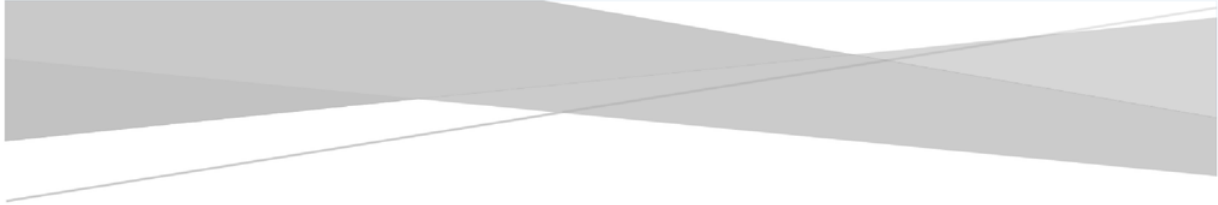


PSDE 5027 Assignment 1

by Nathan Smith

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HND ELECTRICAL & ELECTRONIC ENGINEERING

PSDE 5027 POWER & MACHINES

ASSIGNMENT 1

Nathan Smith

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1. Research

1.1 Construction and operation of three phase Wound and Cage type rotor induction motors

Wound induction Rotor motors

A wound rotor three phase motor is constructed with a stator core which will contain a three separate phase windings, with an wound internal rotor containing slip rings, brushes, brushes, Rotor terminals, Rotor coils, Rotor slots and two individual shields ends which will house the rotor bearings to support the shaft of the rotor. Figure 1, shows the basic parts of a three-phase, wound type rotor induction motor. (Industrial-electronics, 2014)

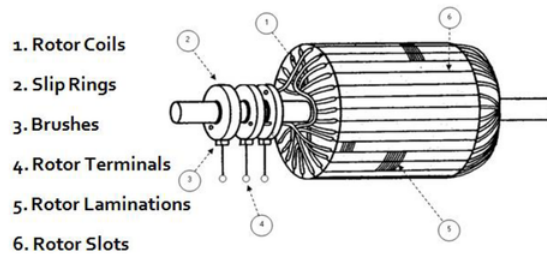


Figure 1 Construction of Wound Rotor

Construction of Wound Rotor

The stator typically used will consist of a three-phase winding which is held into place by fitting into slots in the laminated steel core of the stator. The windings consist of formed coils which are built, housed and terminated inside the rotor to create an individual phase for the three phase supply with the electric 120° spacing. Each three phase winding is connected in two types of connection types, these are known as Delta connection or Star connection. Three individual cables or leads are connected to a junction box which is usually positioned on the shell of the motor or on top of the motor. (Industrial-electronics, 2014)

The rotor is constructed with a cylindrical core which is made up of steel laminations. This cylindrical core has slots cut into it which will secure the formed wire coils for the rotor's winding. As stated above the motor is connected in one of the two connection types which are Delta configuration or Star configuration, Figure 2, the rotor windings must have an identical amount of poles with the stator winding.

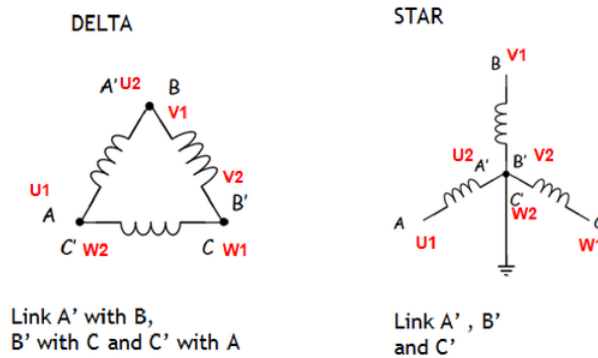


Figure 2: Star, Delta Configurations

(Industrial-electronics, 2014) States “The three leads or cables from the three phase rotor winding terminate at the slip rings which are mounted on the rotor shaft. Leads from carbon brushes which ride on these slip rings are connected to an external speed controller to vary the rotor resistance for speed control. The brushes are held securely to the slip rings of the wound rotor by adjustable springs mounted in the brush holders”.

These brush holders are mounted in one fixed position. The shell of the motor is usually constructed from steel which is cast or formed with the stator core attached to the shell by pressing it. The set of end shields are connected to the steel shell with one shield end being bigger than the other as it houses the brushes and brushes holders which ride on the slip rings of the motor.

The arrangement that the bearings are positioned is identical to the positioning of a squirrel caged type motor in that ball bearing are used in the shield ends or a sleeve type bearing. (Industrial-electronics, 2014)

(Bridger, 2005) States “Wound rotor motors have some drawbacks. Both the motor and the controller are more complex and cost more than a similar squirrel cage motor and its controller. The added running resistance in the rotor circuit of the motor on speed control increases losses, and thus operating costs, and the maximum speed is limited to something less than synchronous speed for the number of poles in the motor”.

Operation of Wound Rotor

When the three currents from each phase pass through each winding in the slots in the stator core, a magnetic field which is a rotating type is created. The magnetic field passes around the stator with the magnetic field speed depending on the amount of stator poles along with the frequency at which the power supply is running at, (e.g. 50Hz or 60Hz). This is the synchronous speed which is determined by applying the formula shown below;

$$N_s = F_s / P \times 60$$

$$F_s = \text{Supply frequency is Hz}$$

$$P = \text{Pole Pairs}$$

When the rotor speed is at its synchronous speed, the three phases are cut and a voltage is induced inside the winding. All three slip rings of the rotor which are connected to the shaft of the rotor have the rotor windings connected to them. Each brush which is positioned on slip rings have a connection to a star configuration set of resistors. Voltages which are created or induced from the rotor windings will create a current which connect to the speed controller from the winding. A magnetic field is created in the rotor from these currents which is similar to a transformer operation, the magnetic fields from the rotor make torque by reacting with stator field and powers the rotor which turns or rotates. This is called the secondary resistance control. Figure 3 below shows the three phase supply with the correct sequence for the stator coils. (Industrial-electronics, 2014)

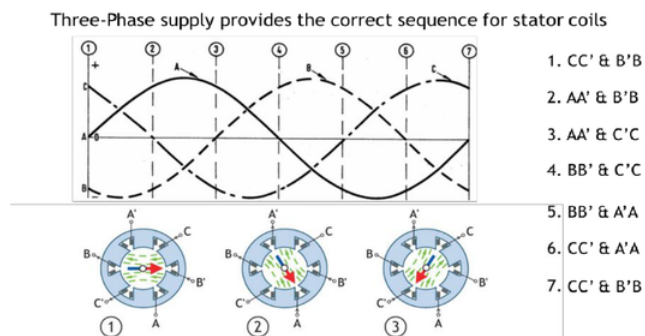


Figure 3, Three Phase Supply to Coils

Three Phase Cage Induction Motor

The cage rotor is constructed with a stack or row of lamination which are made from silicon steel. These laminations have slots punched around the outside of the rotor with even spacing between each slot. The face of these laminations are coated in an oxide layering which will act as an insulator, thus preventing any unwanted axial eddy currents from flowing within the iron.

The cage rotor is constructed as follows and may be regarded as the most popular type of rotor, each one of the rotor slots will contain a conductor bar with all the conductors electrically and physically joined to each other at the end of the rotor by end rings which are conducting. Figure 4 shows the construction of a cage rotor and Figure 5 shows the construction of a squirrel cage rotor motor.(Hughes & Drury, 2013)

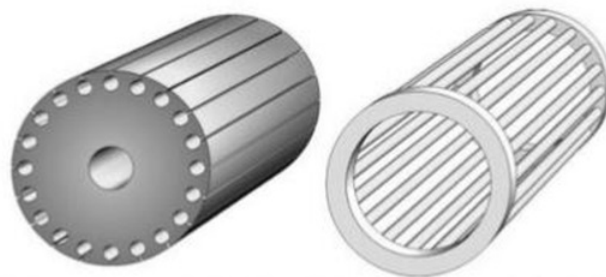


Figure 4: Cage Rotor Induction Motor(Hughes & Drury, 2013)

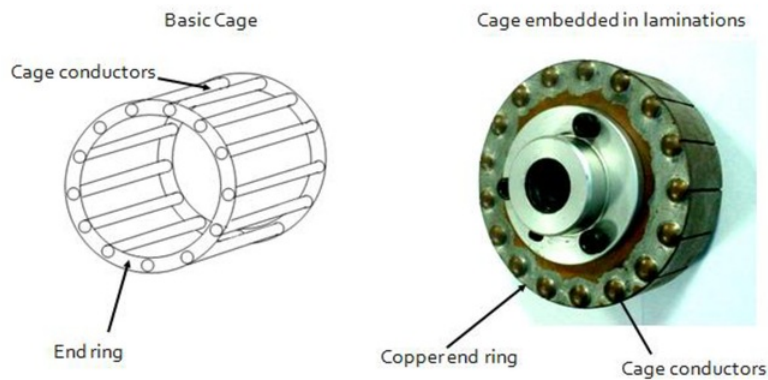


Figure 5: Squirrel Cage Induction Motor

In the larger size cage rotors the conductors will be made from copper and will have the end rings brazed onto them, and in the medium and small size, the conductor of the rotor can still be copper or may be made by aluminium. They were called squirrel cage as the rotor bars and end rings look similar to cages in the past to exercise small rodents.

With the lack of any way to make any electrical contact to the rotor directly this emphasises the rotor currents can be induced by a field containing an air gap to the induction motor. Zero control from an external source can be operated over the resistance of the circuit after the rotor has been made due to short circuited conductors. This creates a disadvantage to the wound rotor which can overcome this or avoid it.(Hughes, 1993)

Operation of Cage Rotor

To start a cage rotor induction motor there is six different ways of starting which will be explained in this section. The first starting method is the 'Direct Starting' method, this would be a case of simply switching on the supply to the motor and letting it run. This method has serious drawbacks as motors over a few Kw as the start-up of these motors requires a lot of current which will drop the supply voltage when starting and could cause other problems in other systems due to voltage drops.

The next type of starting system is a Star/delta starter, this is a simple type of starting and provides the motor windings to be connected in start to start with which reduce the voltage supplied to each phase to 58% of its direct on line value. Once the speed of the motor comes close to the running figure the winding are changed to delta configuration to take over. This is a simply method but has the draw backs of low starting torque. To help with starting we can also use other methods like autotransformer starters, resistance/reactance, solid state soft starters or starting using a variable frequency inverter.(Hughes & Drury, 2013)

The motor will need sufficient torque to start so in addition the motor will need sufficient load to bring it up to maximum speed. The speed curves bases on torque, load and total inertia will calculate how speed rises once the motor has been powered up.(Hughes & Drury, 2013)

(Hughes & Drury, 2013)States “By way of example we can look at the case of a motor with two different loads (figure 6). The solid line is the torque-speed curve of the motor, while the broken lines represent two different load characteristics. Load (A) is typical of a simple hoist, which applies constant torque to the motor at all speeds, while load (B) might represent a fan. For the sake of simplicity, we will assume that the load inertias are the same”.

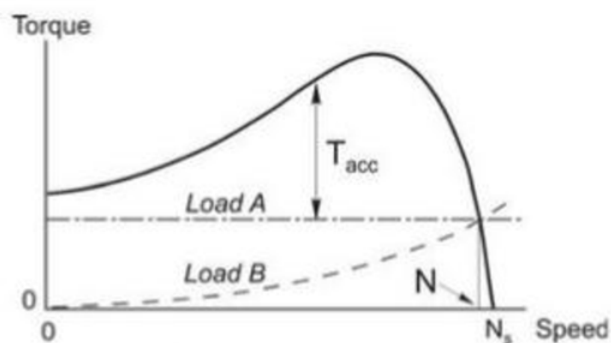


Figure 6: Typical Torque Speed Curve

1.2 Approximate equivalent circuit of a wound-rotor type induction motor.

Explain the significance of each parameter used.

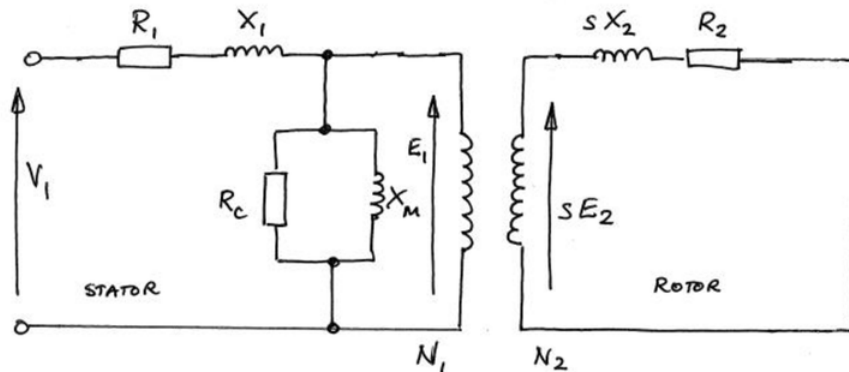


Figure 7- Equivalent Circuit of Wound Induction Motor

(electrical4u, 2011) States "Induction motor is a well-known device which works on the principle of a transformer". A wound rotor induction motor can be treated as a rotating transformer where the stator is the primary winding and the rotor is the secondary. Figure 7 above is the per phase equivalent circuit and the each parameter is shown below;

- R_c and X_m are representing the stator laminations
- R_1 and X_1 are the stator resistance and the leakage reactance
- R_2 and X_2 are representing the rotor resistance and leakage reactance. (R_2 includes the external resistance)
- V_1 is the stator phase voltage
- E_1 and E_2 are the stator and rotor induced EMF's at standstill
- N_1/N_2 represents the stator : rotor winding ratio
- $E_2 = (N_2/N_1)E_1$ at standstill

The frequency of the rotor current will depend upon the relative speed between the stator and the rotor (Frequency $f_r = sf_s$) and the rotor is stuck at standstill ($s = 1$; $f_r = f_s$) as the rotor increased its speed ' s ' will drop and the f_r will also drop or reduce. X_2 depends upon this frequency so the actual leakage reactance is (sX_2) and the secondary induced EMF will = sE_2 . The rotor resistance is unaffected by slip

As stated above a wound induction motor is almost identical in construction to a transformer. The motor has the same 3 identical windings inside the motor and also three of the same secondary windings. When the motor is at its standstill position it works like a normal conventional transformer and the equivalent circuit above is similar to that of a transformers. (Wildi, 2013)

1.3 Suitable formulae of torque and rotor current

The Torque formulae has been taken for the notes of (Davies, 2017), we take the equations for power loss in the rotor and power loss for copper to compare are Create the equation for torque. The new equivalent circuit with stator winding impedance neglected is as shows below is figure 8.

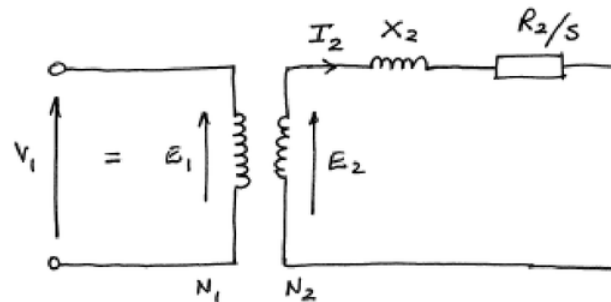
The power loss equations are;

Power loss is rotor:
$$P_{loss} = \frac{s^2 |E_2|^2 R_2}{(R_2^2 + s^2 X_2^2)}$$

Power loss in the form of heat:
$$P_{loss} = 2\pi S n_s T$$

So transposing and cancelling out one of the 'S' we get the equation for Torque which is;

$$T = T = \frac{1}{2\pi n_s} X \frac{S |E_2| R_2}{(R_2^2 + s^2 X_2^2)} \text{ [NM]}$$



$$|E_2| = \frac{N_2}{N_1} \times |E_1| \quad \text{since } E_1 = V_1$$

$$\therefore |E_2| = \frac{N_2}{N_1} \times |V_1|$$

Figure 8

Based upon the above circuit figure 8, the formulae for Rotor current can be found E_2 and Z_2 . E_2 is shown in figure 8 and Z_2 is the rotor impedance as shown in figure 9 below.

$$|Z_2| = \sqrt{\left(\frac{R_2}{s}\right)^2 + X_2^2}$$

Figure 9: Rotor Impedance

$$\text{Rotor Current } |I_2| = \frac{|E_2|}{|Z_2|}$$

$$= \frac{|E_2|}{\sqrt{\frac{R_2^2}{s^2} + X_2^2}} = \frac{|E_2|}{\sqrt{\frac{R_2^2}{s^2} + \frac{s^2 X_2^2}{s^2}}}$$

$$|I_2| = \frac{|E_2|}{1/s \sqrt{R_2^2 + s^2 X_2^2}}$$

$$|I_2| = \frac{s |E_2|}{\sqrt{R_2^2 + s^2 X_2^2}} \text{ This is the equation used to find the rotor current.}$$

With the equation for Torque worked out it now relates to electrical and mechanical parameters to allow the performance of the motor to be worked out. The graph for this can be shown below is figure 10, and plotted as Torque against Slip.

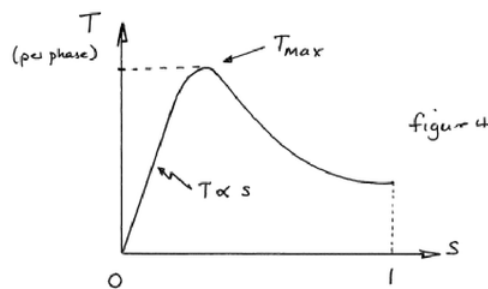


Figure 10: Torque against Slip

T_{max} can be found by differentiating T with respect to s and equating to zero.

1.4 Methods of speed control and braking for cage and wound rotor induction motors typically used in industrial applications.

For an induction motor to run at an efficient state, the motor has to operate with a small percentage of slip. To efficiently control the speed the method is based upon changing or increasing/decreasing the synchronous speed of the field and not slip. The two main ways to determine the speed of the field are the pole numbers and the supply frequency.

Speed Control

On a wound rotor the method that we can vary the rotor resistance allows the slip to be controlled from the rotor side with the frequency and stator supply constant. This method may be inefficient but is still used due to its simplicity and low costs.

On a cage motor id efficiency isn't of high priority, controlling torque on a cage motor can be done with the alterations of the voltage supplied. Torque is equivalent to the square from the voltage so to reduce the speed we can simply reduce the voltage. This isn't suitable for low resistance cage type motors due to speed in the stable operating region is limited.

Braking

There are two main types of braking for induction motors, Plug reversal and plug braking, and injection braking.

Plug braking and Plug reversal follow methods that due to the rotor playing catch-up with the rotating field, if we interchange two power leads the rotating field is reversed. This is done by having separate three pole connectors with one for reverse direction and the other for forward direction. (Hughes & Drury, 2013)

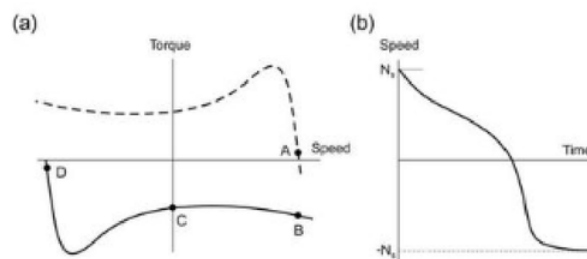


Figure 11: Torque speed curve/speed time curves for plug reversal(Hughes & Drury, 2013)

Figure 11, shows the torque speed curve and speed time curve for plug reversal braking. Rapid reversal is possible with plugging but large motors can only be plugged if they can withstand the high currents involved. Recurrent plugging causes overheating so it's not advised as a frequent action. Plugging can stop the motor fast but it is then the supply will need to be isolated when it comes to a stop.

Injection braking is a popular way of braking, once stop signal is send to the motor the three phase supply is interrupted and an DC supply is fed into the stator though two of its terminals. The air gap field rotation speed is equivalent to that of the frequency supply, which makes the DC at zero frequency. The rotor will try to run at the same as the field so when the field is stationary and the rotor isn't, the braking torque will be exerted. (Hughes & Drury, 2013)

With DC injection braking on a three phase motor the VFD outputs a DC current which is injected into two of the windings of the motor, this then causes the motor to quickly brake. DC injection braking is usually only effective at low speeds and can also be used to preheat the motor and prevent no water vapour can condensate inside the motor. (Toshiba International Corporation, 2011)

Frequency reducing can also be used as a method of braking, it has a similar effect as injection type braking but with a gentler amount of torque.

2. Simulation

This part of the assignment required a spread sheet to be created using Microsoft Excel, that will generate data to plot two graphs for the operating regions of a motor. The first graph will be for, 'Torque against fractional slip' and the second graph will be for, 'Rotor current against fractional slip. The data was generated for values of fractional slip between -1 and 2 and incremented in values of 0.1. The motor information and values was given in the assignment brief which was used to insert into Excel and used to calculate the equations researched in task 1.

The Equations for Rotor current and Rotor Torque can be found in task 1.3, page 9 and 10.

A table of results was made up on excel as shown below in figure 12 and with the equations used to work out the Torque and Current shown in figure 13 and 14, also below.

Fractional slip	Rotor speed	Torque	Rotor Current
-1.00	6000.00	-0.7522645	-4.05115604
-0.90	5700.00	-0.8330201	-4.044293724
-0.80	5400.00	-0.9327337	-4.034758219
-0.70	5100.00	-1.0587082	-4.020970042
-0.60	4800.00	-1.22231	-4
-0.50	4500.00	-1.4418947	-3.965933765
-0.40	4200.00	-1.747797	-3.905432923
-0.30	3900.00	-2.1873141	-3.783640733
-0.20	3600.00	-2.7913105	-3.489898222
-0.10	3300.00	-3.0913063	-2.596956704
0.00	3000.00	-7.21E-15	-4.67219E-15
0.10	2700.00	3.09130635	2.596956704
0.20	2400.00	2.79131053	3.489898222
0.30	2100.00	2.18731412	3.783640733
0.40	1800.00	1.74779705	3.905432923
0.50	1500.00	1.44189467	3.965933765
0.60	1200.00	1.22230998	4
0.70	900.00	1.05870816	4.020970042
0.80	600.00	0.9327337	4.034758219
0.90	300.00	0.83302013	4.044293724
1.00	0.00	0.7522645	4.05115604
1.10	-300.00	0.68559973	4.056255921
1.20	-600.00	0.62967297	4.060147721
1.30	-900.00	0.5821063	4.063184219
1.40	-1200.00	0.5411698	4.065598441
1.50	-1500.00	0.50557665	4.067549252
1.60	-1800.00	0.47435076	4.069147939
1.70	-2100.00	0.44673887	4.070474321
1.80	-2400.00	0.42215071	4.071586842
1.90	-2700.00	0.40011738	4.072529081
2.00	-3000.00	0.38026179	4.073334067

Poles	2	
Frequency	50	ns
EMF	161.6	E2
Rotor resistance	4.8	R2
locked rotor reactance	39.6	X2

Figure 12: Rotor Current and Torque Table

D2		=SUM((A2*\$B\$36)/SQRT(\$B\$37*\$B\$37+A2*\$B\$38*\$B\$38))				
	A	B	C	D	E	F
1	Fractional slip	Rotor speed	Torque	Rotor Current		
2	-1.00	6000.00	-0.7522645	-4.05115604		
3	-0.90	5700.00	-0.8330201	-4.044293724		
4	-0.80	5400.00	-0.9327337	-4.034758219		
5	-0.70	5100.00	-1.0587082	-4.020970042		
6	-0.60	4800.00	-1.22231	-4		
7	-0.50	4500.00	-1.4418947	-3.965933765		
8	-0.40	4200.00	-1.747797	-3.905432923		

Figure 13: Rotor Current Sum

C2		=SUM((1/(2*3.1415926*\$B\$35))*A2*\$B\$36*\$B\$36*\$B\$37/(\$B\$37*\$B\$37+A2*\$B\$38*\$B\$38))								
	A	B	C	D	E	F	G	H	I	J
1	Fractional slip	Rotor speed	Torque	Rotor Current						
2	-1.00	6000.00	-0.7522645	-4.05115604						
3	-0.90	5700.00	-0.8330201	-4.044293724						
4	-0.80	5400.00	-0.9327337	-4.034758219						
5	-0.70	5100.00	-1.0587082	-4.020970042						
6	-0.60	4800.00	-1.22231	-4						
7	-0.50	4500.00	-1.4418947	-3.965933765						
8	-0.40	4200.00	-1.747797	-3.905432923						
9	-0.30	3900.00	-2.1873141	-3.783640733						

Figure 14: Rotor Torque Sum

Using the results for the Rotor current and Rotor Torque a graph was created to show the Current and Torque against Fractional slip as show below in Figure 15.

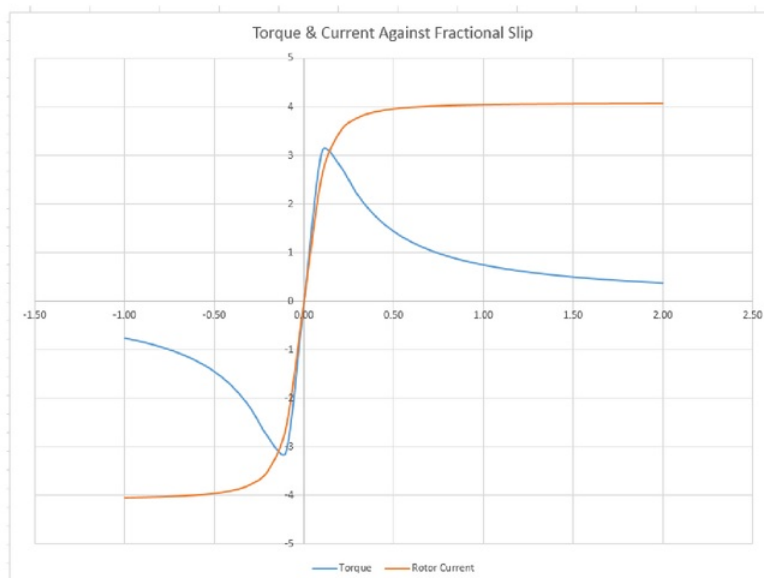


Figure 15: Torque & Current against Fractional slip

The graph shows Torque in blue and the current in red plotted against the fractional slip on the x axis, there are 3 stages when operating a motor, these are, braking, motoring and generating.

The braking region is found on the positive axis of the graph, the motor is braking when the motor is turning to the opposite direction to the stator field which is rotating. This gives us a value for N_r which is negative. Braking occurs on these results after around 1 on the graph.

The motoring stage is at the centre of the graph and is where Torque in a positive form is created due to the rotor travelling slower than stator field. N_r is equal to '0' at this stage; Motoring on the graph is between the values of 0.00 and 1.00 and at 0 the motor changes in operating regions from generating to motoring as shown in figure 15.

The Generating stage is at the negative axis of the graph because ' S ' is a negative value. Generating is created when the motor is travelling faster than the stator field usually by a source which is external to the motor. N_r is greater than N_s in this region. The value is shown as negative as above in figure 15, as the speed of the motor is faster than its synchronous speed, thus creating a slip.

The machine used in the simulation has a high initial starting current but the motoring and generating areas are remain steady showing an overall good performing motor. The Simulation worked as expected and produced the correct set of results and operating regions for braking, generating and motoring as we would expect. The best operating region for an induction motor would be when motoring and running at synchronous speed, this is the optimum region to operate as shown in the graph.

3. Practical Investigation

This part of the assignment required a practical experiment to take place to show the operating regions and provide a practical set of results to compare against the research and simulation of the motor.

The motor was configured in DELTA, figure 24, with a VSD motor for generating and a manual brake, figure 23, used for motoring region or load region. A set of instruments was acquired to measure the values needed to plot a table of results as stated in the brief.

B) This is the part of the investigation where load was to be added onto the motor, the motor was first turned on with the VSD off and a reading was taken to gain the no load value. With this value the fractional slip was then calculated using the formulae of $(N_s - N_r)/N_s$. A table of results was drawn up below in figure 16, to show the results gained from the experiment. Synchronous speed was given at 3000.

	A	B	C	D	E	F	G	H	I	J
1	Fractional Slip	PF	Rotor Speed	VAR	VA	Watts	Current	Load	Voltage	Motoring
2	0.017	0.53	2950	177	209	110	565	0.000	215	
3	0.033	0.64	2900	175	230	148	621	0.050	215	
4	0.050	0.67	2850	174	233	152	639	0.100	215	
5	0.067	0.75	2800	172	259	195	705	0.200	215	
6	0.083	0.81	2750	170	289	230	779	0.400	215	
7	0.100	0.85	2700	171	326	278	883	0.500	215	
8	0.117	0.87	2650	174	359	314	990	0.700	215	
9	0.133	0.88	2600	175	364	325	1040	0.800	215	
10	0.150	0.9	2550	188	425	371	1130	0.900	215	
11	0.167	0.91	2500	189	451	407	1250	1.000	215	
12										

Figure 16: Practical Experiment table

The load was increased by a value of 0.2 with the manual brake but the accuracy of the results may not be perfect due to wear of the brake making accurate adjustments difficult. As shown in the table of results the fractional slip increases as we increase the load which proves the difference in the motoring region as shown in figure 17.

The power factor increases as the load is applied but remains lagging as it is under the value of 1. The VAR steadily increases and the VA also increases showing the power in the motor.

The speed of the rotor is slowing as we increased the load as well as the current increasing due to more load meaning more current needed to move the motor. The voltage differed slightly but was recorded as a standard 215v as instructed during the exercise.

The first graph figure 17, plotted is for motoring, load against fractional slip. As stated above this graph proves that as we increase the load on the motor the fractional slip also rises, the graph shows a linear steady line with accuracy being down to instrument calibration but proves the first part of the experiment a success as the motor is performing how we predicted and to a good standard of results.

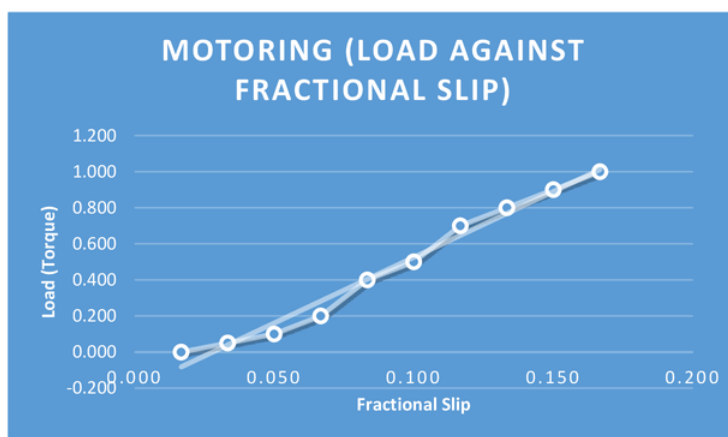


Figure 17: Motoring, Load against Fractional Slip

C) This part of the investigation was to demonstrate the generating region of the motor via the use of the VSD. The VSD will provide an outside source for the motor to push it above its synchronous speed, as above the formulae was used to gain the fractional slip and the results were entered below into the graph, figure 18.

13											
14	Fractional Slip	PF	Rotor speed	VAR	VA	Watts	Current	Load	Voltage	Calculated Power	Generating
15	0.000	0.2	3000	196	200	40.6	536		214	39.735	
16	-0.017	-0.21	3050	-213	218	42.1	577		216	-45.332	
17	-0.033	-0.36	3100	-231	248	91.2	657		217	-88.897	
18	-0.050	-0.47	3150	-244	275	128	732		218	-129.905	
19	-0.067	-0.6	3200	-268	334	200	885		218	-200.499	
20	-0.083	-0.65	3250	-286	379	248	998		219	-246.064	
21	-0.100	-0.67	3300	-306	423	294	1120		219	-284.641	
22											

Figure 18: Generating region of Motor

We can see the fractional slip has now become a negative value due to the generating region along with the power factor and VAR. The rotor speed was now increasing due to the VSD acting upon the motor and the VA increased along with the power increasing due to being above synchronous speed and outputting more power back into the system. The voltage was increasing as expected as we are now generating, an example would be like a wind turbine creating power by generating and supplying power and voltage back to the grid.

This shows that the experiment working on generating is doing as we would expect and has provided a set of results to prove that we are now generating with the help of the VSD.

A series of four graphs has been created to show a set of results.

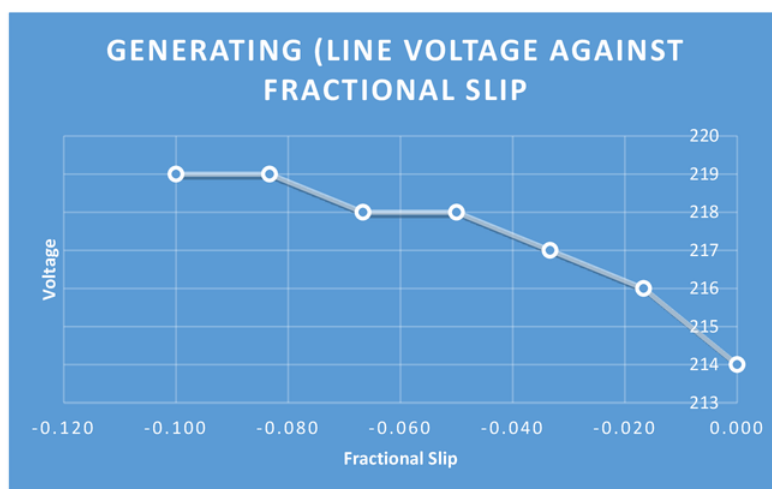


Figure 19: Line Voltage against Slip

The above graph, figure 19, shows that and increasing line voltage resulted in a increased fractional slip on the negative generating axis.

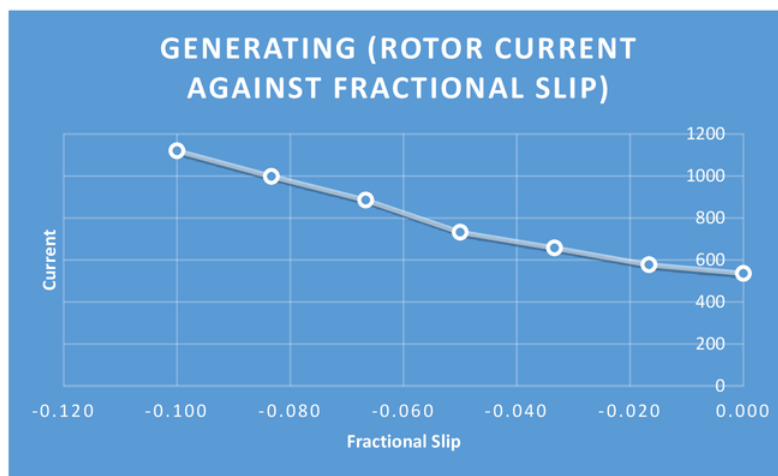


Figure 20: Rotor Current against Slip

Figure 20, above shows with increasing current the slip will also increase as shown in the table of results. This is also on the negative axis due to being the generating region.

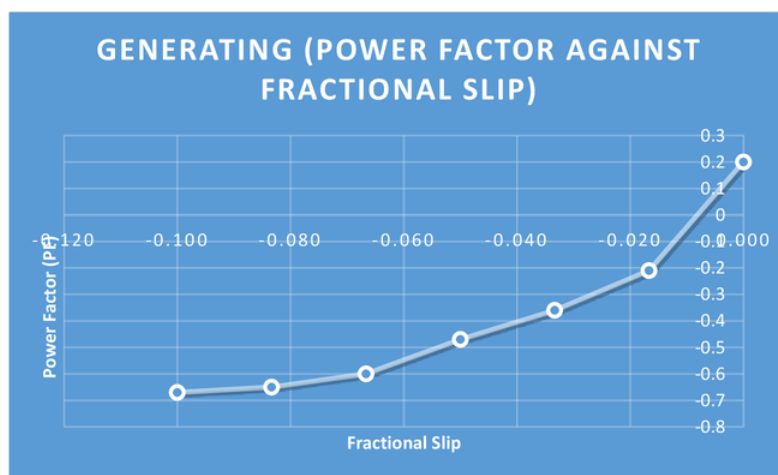


Figure 21: PF against Slip

Figure 21, above shows as the PF decreases the slip will also decrease.

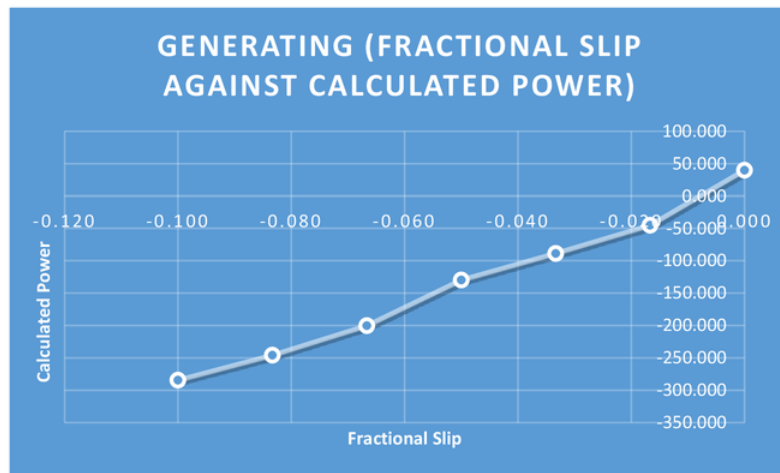


Figure 22: Slip against Power

Figure 22 above shows the generating region and the decreasing of the slip against the calculated power.

Below I have added a variety of photos showing the experiment through each phase.



Figure 23: Prony brake to Simulate Load



Figure 24: Star supply



Figure 25: Recording Instruments with Results



Figure 26: Recording Instruments



Figure 27: Rotor Speed



Figure 28: Results Recorded



Figure 29: RPM

4. Conclusions and Recommendations

Task 1 conclusion

I feel that the research carried out has given me the knowledge to understand in detail the operation and construction of induction motors. The research was gained from creditable sources which provide good background reading to understand what the task was asking and more, the books used in lecturers along with lecture notes and theory gained from working in industry also helped to relate to the research on these types of motors. I have concluded that the cage type induction motor is the most widely spread used motor in industry and is the motor of choice in industrial application due to the advantages stated in the research. This task gave me a greater understanding of the subject and also tied into task 2 and 3 as it provided calculations to be used to simulate the motor as asked.

Task 2 conclusion

This task required the use of the theory learned from task 1 to use as a simulation on Microsoft excel to simulate an induction motor using the parameters given in the task description. A table was produced and the calculations entered to calculate all the information needed. A graph was plotted which showed torque and current against fractional slip. The graph was created as expected and displayed the three operating regions of generating, braking and motoring. The graph showed a high starting current from the motor with our parameters entered and showed that the best operating regions would be when running at synchronous speed when motoring and also when generating as we can provide power like a turbine would do. With too much load on the motor when braking we could cause overheating or a stall which is not ideal. I have learnt how to input the torque and current equations in this task and also how to relate this to the running figures of motors to show their current and torque against slip.

Task 3 Conclusion

This task required the use of a physical motor and supply along with a VSD and measuring tools to carry out a practical investigation to relate to the simulation and research. The experiment showed that when motoring with added load on the motor the motors values for speed, PF, VAR, VA, current, watts and slip. The first experiment showed that as we add load to our motor a lot more current was shown and the speed was decreasing as the load was increasing, this shows the motor is having to work a lot harder as we add load which would eventually lead to a stall or overheat. The second part showed the introduction of a VSD to show the generating region, this experiment proved in the tables and graphs that our speed, power and voltage are increasing while generating as we would expect to see as proved in the simulation and theory.

Overall each task was very helpful in understanding the operation, use and practice of induction motors and all results were as we would expect to see from theory.

5. Citation List

Works Cited

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6. Appendices

PSDE 5027 Assignment 1

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

64/100

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GRADING FORM: CSG-RUBIC

NATHAN SMITH

64

RESEARCH-INFORMED LITERATURE



Section 1: Your research - Good evidence of background reading and research covering most aspects of induction machines. Further marks were available for more detailed explanations. (17/25)
Section 5: Your use of Harvard referencing for citing and listing - A good range of sources listed correctly and cited mostly correctly. (4/5)

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KNOWLEDGE AND UNDERSTANDING



Section 2 - Explanation of simulation - A brief explanation given with reference to theory. (7/10)
Section 3 - Explanation of practical investigation - Good explanations given with supporting photos. Further marks were available for a schematic diagram. (7/10)

14

ANALYSIS



Section 2: Analysis of simulation - A good analysis of results identifying regions of operation. Further marks were available for more detailed explanations. (6/10) Section 3: Analysis of practical experimental results - Some analysis carried out on results and graphs plotted.. Most results are described rather than explained with reference to theory. Further marks were available for detailed conclusions. (5/10) Section 4: Overall conclusions and recommendations - Some good conclusions offered. Further marks were available a more objective approach with less emphasis on your feelings and more about what you now know about inductions machines. (5/10)

PRACTICAL APPLICATION AND DEP.



Section 2: Presentation of simulation results - Good presentation of results in table and graph format. (3/5) Section 3: Presentation of practical results - Good presentation of results in table and graph format with supporting photos. (4/5)

7

SKILLS FOR PROFESSIONAL PRAC.



All sections - Report is well structured and presented with good sets of figures also listed at the front. I suggest you consider proof reading your work before submission and always write in the third person unless told otherwise. (6/10)

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