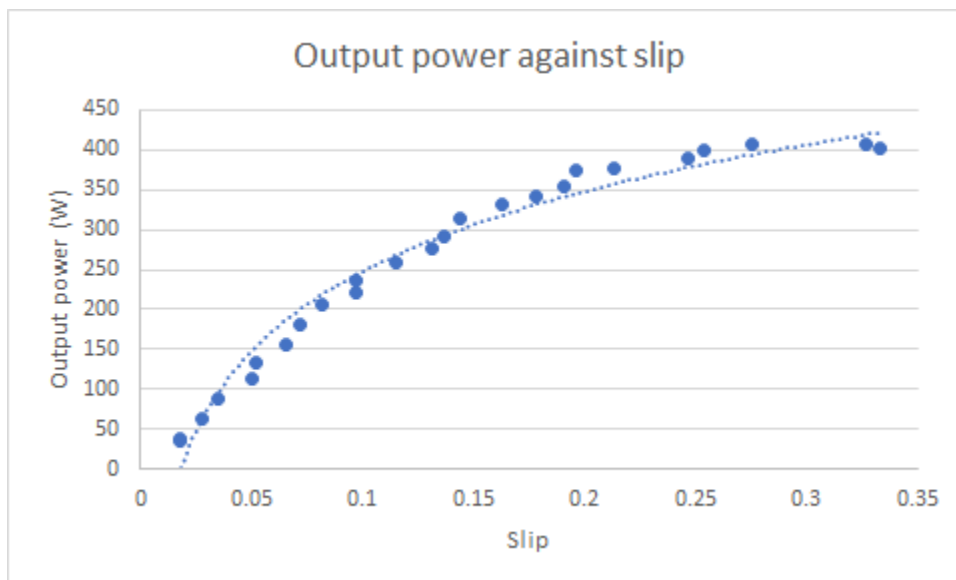
Increase torque										o/p power i/p power motor err						
No.	Voltmeter	Voltmeter	Voltmeter	Ammeter	Ammeter	Ammeter	UM1	UM2	UM3	Torque Nm	Speed rpm	rad/second	P=Tw	P=I1V1	o/p / i/p	slip efficien
1	383	23	382	0.346	0.39	0.326	90	-123.7	0.339	0.118	2946	308.5044	36.40352	132.518	0.274706	0.018
2	384	1	381	0.345	0.4	0.325	91	-129	0.354	0.124	2946	308.5044	38.25455	132.48	0.288757	0.018
3	383	1	379	0.365	0.56	0.342	126	-81.2	0.467	0.209	2917	305.4675	63.84271	139.795	0.456688	0.0277
4	382	1	382	0.384	0.68	0.362	141	-83.2	0.494	0.287	2896	303.2684	87.03803	146.688	0.593355	0.0347
5	382	1	381	0.433	0.86	0.407	174	-78.8	0.541	0.383	2849	298.3466	114.2667	165.406	0.690826	0.0503
6	384	1	381	0.445	0.97	0.407	204	-140.3	0.623	0.447	2844	297.823	133.1269	170.88	0.779066	0.052
7	383	1	381	0.489	1.24	0.459	254	-70.1	0.698	0.529	2803	293.5295	155.2771	187.287	0.829086	0.0657
8	382	1	381	0.493	1.25	0.482	255	-90.1	0.681	0.62	2785	291.6445	180.8196	188.326	0.960141	0.0717
9	383	1	380	0.538	1.35	0.506	285	-64.5	0.712	0.712	2755	288.5029	205.4141	206.054	0.996894	0.0817
10	383	1	378	0.595	1.55	0.557	322	-69.6	0.731	0.779	2710	283.7905	221.0728	227.885	0.970107	0.0967
11	383	1	380	0.58	1.58	0.556	323	-59.7	0.741	0.829	2710	283.7905	235.2624	222.14	1.059072	0.0967
12	383	1	380	0.649	1.83	0.61	364	-58	0.756	0.928	2656	278.1357	258.1099	248.567	1.038392	0.1147
13	383	1	378	0.712	1.95	0.681	410	-55.7	0.771	1.014	2605	272.795	276.6141	272.696	1.014368	0.1317
14	381	1	381	0.717	2.08	0.69	419	-71.3	0.779	1.076	2591	271.3289	291.9499	273.177	1.068721	0.1363
15	382	1	382	0.754	2.21	0.717	444	-54.5	0.787	1.168	2569	269.0251	314.2213	288.028	1.09094	0.1437
16	382	1	380	0.816	2.41	0.783	485	-74.6	0.793	1.257	2511	262.9513	330.5298	311.712	1.060369	0.163
17	383	1	381	0.859	2.55	0.83	527	-71.3	0.812	1.324	2467	258.3436	342.047	328.997	1.039666	0.1777
18	382	1	381	0.887	2.66	0.86	541	-51.5	0.808	1.39	2429	254.3643	353.5664	338.834	1.04348	0.1903
19	382	1	380	0.909	2.77	0.877	549	-51.2	0.802	1.487	2411	252.4793	375.4368	347.238	1.081209	0.1963
20	382	1	380	0.962	2.93	0.934	590	-50.6	0.812	1.525	2360	247.1386	376.8864	367.484	1.025586	0.2133
21	383	1	378	1.027	3.18	1.021	640	-57.2	0.817	1.649	2259	236.5619	390.0906	393.341	0.991736	0.247
22	382	1	380	1.051	3.3	1.042	653	-55.5	0.816	1.702	2239	234.4675	399.0637	401.482	0.993977	0.2537
23	382	1	379	1.081	3.5	1.067	677	-48.6	0.824	1.787	2173	227.556	406.6426	412.942	0.984745	0.2757
24	383	1	379	1.125	3.84	1.119	716	-79.2	0.834	1.918	2020	211.5339	405.722	430.875	0.941624	0.3267
25	382	1	378	1.137	3.88	1.116	711	-48.6	0.826	1.916	2000	209.4395	401.2861	434.334	0.923911	0.3333

Firstly, I converted rpm to rad/s (by using $\text{Rad/s} = \text{RPM} * 6.283185307 / 60$)

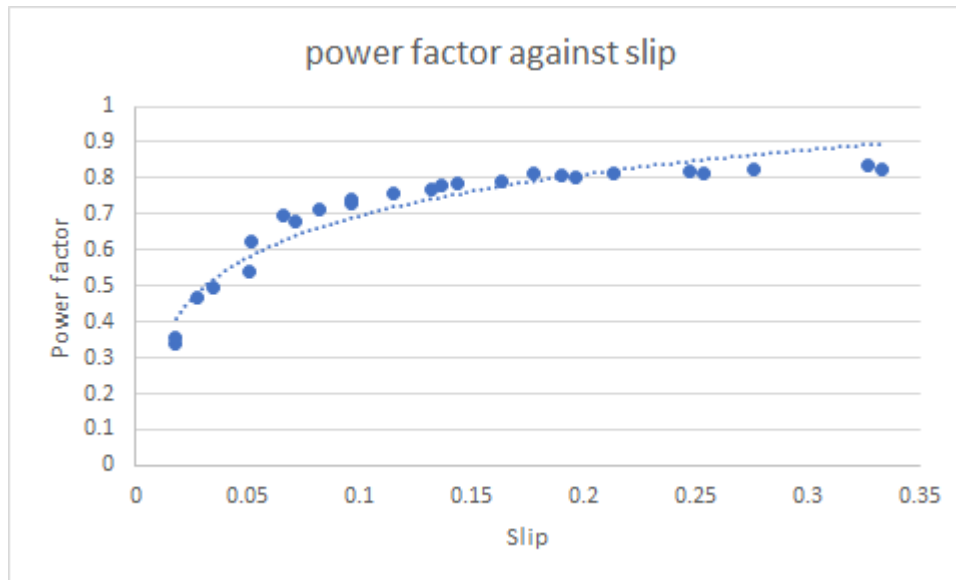
Then using $P=T \omega$, to work out the mechanical output power, T being the mechanical torque (Nm), and ω being the rotor speed in rad/s. Using $P=I*V$ to work out the input power, and as a result working out the motor efficiency by doing the $(P=T \omega)/(P=I*V)$ which is the output power/input power.

The slip efficiency being (3000-speed in rpm)/3000.

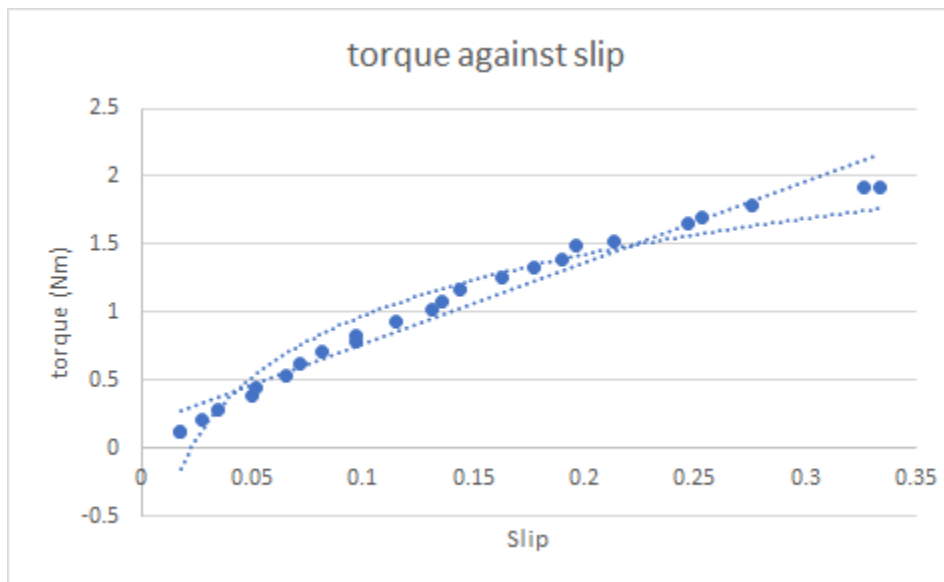
Output power against slip: logarithmic trend, or exponential



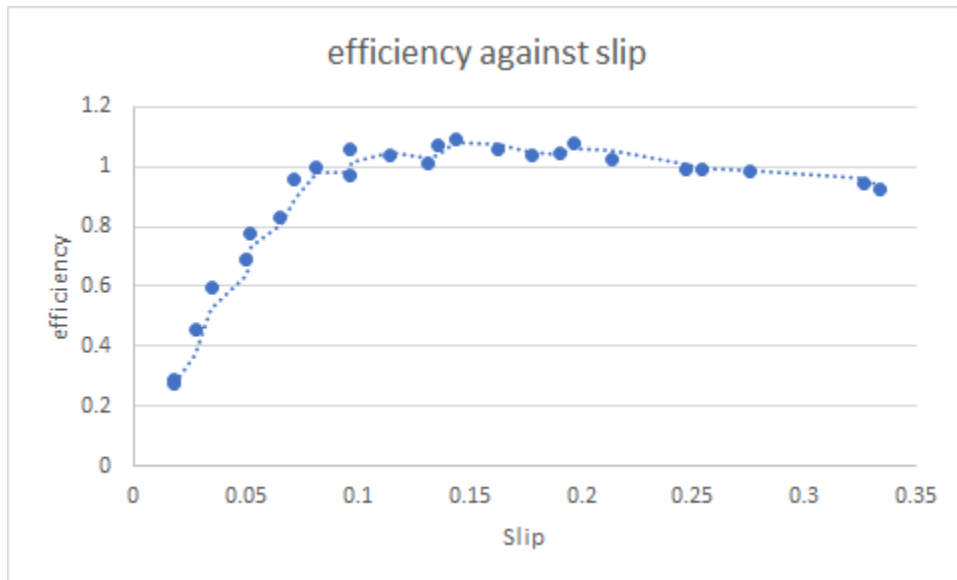
Power factor against slip: logarithmic trend or exponential



Torque against slip: slightly linear and slightly exponential.



Efficiency against slip: slightly logarithmic/ exponential also.



At max efficiency (1.09) slip is 0.144.