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Automated Central Refuse Collection System

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ABSTRACT: *Today waste collection for resident is not simple regularly routine process. Waste management should be considered to make sure that the system should provide a clean, tidy and hygienic for living environment. The adoption of automated central refuse collection system is a step forward to provide a healthy living environment. This dissertation ensure using VVVF controller to operate induction motor study on the application of automatic refuse collection system. There was comparison the operations & maintenance, environmental issues, risks of breakdown and cost of the waste collection method between traditional and automatic mode in the report. Also there was analyzed the history and application between global and local by using the automated central refuse collection system. And introduction structure and the component function, specification and application of automated refuse collection system. Site survey was carried out in Tin Heng Estate by Hong Kong Housing Authority to test the efficiency of automatic refuse collection system. The test was reviewed 4-step output VVVF controller provide power for three phase squirrel cage induction motor. The results were summarized in the report. And this survey was observed arrangement of automatic refuse collection system for provide convenient, hygienic and healthy environment. It was suggested to adopt the Automated Central Refuse Collection System which can collect the waste in an environmental friendly reduce human resource and healthy environment.*

Keywords: *Automated Central Refuse Collection System, resident, squirrel cage induction motor;*

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I. INTRODUCTION

In Hong Kong, residents or tenants use peer to peer method. They always place their refuse with package in the staircase, corridor or lift lobby of the residential flats. Then the management company arranges cleaners to collect the refuse at the fixed time. It is also call door to door method. And commonly once per day to provide refuse collect service. The solid waste will be placed on each floor at a certain time period every day. And it will make the unhygienic condition.

Until then the cleaner to collect refuse. The refuse will be taken dumped into the refuse chute on every floor. Next step is received by the refuse bin which is located the end of below of chute in the refuse chamber. Another method is transferred to the refuse chamber by using staircase / elevator. The functions of refuse chamber are used to stores and collect all solid waste of whole building as refuse collection point. The garbage bins are taken to the refuse collection point for though out the garbage by the refuse collection vehicles. There is a traditional refuse collection method will incur various environmental problems such as odour, dirt, bacteria, inside the lifts cars near the staircase, lift lobby, public corridor and refuse chamber. Besides that the traditional method should be provided couple of workers to collect the refuse. And management company will be clean the waste collection area if the refuse was placed on the flats lobby or public corridor. Therefore we would to introduce the automatic method to use. Residents should take their refuse into the flat inlet. Then the refuse will be automatically via refuse chute and separate pipe transfers to refuse chamber or centralize to plant room.

II. AUTOMATED CENTRAL REFUSE COLLECTION SYSTEM

2.1.1 Mobile type of Automated Central Refuse Collection System (ACRCS)

Mobile type of ACRCS, there is suitable for use in higher density building arrangement. The principle of mobile type is solid waste have been collected to refuse tank in refuse chamber while the refuse pass through the refuse chute. The whole building refuse will store in refuse tank of each building chamber. Then the refuse collection vehicles use vacuum suction device to collecting from refuse tank. The advantage of mobile type is less cost free for rebuild the refuse system of the whole building.

Because majority building have equipped with refuse chute from each floor (disposal inlet) to ground floor (refuse tank). Also if the density of building is higher, then the refuse collection vehicle should be arranged to each refuse tank of building to collect. Thus, there is will reduce transportation waste of vehicle resource. But mobile type have maintain unavoidable odour, dirt, bacteria in the refuse chamber. And it should be provided worker to operate connect vacuum suction to the tank and work at refuse chamber. Therefore it is suitable for low-rise buildings condition and for less densely built areas.

2.1.2 Stationary type of ACRCS

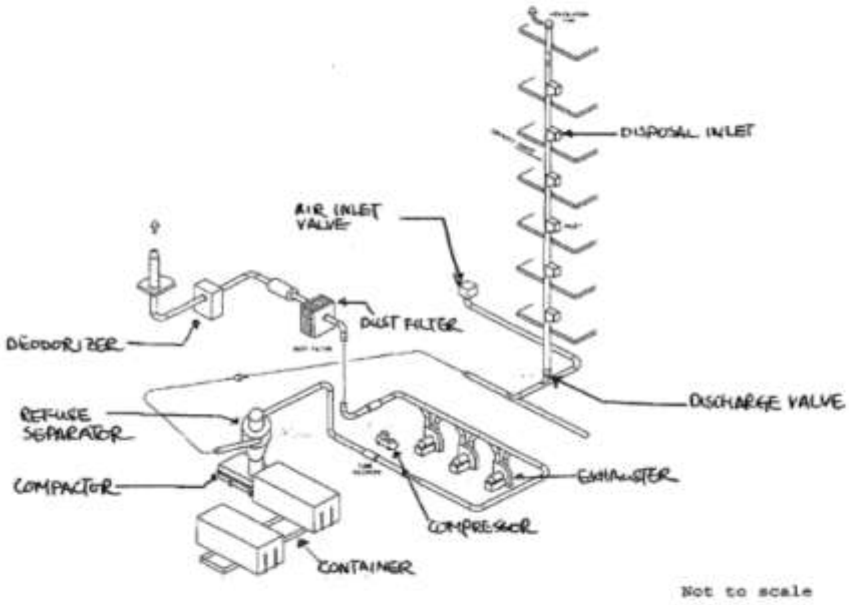
Another stationary type of ACRCS, it is same as mobile type until the refuse store to the tank status when the refuse arrive ground floor level. The different of stationary type is combine with other chamber to central operate. Then it will transmit to central collection plant by the conveyor pipe automatically. The conveyor pipe should be installed at underground level and there should equip with vacuum suction pump. Refuse collection vehicles will arrange to one location carry out collecting process. This method is point to point for the refuse from disposal inlet to central refuse collection plant. It will save the space of provide refuse chamber of ground floor. And the management company arrange worker to operate less than both mobile type and traditional method. Also it could make the hygienic environment condition.

Now stationary type would be common to use. It is Automated Central Refuse Collection system (ACRCS) is meaning to the pre-laying through the pipe line system. And domestic refuse will be transferred to the central refuse chamber section by using the Low Vacuum Technology. And then transported by the compressed vehicle to landfill or reuse center for the waste disposal process. Low Vacuum Technology is use the motor to draw out the air inside laying pipe in the short time. In this state the inside air pressure level is lower than outside pressure level due to draw out the air inside laying pipe in the short time. As a result air pass through gap or access to move from the higher pressure (pipe outer) to the lower pressure (pipe inner), resulting in winds of higher speeds running inside the pipe.

2.1.3 Compared with Stationary and Mobile type of advantage

The Stationary type of ACRCS operates refuse for the residents have good hygienic condition. And stationary type simplify than that of human resource for operating at refuse chamber for cleansing and disposal process. Moreover stationary type shall be arranged vehicles collected the refuse at central refuse plant for daily collection. Also Stationary type can save more space of the building because it can without refuse chamber on ground floor. Stationary type of ACRCS enables effective and safe urban waste collection and less offer a cleaning worker, quieter and less smelly solution to urban waste collection, when compared with the traditional waste collection method. But the Stationary type of ACRCS should be connected with more than one building for auto refuse collect.

2.2.1 Summarizing ACRCS Layout

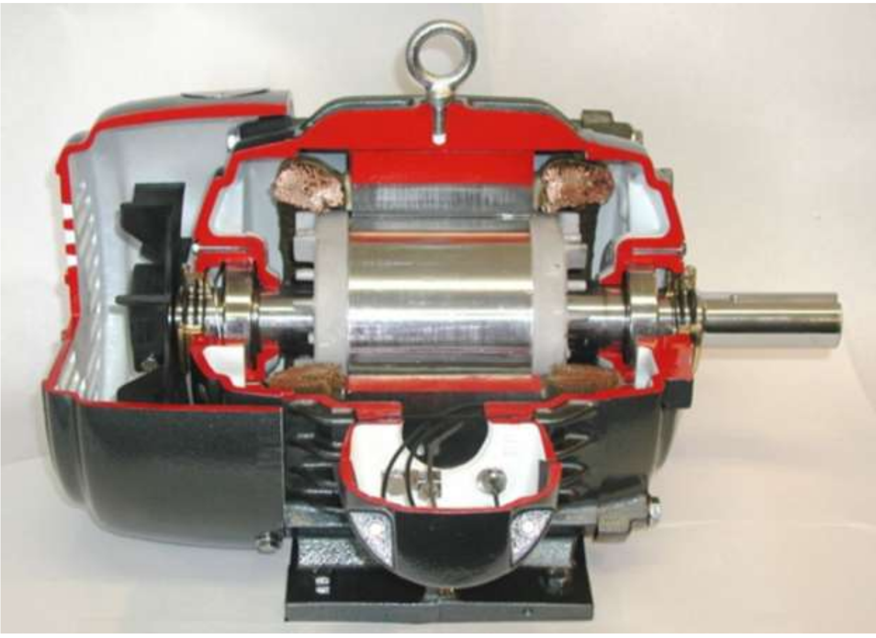


The system collects and handles refuse in a totally concealed manner located in refuse room or underground level. Residents/Tenant delivers waste to disposal inlets in designated area (on each floor of high-rise buildings, and in strategically positioned points outside buildings). Refuse may be temporarily transferred to the storage unit. Then the refuse will be automatically sucked by vacuum at a pressure of up to 0.6 bar. After that it will transported through underground pipes to a central collection station/unit. The air vacuum which delivers waste from the temporary storage unit permits transport of up to 0.8m3 of refuse per sequence. At the central collection plant unit, refuse is automatically separated by the separator. And refuse will compact into the containers by the compactor and loaded on to trucks, without ever being handled by human hands. ACRCS take the waste to the trucks, rather than bringing the trucks to the source.

III. METHODOLOGY

3.1.1 Structure and Principle of Squirrel Cage Induction Motor

The basic principle of operation is referred by Faraday's Law $\varepsilon=-N\,(d\emptyset)/dt$. The electromotive force (ε) is equal to the no. of turns of coil (N) multiplied by the rate of changing magnetic flux at the changing time $((d\emptyset)/dt)$. The machine rotor is at a standstill and the armature is excited by the stator winding provide rotating field (NS) in the starting state. Also, the rotating field of stator equation $N_S=60f/p$, f is frequency, p is pole pairs of the stator. Then the armature induces the rotating field of the stator which is moving with respect to the rotor. Theoretically, the starting speed between the rotating field and the rotor is step by step to approach synchronous speed or called rotating field. In this moment, the rotating field of the stator induces the voltage to the rotor. Then the rotor bars received rotating field. The large voltage produces a large current in the squirrel-case and then it's generates a magnetic field in the squirrel-case of the rotor. The armature magnetic field interacts with the rotor magnetic field, and the starting torque is produced. If produced the starting torque is larger than the load torque, afterward the motor shaft will be beginning to move to no load speed (Nr). As the rotor accelerates to the on load running speed, rotating speed difference between the rotor and the armature field will reduced. The causes of reduced rotating speed difference also call slip (S) is the rotor current to be decrease, the induced rotor voltage to be drop, the torque developed by the machine to be reduced and the rotor flux to be drop. The slip is a ratio, $s=(N_s-N_r)/N_s$. Usually the slip 2-5%, and rotational speed will be slower than synchronous speed. In contrast, if the motor rotational speed will be faster than synchronous speed then it like as a generator. At last, the torque demanded by the load equals the torque developed by the motor, and the motor settles to a balance rotor loading speed, pointed out by Jerry R. (2012) [1].



All induction motor has a rotor, a stator and bearings. The structure of stator for any induction motor is always the same. But the structure of rotor has different characteristics with respect to the type which is subject to demand.

3.1.2 Stator of Induction Motor

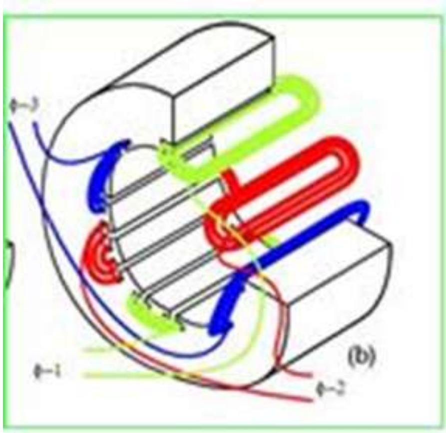


Figure 3.1.2-1: 3 phase stator winding layout

The outer most component in the motor is stator which can be seen. It can be classified to single phase and three phase motors. But basically only changing the stator windings arrangement, it would not be changing the basic arrangement of the stator. It is nearly same for any layout of a generator or a synchronous motor. It is frame by number of pressings, which are slotted to locate the stator windings. The stator windings are arranged on the slots of laminated core with electrically spaced 120 degrees apart. Therefore the stator windings are terminated as either delta or star which is based on the requirement. The leads will be taken out usually three or six in number, and it through out to the terminal box mounted on the motor surface frame. Generally varnish or oxide coated shall be used to insulation process between the each winding.

3.1.3 The Rotor Squirrel Cage Rotor

The rotor adopts copper or aluminum or its alloys for rotor conductors bars. It have a cylindrical laminated core with parallel slots for consists of rotor conductors. The conductor bars in each slot, which are interjected from one end of the rotor. There are end rings are located at the both end of the rotor and welded or electrically fixed at both ends of the rotor, thus it could keep the electrical continuity. Moreover end rings are short-circuited they give a look similar to a squirrel thus the nickname.

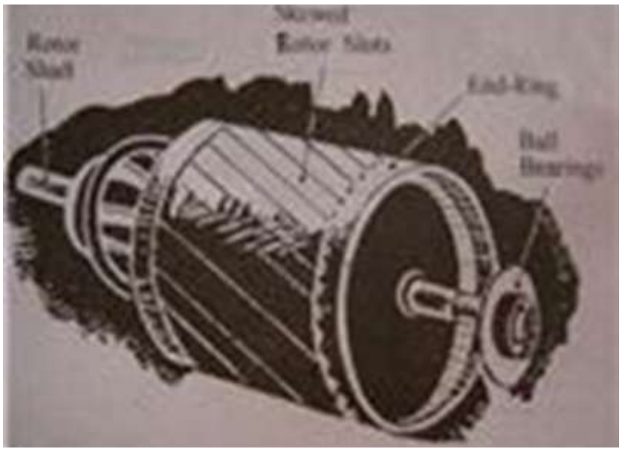


Figure 3.1.3-1: 3 phase rotor layout

Another side that the rotor conducting bars and the both end rings and are permanently connected short-circuit, therefore it could not to arrange any external resistor or reactance connect with conducting bars of the rotor in series for starting. Usually, the conducting bars are not located in parallel on the shaft, but are intentionally arranged slight skew. It could increase in motor efficiency ratio of transformation from stator to rotor, reduce magnetic hum, keeping the motor quiet, increased the slip for a given load torque and assists to avoid “Cogging". And the rotor is manufactured in a different method. The rotor metal commonly used aluminium alloy the purposed for reduce eddy current in rotor operate. The end-rings & rotor bars are cast into one piece and the whole rotor core is arranged in a mould.

They have been classifying under 6 different Categories for majority squirrel cage type motor by the National Electrical Manufacturers Association (Rosslyn (2004)) [2]. This categorization is based upon the electrical and machines torque-speed characteristics of the rotor and its structure.

- Class A: The basically genera structure of the slots. It is such that the conducting bars are placed close to the rotor surface which would be reducing the reactance. The rotor has relatively low reactance and resistance.

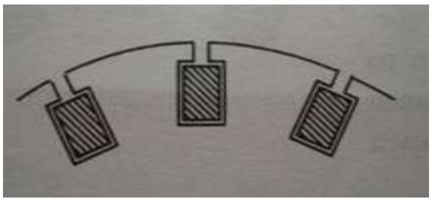


Figure 3.1.3-2: Class A rotor conducting bars arrangement

- Class B: This type can be started at full-load states when developing normal starting torque. It also called direct on line start method. The rotor is structured with narrow and deep slots which it could obtain high reactance when starting.

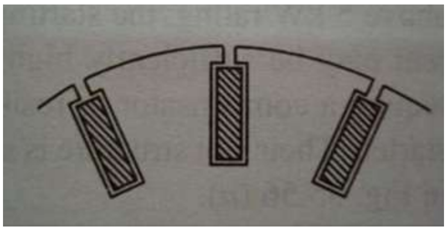


Figure 3.1.3-3: Class B rotor conducting bars arrangement

- Class C: This is double squirrel cage type motors. This double layer rotor arrangement is combined with low starting currents and high starting torques. This motor has innate high starting torque unique. It has suitable for reduced voltage starting. But the cost of motor will be high.

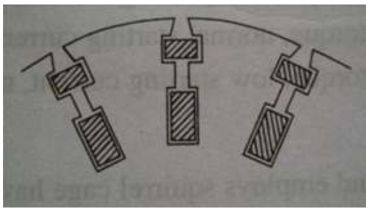


Figure 3.1.3-4: Class C rotor conducting bars arrangement

- Class D: It has high starting torque. Because it is design the thin rotor bars in the rotor slots. Therefore it would reduce the flux leakage of the rotor and maintain the flux high.

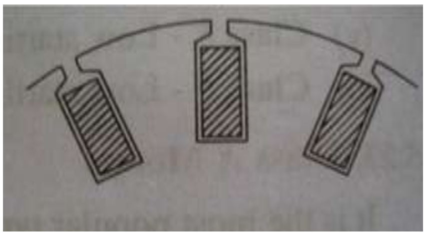


Figure 3.1.3-5: Class D rotor conducting bars arrangement

- Class E: It has compare with low starting current and torque. And it will be needs full voltage when the rotor starting. This is arrangements of the rotor slot is shown in the figure 3.1.3-6.

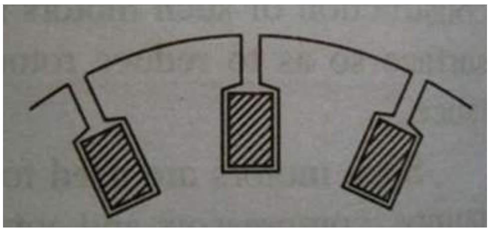


Figure 3.1.3-6: Class E rotor conducting bars arrangement

 Class F: It has very low slip at the rated load. For motors above 5 kW rating, the starting current may be sufficiently high as to require a compensator or a resistance starter.

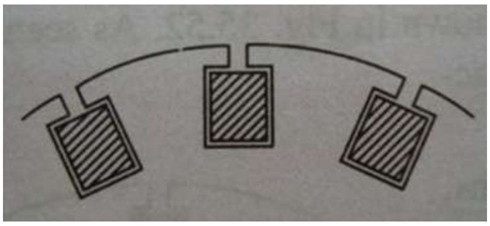
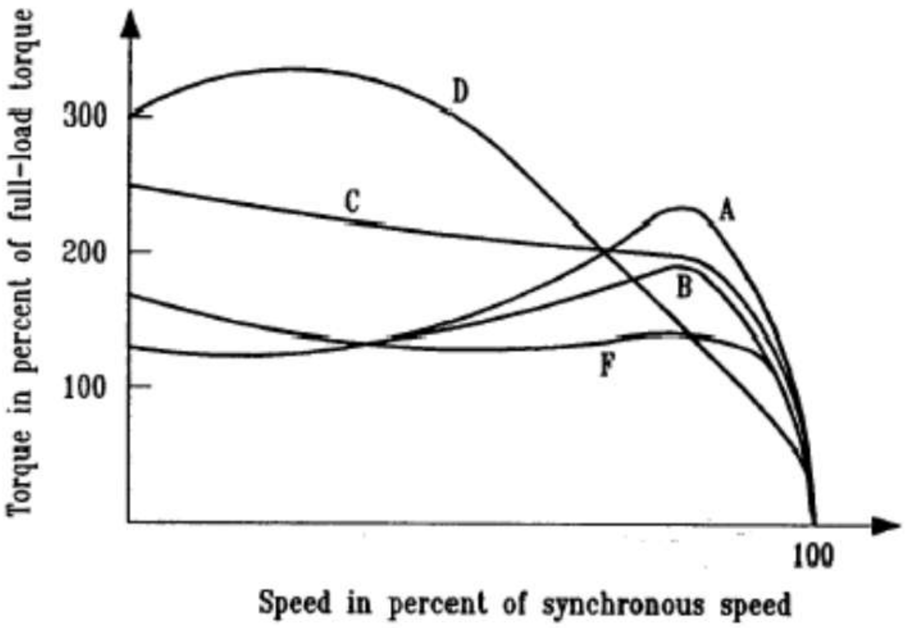


Figure 3.1.3-7: Class F rotor conducting bars arrangement

Table 4.1.4-8 this is classified the type of rotor in the below:

Class	Starting Torque	Starting Current	Slip	Uses	Locked-Rotor Voltage Current with Full Load
A	Normal	Normal	Normal	Pumps, Fans, Low inertia load (frequently started & stopped)	More than 6 times the rated full load current
B	Normal	Low	Normal	Large Fans Pumps, Loads has high moment of inertia	5 to 5.5 times at the full load current
C	High	Low	Normal	Crushers, Boring mills, Conveyors, Wood working equipment	5 to 5.5 times at the full load current
D	High	Low	High	Bulldozers, Shearing machines, Punch presses, Hoists, Foundry & Stamping machines	5 to 5.5 times at the full load current
E	Low	Low	Normal		5 to 5.5 times at the full load current
F	Low	Normal	Low		



3.1.4 Mathematical Model

Hubert & Charles I. (2002) [3] demonstrated that "The Steinmetz equivalent circuit" can able to use in motor relationships between voltage, current, speed, torque, time and power factor. It can be acquired from a mathematical model for calculate electrical input transformed into mechanical output.

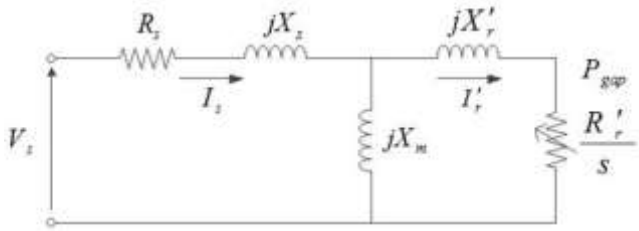


Figure 3.1.4-1: Steinmetz equivalent circuit machines.

Table 3.1.4-2 Definitions of Circuit Parameter:

Nomenclature	Meaning
V_S	Stator supply phase voltage (Units:V)
I_S	Stator input current (Units:A)
R_S	Stator coil resistance per phase (Units:Ω)
jX_S	Stator leakage reactance per phase, j=$\sqrt{}$(-1) imaginary number (Units: Ω)
jX_m	Magnetizing reactance, j=$\sqrt{}$(-1) imaginary number (Units: Ω)
I_r'	Rotor current usually referred to stator side (Units:A)
jX_r'	Rotor leakage reactance,j=$\sqrt{}$(-1) imaginary no.,referred to stator side(Units: Ω)
R_r'	Rotor resistance (Units:Ω)
S	Slip (ratio only without unit)

From the slip equation,

$S = \frac{N_S - N_r}{N_S}$ *N_r is rotor output speed

Angular synchronous speed (stator): (ω_s or N_S)

$\omega_S = \frac{2\pi f_s}{p}$ (Units: rad/s) *or* $N_S = \frac{60 f_s}{p}$ (Units: r.p.m.) *p is pole pairs of the stator

The motor input equivalent impedance (Z_m):

$$Z_m = R_S + jX_S + \left[jX_m \;//\left(jX_r' + \frac{R_r'}{S}\right)\right]$$

$$\therefore \quad Z_m = R_S + jX_S + \frac{\left(\frac{R_r'}{S} + jX_r'\right)(jX_m)}{\frac{R_r'}{S} + j(X_r' + X_m)} \qquad \text{(Units: }\Omega)$$

Then the stator input current (I_S):

$$I_s = \frac{V_S}{Z_m} = \frac{V_S}{R_S + jX_S + \frac{\left(\frac{R_r'}{S} + jX_r'\right)(jX_m)}{\frac{R_r'}{S} + j(X_r' + X_m)}} \qquad \text{(Units: A)}$$

Therefore, the rotor current (I_r') referred to the primary side (stator) in terms of I_S:

$$I_r' = I_s \frac{jX_m}{\frac{R_r'}{S} + j(X_r' + X_m)} = \frac{V_S}{R_S + jX_S + \frac{\left(\frac{R_r'}{S} + jX_r'\right)(jX_m)}{\frac{R_r'}{S} + j(X_r' + X_m)}} \cdot \frac{jX_m}{\frac{R_r'}{S} + j(X_r' + X_m)}$$

$$\therefore \quad I_r' = \frac{jX_m \cdot V_S}{\left[\frac{R_r'}{S} + j(X_r' + X_m)\right]\left[R_S + jX_S + \frac{\left(\frac{R_r'}{S} + jX_r'\right)(jX_m)}{\frac{R_r'}{S} + j(X_r' + X_m)}\right]} \qquad \text{(Units: A)}$$

In motor power, from Steinmetz equivalent circuit:

$$\frac{R_r'}{S} = \frac{R_r'(1-S)}{S} + R_r' \qquad \text{(Units: }\Omega)$$

the air gap power (P_{gap}):

$$P_{gap} = P_{em} + P_{cu} = \frac{3I_r'^2 \cdot R_r'}{S} \qquad \text{(Units: W)}$$

and, the rotor copper losses (P_{cu}):

$$P_{cu} = 3I_r'^2 \cdot R_r' \qquad \text{(Units: W)}$$

and, the electromechanical power (P_{em}):

$$P_{em} = \frac{3I_r'^2 \cdot R_r'(1-S)}{S} = P_{gap}(1-S) \qquad \text{(Units: W)}$$

In torque, we have known that output power (P_{em}) is equal to output machine torque (T_{em}) times shaft speed (ω_r), therefore,

$$P_{em} = T_{em} \cdot \omega_r$$

$$\therefore \; T_{em} = \frac{P_{em}}{\omega_r} = \frac{\frac{P_{cu}}{S}}{\omega_s} = \frac{P_{cu}}{\omega_s \cdot S} = \frac{3I_r'^2 \cdot R_r'}{\omega_s \cdot S} = P_{gap} \cdot \omega_s \quad \text{(Units: Nm)}$$

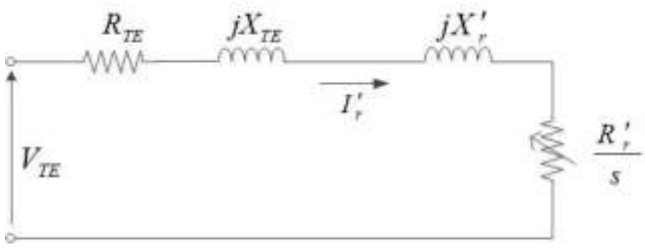


Figure 3.1.4-3: Thevenin equivalent circuit.

In addition, IEEE 112 (2004) [4] suggested that R_s, X_s and X_m is represent sum of the motor equivalent resistance, leakage reactance and magnetizing reactance respectively be converted to total equivalent impedance (Z_{TE}) by the "Thevenin equivalent circuit" method as shown in Figure 3.1.4-3 that is:

$$V_{TE} = \frac{X_m}{\sqrt{R_s^2 + (X_s + X_m)^2}} \cdot V_s \quad \text{(Units: V)}$$

$$Z_{TE} = R_{TE} + jX_{TE} = \frac{jX_m(R_s + jX_s)}{R_s + j(X_s + X_m)} \quad (\text{Units: }\Omega)$$

$$Z_{TE} = R_{TE} + jX_{TE} = \frac{jX_m(R_s + jX_s)}{R_s + j(X_s + X_m)} \quad (\text{Units: }\Omega)$$

Thus by Özyurt (2005) [5] method to find out the torque.
Since $X_m \gg X_s$ and the $R_s^2 \gg (X_m + X_s)^2$
Letting "Thevenin reactance factor" $K_{TE} = \frac{X_m}{X_m + X_s}$
and $Z_{TE} \approx {K_{TE}}^2 \cdot (R_s + jX_s)$; $V_{TE} \approx Z_{TE} \cdot V_s$

$$\therefore\ T_{em} = \frac{3{V_{TE}}^2}{\left(R_{TE} + \frac{R_r'}{S}\right)^2 + (X_{TE} + X_r')^2} \cdot \frac{R_r'}{S} \cdot \frac{1}{\omega_s} \quad \text{(Units: Nm)}$$

$$\text{OR,} \quad T_{em} = \frac{P_{em}}{\omega_r}, \rightarrow \quad P_{em} = \frac{3{V_{TE}}^2}{\left(R_{TE} + \frac{R_r'}{S}\right)^2 + (X_{TE} + X_r')^2} \cdot \frac{R_r'}{S} \cdot \frac{\omega_r}{\omega_s} \quad \text{(Units: W)}$$

$$\text{OR,} \quad T_{em} = \frac{\frac{P_{cu}}{S}}{\omega_s} = \frac{P_{cu}}{\omega_s \cdot S}, \rightarrow \quad P_{cu} = \frac{3{V_{TE}}^2}{\left(R_{TE} + \frac{R_r'}{S}\right)^2 + (X_{TE} + X_r')^2} \cdot \frac{R_r'}{S} \cdot \frac{1}{\omega_s} \cdot \omega_s \cdot S$$

$$P_{cu} = \frac{3{V_{TE}}^2 \cdot R_r'}{\left(R_{TE} + \frac{R_r'}{S}\right)^2 + (X_{TE} + X_r')^2} \quad \text{(Units: W)}$$

In low slip motor (S), the equivalent rotor resistance (R_r') is more than both leakage reactance (X_r') and stator equivalent resistance (R_{TE}).

$$\text{Since, } R_r' \gg R_{TE} \text{ and } R_{TE} + R_r' \gg R_{TE} + X_r'$$

$$\therefore\ T_{em} = \frac{3{V_{TE}}^2}{R_r'} \cdot \frac{1}{\omega_s} = \frac{3{V_{TE}}^2}{R_r' \cdot \omega_s} \quad \text{(Units: Nm)}$$

In high slip motor (S), the equivalent rotor resistance (R_r') is less than both leakage reactance (X_r') and stator equivalent resistance (R_{TE}).

$$\text{Since, } R_r' \ll R_{TE} \text{ and } R_{TE} + R_r' \ll R_{TE} + X_r'$$

$$\therefore\ T_{em} = \frac{3{V_{TE}}^2}{(X_s + X_r')^2} \cdot \frac{R_r'^2}{S} \cdot \frac{1}{\omega_s} = \frac{3{V_{TE}}^2 \cdot R_r'^2}{S \cdot \omega_s \cdot (X_s + X_r')^2} \quad \text{(Units: Nm)}$$

For breakdown torque or maximum torque (T_{max}), it is independent of rotor resistance.

$$T_{max} = \frac{3{V_{TE}}^2}{R_{TE} \pm \sqrt{{R_{TE}}^2 + (X_{TE} + X_r')^2}} \cdot \frac{1}{2\omega_s} \quad \text{(Units: Nm)}$$

* noted that " + " for motor ; " – " for generator

where corresponding slip (S), during breakdown torque or maximum torque/

$$S = \frac{R_r'}{\sqrt{{R_{TE}}^2 + (X_{TE} + X_r')^2}}$$

With refer chapter 3.7 we have known that the motor output power should be 75kW and suction will be air required at a rate of up to 500m^3/min is required. Thus motor rating should be selected 'Y-280S-4' model by the data researched from Alibaba.com and the relevant data a below. Also obtained the model'Y-280S-4' of the rotor is class B type. It can be directly-on-line starting the motor. But the National Electrical Manufacturers Association (Rosslyn (2007)) [6] pointed out that there is occurred locked rotor current states that it was up to typically ranging between six and seven times rated current in class B rotor. And the locked rotor current I_{LRC} is less than $\frac{V_s}{X}$. Also $S \approx \frac{R_r'}{x}$ and $I_s \approx 0.7LRC$. Therefore the breakdown torque $T_{max} \approx K \cdot \frac{V_s^2}{2X}$. Also EMSD (2015) [7] pointed out that in order to achieve the "*Code 26C Electric Motor in CoP for the electricity (Wiring) regulations 2015 edition of EMSD* " in Hong Kong law Electricity Ordinance (Chapter 406) which is limit "the motor starting current not more than 2.5 times at the rated current while the motor at more 55kW". Thus the motor should be selected suitable control drive for motor starting to limit the current and it would be discuss in next section. The information a below provided a torque-speed characteristics manufacturer data and specification for air blower motor fans represented by Alibaba.com.

双一风机 SHUANGYIFENGJI

C 式联接

机号	转速 r/min	全压 Pa	流量 m³/h	电动机		三角带		风机槽轮 代号	电机槽轮 代号	电机滑轨 代号
				型号	功率KW	型号	数量			
6C	2240	2726–1883	10600–19600	Y180M–4	18.5	B2800	4	50–B_4–240	48–B_4–370	FT542–2
	2000	2177–1500	9500–17600	Y160M–4	11	B2500	3	50–B_3–240	42–B_3–330	FT542–2
	1800	1765–1216	8520–15800	Y132M–4	7.5	B2240	2	50–B_2–240	38–B_2–300	FT542–1
	1600	1393–961	7560–14000	Y132S–4	5.5	B2240	2	50–B_2–240	38–B_2–260	FT542–1
	1250	843–579	5920–11000	$Y100L_2$–4	3	B2240	2	50–B_2–240	28–B_2–216	FT542–1
	1120	686–471	5300–9800	$Y100L_1$–4	2.2	A2240	2	50–A_2–240	28–A_2–190	FT542–1
	1000	539–373	4730–8750	$Y100L_1$–4	2.2	A2240	2	50–A_2–240	28–A_2–165	FT542–1
	900	441–304	4250–7850	$Y100L_1$–4	2.2	A2240	2	50–A_2–240	28–A_2–155	FT542–1
	800	333–226	3780–7000	Y90S–4	1.1	A2240	2	55–A_2–240	24–A_2–130	FT542–0
8C	1800	3119–2363	20100–34800	$Y200L_1$–2	30	B2500	6	55–B_6–320	55–B_6–200	FT542–3
	1600	2471–1844	17920–31000	$Y180M_2$–2	22	B2240	5	55–B_5–320	48–B_5–175	FT542–2
	1250	1510–1138	14000–24200	Y160M–4	11	B2500	3	55–B_3–320	42–B_3–275	FT542–2
	1120	1206–912	12500–21650	Y132M–4	7.5	B2500	2	55–B_2–320	38–B_2–250	FT542–1
	1000	961–726	11200–19300	Y132S–4	5.5	B2240	2	55–B_2–320	38–B_2–220	FT542–1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	FT542–1
	800	618–461	8960–15500	$Y100L_2$–4	3	B2240	2	55–B_2–320	28–B_2–175	FT542–1
	710	481–373	7920–13710	$Y100L_1$–4	2.2	B2240	2	55–B_2–320	28–B_2–155	FT542–1
	630	382–284	7040–12200	$Y100L_1$–4	2.2	B2240	2	55–B_2–320	28–B_2–140	FT542–1
10C	1250	2344–1863	34800–50150	Y225S–4	37	C3550	5	55–C_5–400	60–C_5–345	FT542–3
	1120	1883–1491	31200–45000	Y180L–4	22	C3150	5	55–C_5–400	48–C_5–310	FT542–2
	1000	1500–1187	27800–40100	Y180M–4	18.5	C3150	4	55–C_4–400	48–C_4–275	FT542–2
	900	1216–961	25050–36100	Y160L–4	15	B3150	3	55–B_3–400	42–B_3–250	FT542–2
	800	961–765	22150–32100	Y160M–4	11	B3150	3	55–B_3–400	42–B_3–220	FT542–2
	710	755–598	19780–28500	Y132M–4	7.5	B2500	2	55–B_2–400	38–B_2–195	FT542–1
	630	598–471	17540–25280	Y132S–4	5.5	B2500	2	55–B_2–400	38–B_2–115	FT542–1
	560	471–373	15600–22470	$Y100L_2$–4	3	B2240	2	55–B_2–400	28–B_2–155	FT542–1
	500	382–294	13910–20100	$Y100L_2$–4	3	B2240	2	55–B_2–400	28–B_2–140	FT542–1
12C	1120	2717–2148	53800–77500	Y280S–4	75	C4000	7	75–C_7–480	75–C_7–370	FT542–4
	1000	2167–1716	48100–69300	Y250M–4	55	C3550	6	75–C_6–480	65–C_6–330	FT542–4
	900	1746–1383	43200–62200	Y225M–6	30	C4000	4	75–C_4–480	60–C_4–450	FT542–3
	800	1383–1098	38600–55700	$Y200L_2$–6	22	C4000	3	75–C_3–480	55–C_3–400	FT542–3
	710	1089–863	34200–49500	$Y200L_1$–6	18.5	C3550	3	75–C_3–480	55–C_3–360	FT542–3
	630	863–686	30400–43900	Y180L–6	15	C3550	4	75–C_4–480	48–C_4–310	FT542–2
	560	677–539	27000–38900	Y160M–6	7.5	C3550	2	75–C_2–480	42–C_2–280	FT542–2
	500	539–432	24100–34800	$Y132M_2$–6	5.5	C3550	2	75–C_2–480	38–C_2–250	FT542–1
	450	441–343	21650–31200	$Y132M_1$–6	4	C3550	2	75–C_2–480	38–C_2–225	FT542–1
	400	353–275	19280–27800	Y132S–6	3	C3150	2	75–C_2–480	38–C_2–200	FT542–1

— 3 —

Figure 3.1.3-4: The air blower motor manufacturer data represented by Alibaba (2016)

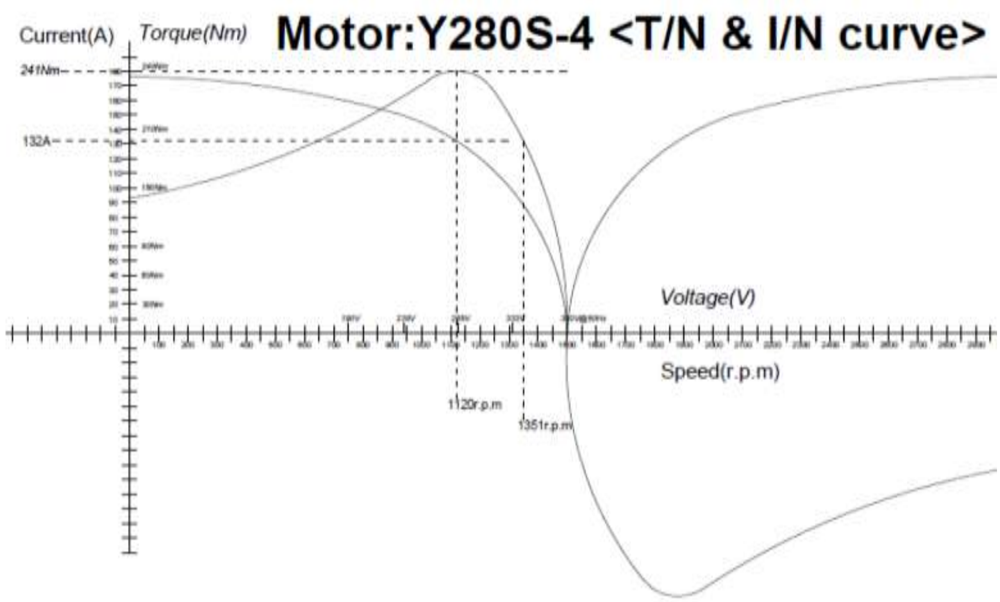


Figure 3.1.4-5: The torque-speed characteristics manufacturer data for air blower motor fans represented by Alibaba (2016) [8]

IV. CONCLUSION

With the aims of provide environmental friendly and efficiency for saving human recourse and convenient for tenant which have been successfully achieved. Through objectives of this project to study the induction motor used in ACRCS systems. It can obtain to control vacuum pressure by operate the air blower motor of VVVF controller. Especially the squirrel cage type induction motor control adopt VVVF provide more efficiency. The project have been analyzed advantage of VVVF controller are provided larger torque is obtained with a smaller current, load can be gradually accelerated by progressively step-by-step increasing the voltage and frequency, avoiding high starting current, during start-up period, the voltage and frequency can be varied automatically. This ensures a rapid acceleration at practically constant current. Operation the base speed is done at a constant terminal voltage, giving constant power operation a closed-loop drive.

Also the project have been investigated the squirrel cage type induction motor advantage are simple and robust in construction, less cost, lower weight, easy and lower maintenance requirements, better reliability, ability to operate in dirty and explosive environments. To concerning structure and characteristic of the squirrel cage type induction motor in operate of air blower. It can be provide negative pressure inside the conveyer pipes system. Therefore the squirrel cage type induction motor is practicable and suitable for use to ACRCS.

The ACRCS operates refuse for the residents have good hygienic condition. And it is simplify than that of human resource for operating at refuse chamber for cleansing and disposal process. Moreover it shall be arranged vehicles collected the refuse at central refuse plant for daily collection. Also ACRCS can save more space of the building because it can without refuse chamber on ground floor. It is reflected in the site visit and test report. The experiment can be found out that the VVVF provided 4-step output level for the air blower motor by using the conveyer pipes detector is successfully accomplished to operation.

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