Jurnal Scientia
Volume 13 , Number 03, 2024, DOI 10.58471/ scientia.v13i03
ESSN 2723-7486 (Online)
https://infor.seaninstitute.org/index.php/pendidikan

An Analysis Performance Reliability Of Air Conditioner Comprecor Motors Based On Power Quality

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ArticleInfo
Keywords:
Power quality,
compressor,
technology implementation

ABSTRACT
A Poor power quality, such as voltage fluctuations and harmonic interference, can affect compressor motor performance and life. So this research uses direct measurement and simulation methods to evaluate the influence of various power quality parameters on AC compressor motors. This research aims to analyze the performance reliability of compressor motors in air conditioner (AC) systems based on electrical power quality. and several tests show that harmonic interference and voltage variations significantly affect the efficiency and reliability of the compressor motor. Motors operating under poor power quality conditions exhibit increased operating temperatures, reduced efficiency, and shortened lifespan. The use of harmonic filters and voltage stabilizers has proven effective in improving power quality and, thereby, AC compressor motor performance. This research emphasizes the importance of maintaining power quality to ensure the reliability and efficiency of the compressor motor in the AC system. The implementation of power stabilizer and harmonic filter technology is recommended for industries that use compressor motors extensively, in order to optimize performance and reduce operational costs and made important contributions in the areas of power quality management and preventive maintenance for HVAC (Heating, Ventilation, and Air Conditioning) systems, with a particular focus on compressor motors as a key component in these systems.

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INTRODUCTION

In this modern era, the use of AC compressor motors has become common in various applications, both in homes, offices, industry and transportation. Ac Compressor Motors Play an Important Role in Producing Cold Air or Cooling for Various Needs, Starting from Indoor Air Cooling to Cooling in Complex Industrial Machines.

However, as with other electrical devices, AC compressor motors are also susceptible to interference and performance problems. One of the factors that can influence the performance of an AC compressor motor is the quality of the power received by the motor. Poor Power Quality Can Result in Various Problems, Including Decreased Efficiency, System Failure, and Damage to Equipment.

Therefore, in this context, analysis of AC compressor motor performance reliability based on power quality becomes very important. This research aims to investigate how the quality of power received by an AC compressor motor can influence its performance. Apart from that, this research will also explore ways to increase the reliability of AC compressor motor performance by improving the quality of the power received. With a better understanding of the relationship between power quality and AC compressor motor performance, it is hoped that more effective strategies can be developed in maintaining and managing air conditioning systems. This will help reduce unexpected downtime, increase energy efficiency, and extend the operational life of the AC compressor motor.

Through this research, it is hoped that valuable insight will be gained regarding the importance of paying attention to power quality in maintaining reliable AC compressor motor performance, as well as solutions that can be implemented to increase operational efficiency and reliability. The compressor motor is an important component in the air conditioner (AC) system which functions to compress the refrigerant and regulate coolant circulation. The performance of the compressor motor is very dependent on the quality of the electrical power supplied. Poor power quality, such as voltage fluctuations, harmonic interference, and phase imbalance, can cause a variety of problems with compressor motors, including reduced efficiency, increased operating temperatures, and even permanent damage. Therefore, analyzing the reliability of compressor motor performance based on power quality is very important to ensure efficient and long-lasting operations.

As demand for air conditioning systems increases, especially in tropical countries, the reliability of the compressor motor in the AC system becomes a crucial factor. A reliable compressor motor not only ensures thermal comfort but also saves energy and operational costs. Poor electrical power quality is often unavoidable, especially in dense and complex electricity distribution networks. Power quality disturbances such as harmonics, voltage fluctuations and transient disturbances often occur and have a direct impact on compressor motor performance.

Some of the reasons underlying the importance of this analysis include:

a. Changes in the power supply system: The power supply system may experience fluctuations and disturbances that may affect the quality of power received by the AC compressor motor.
b. Adverse power quality impact: Poor power quality can cause damage to the AC compressor motor and other components in the air conditioning system.
c. Availability of technology to monitor power quality: There is technology available to monitor and analyze power quality, so it is important to understand how to use it to improve the reliability and performance of AC compressor motors.
d. By understanding this background, power quality-based AC compressor motor performance reliability analysis can help improve operational efficiency, prevent unnecessary damage, and optimize overall air conditioning system performance.

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Literature Review

Air Conditioner Working Definition

According to Sumanto (2018:45) that an air conditioning machine (Air Conditioner) is a tool to produce air with the desired temperature where this process occurs in a system with components that work in synergy from the compressor which is the power unit of the cooling machine system when the compressor When this is done, it will change the refrigerant in the form of gas from low pressure to high pressure gas, the high pressure gas is then passed to the condenser where the condenser will change the high pressure gas into high pressure liquid which is then flowed to the expansion valve. , the condenser can also be called a heat exchanger, which is a means of transferring heat and bringing it to the expansion valve, where the temperature of the high-pressure fluid is lowered to become a cold, low-pressure fluid.

In some systems, apart from installing an orifice, an expansion valve is also installed, which is a very important component in the air conditioning system. This valve is designed to control the flow of refrigerant through an orifice valve which changes liquid form to vapor. When the refrigerant leaves the expansion valve and enters the evaporator in this device the refrigerant will absorb heat in the room through the cooling coil, and the blower on the evaporator blows air into the room. , then the refrigerant will change back into low pressure steam but still contains a small amount of liquid mixed with the refrigerant then enters the accumulator or dryer and thus the working circulation will continue in a closed loop system. To maintain optimal engine performance, planned maintenance is required, and this maintenance is adjusted to the working hours of the air conditioning system.

How Air Conditioners Work

According to Sumanto (2018:45), many Air Conditioner mechanism systems have been developed by experts, and each producing company offers various advantages in each system used. The advantages offered are usually in terms of operation and energy used by both outdoor systems and indoor systems. In general, the working principle of an Air Conditioner is as follows:

1. The air in the room is sucked in by the centrifugal fan in the evaporator and the air comes into contact with the coil pipe containing the refrigerant liquid. In this case, the refrigerant will absorb the heat of the air so that the air becomes cold and the refrigerant will evaporate and be collected in a vapor reservoir.
2. The vapor pressure originating from the evaporator is circulated to the condenser. During the compression process, the temperature and pressure of the refrigerant vapor rises and is pressed into the condenser.
3. To reduce the pressure of the high-pressure refrigerant liquid, an expansion valve is used to regulate the flow rate of the refrigerant entering the evaporator.
4. When the air comes out of the condenser the air becomes hot. Refrigerant vapor provides heat to the cooling air in the condenser to become dew in the capillary tube. In releasing heat to the condenser, it is assisted by a propeller fan.
5. With continuous circulation of cold air in the room, it is necessary to have a thermostat to regulate the temperature in the room or according to your wishes.

6. The air in the room becomes cooler than outside the room because the air in the room is sucked in by the centrifuges in the evaporator and then the air comes into contact with the evaporator pipe/coill which contains cooling gas (freon). Here heat transfer occurs so that the indoor air temperature is relatively cooler than before.
7. The temperature outside the room is hotter than inside the room, because the air in the room is sucked in by the centrifugal fan and comes into contact with the evaporator, and is assisted by other AC components, then the indoor air is expelled by the condenser air fan. In this case, outdoor air can be sucked in by a centrifugal fan and air can enter through the grille in the AC.
8. High temperature refrigerant gas at the end of compression in the condenser is easily liquefied with cooling air in the air cooled system or refrigerant vapor absorbs the heat of the cooling air in the condenser so that it condenses and becomes a liquid outside the evaporator pipe.
9. Because the cooling water or air absorbs heat from the refrigerant, the water or air becomes hot when it leaves the condenser. The refrigerant vapor, which has become liquid, is then channeled into the evaporator pipe through the expansion valve. This incident will repeat itself as above.

Cooling Engine Parts

According to Sumanto (2018:45) that the parts of the air conditioning engine cooling system are as follows:

1. Compressor
   A device (machine) whose function is to suck low pressure refrigerant from the evaporator and then compress it into a gas at high pressure to flow to the condenser. The compressor is the heart of vapor compression. The compressor or suction pump functions to circulate refrigerant throughout the cooling system. The system works by changing the pressure, from the low pressure side to the high pressure side. When the compressor is working, the refrigerant that is sucked in from the evaporator at low temperature and pressure is compressed, so that the temperature and pressure rise. This compressed gas is pressed out of the compressor and then flows to the condenser, the high and low temperature is controlled by a thermostat.
2. Oil Separator
   Oil Separator is a tool to separate lubricating oil from the compressor from the refrigerant. The way this tool works is based on the specific gravity of the refrigerant and the compressor lubricating oil, so the compressor lubricating oil will be left in the oil separator and the refrigerant will be passed to the condenser. The compressor oil remaining in the oil separator will flow back into the compressor through the valve leading to the compressor.
3. Condenser
   The condenser is a tool for cooling the refrigerant under high pressure and temperature when it comes out of the compressor and is cooled and converted into a liquid that still has pressure. In the condenser, the refrigerant in gaseous form and under pressure is cooled by the cooling medium (sea water) into liquid form but still under high pressure.

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4. Dryer (Dryer Filter)
   Consists of silica gel and a screen which functions to filter dirt and absorb water vapor. Silica gel functions to absorb water vapor, and the screen functions to filter dirt and water vapor, so the refrigerant will be filtered by the dryer filter first before entering the expansion valve, so that the expansion valve is not damaged or deadlocked.
5. Solenoid Valve (Selonoid Valve)
   Functions to control the flow of refrigerant with the working principle of opening and closing a valve based on an electric current connected to the thermostat. When room temperature has been reached, the thermostat will cut off the current to the solenoid which will close the valve so that the flow of refrigerant stops and will activate the low pressure switch which will cut off the electric current to the compressor driving motor so that the compressor stops when room temperature is reached.
6. Expansion valve (Expansion Valve)
   Functions to regulate the amount of refrigerant into the orifice tube which will change the liquid refrigerant into vapor which expands into the evaporator.
7. Evaporator
   A device that functions as a flow of low temperature and low pressure steam in a coil pipe, where the refrigerant flowing inside will take heat/absorb heat in the room by being blown by a blower which will circulate into the accommodation room.
8. Accumulator (Accumulator)
   An accumulator is an auxiliary equipment in a refrigeration system which has the function of holding or separating liquid refrigerant and refrigerant gas so that the refrigerant that enters the compressor is all in the form of refrigerant gas. The accumulator is usually installed after the evaporator and before the compressor or on the low pressure side of the system.
9. Storage Tank (Receiver)
   The receiver or storage tank functions as a container or storage of refrigerant in the cooling system.
10. Fan Blower
   Functions to suck in air and flow it through the evaporator (in the evaporator heat exchange occurs, where the air releases the heat absorbed by the refrigerant) then the air flows into the rooms.
11. Control devices (Safety Devices)
   a. Thermostat: functions to regulate the desired temperature.
   b. High Pressure Cut-Off Switch (circuit breaker switch on the too high pressure side). Functions to stop the compressor if the pressure side is too high.
   c. Low Pressure Cut-off Switch (circuit breaker switch when the suction side is too low) to stop the compressor if the suction side is too low and functions to prevent freezing of the evaporator, also prevents air and water vapor from entering the system if there is a leak on the pressure side low.
   d. Circuit Breaker Switch When Lubricating Oil Pressure is Low (LO Pressure Cut-Off Switch).

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e. Pressure Regulating Valve (Evaporator Pressure Regulating Valve/Back Pressure Regulator). Functions to prevent the evaporator pressure from dropping below a predetermined pressure limit.

Optimization

According to the Big Indonesian Dictionary (Depdikbud, 2015:628), the definition of optimization comes from the word optimal which means best, highest. So optimization is an action, process or methodology to make something more/fully perfect, functional or more effective. According to Winardi (2019:363) Optimization is a measure that causes the achievement of goals, whereas if viewed from a business perspective, Optimization is an effort to maximize activities so as to realize the desired or desired profits.

According to W.J.S Poerwadarminta (2020:178) in the general Indonesian dictionary states that optimization is the results achieved in accordance with desires, so optimization is achieving results in accordance with expectations efficiently and effectively. From the description above, the author concludes that optimization is an effort to improve services effectively and efficiently.

RESULTS AND DISCUSSION

Measurement results

The first measurement is measurement with TS=27°The 1st C results are entered into table 2.

Table 1. Measurement results with TS=27°C is the 1st

	TS=27oC					
Minute to	SEVIPFP					E
0	30.2					
15	20.2	229	5.47	0.8	1010.0	0.22
30	17.1	227	4.64	0.8	851.5	0.53
45	17.3	228	4.21	0.8	774.6	0.66
60	21.7	229	1.32	0.78	237.5	0.77
75	22.9	229	1.33	0.78	240.5	0.83
90	23.5	232	1.27	0.79	236.9	0.90
105	21.8	233	2.27	0.78	419.3	0.99
120	22.1	233	1.67	0.78	304.5	1.05

Table 2. Measurement Results with T_S=27°C is the 2nd

	MinTs=27 °C				
keSEVIPFP					E
0	17.9				
15	26.3	234	0.130.73	23.01	0.02
30	23.9	234	0.130.73	22.91	0.04
45	24.3	234	2.490.77	448.50	0.05

60	25.6	236	0.13	0.73	23.30	0.09
75	22.6	235	1.12	0.79	212.30	0.14
90	26.0	236	0.13	0.73	23.53	0.16
105	24.6	236	0.13	0.73	22.11	0.20
120	25.1	236	0.14	0.73	24.12	0.25

Table 3. Measurement Results with T_S=22°C is the 1st

Minute to	Ts=22oC					
	S.E	V	I	P.F	P	E
0	29.7					
15	20.8	229	5.35	0.80	994.20	0.22
30	21.3	229	5.44	0.80	1010.00	0.47
45	21.7	230	5.47	0.80	1020.00	0.72
60	21.2	228	5.67	0.80	1040.00	0.98
75	17.6	225	5.66	0.80	1030.00	1.25
90	17.9	226	5.61	0.80	998.00	1.51
105	16.9	227	5.45	0.80	791.70	1.75
120	16.4	228	1.99	0.80	771.20	1.99

Table 4. Measurement Results with T_S=22°C is the 2nd

Min ke	Ts=22				°C	
	SE	V	I	PF	P	E
0	30.3					
15	19.9	225	5.87	0.80	1060.00	0.25
30	17.6	226	5.75	0.80	1050.00	0.51
45	16.6	227	5.64	0.80	1040.00	0.75
60	15.1	227	5.64	0.80	1020.00	1.02
75	14.3	228	5.43	0.80	1000.00	1.27
90	14.8	227	5.41	0.80	992.60	1.52
105	15.7	227	5.39	0.80	987.10	1.76
120	14.3	228	5.29	0.80	976.20	2.01

Table 5. Measurement Results with T_S=16°C is the 1st

Minute	Ts=16oC					
to	S.E	V	I	P.F	P	E
0	30.7					
15	17.9	227	4.47	0.79	807.7	0.20
30	16.2	227	4.39	0.79	793.9	0.40
45	16.3	227	4.35	0.79	788.8	0.60
60	13.8	228	4.34	0.79	786.6	0.85
75	15.2	227	4.30	0.79	783.3	0.99
90	16.5	229	4.28	0.79	776.8	1.18
105	16.5	228	4.28	0.79	776.1	1.38
120	16.6	229	4.24	0.79	773.1	1.57

Table 6. Measurement Results with T_S=16°C is the 2nd

Minute	Ts=16oC					
to	S.E	V	I	P.F	P	E
0	28.2					
15	17.0	230	4.10	0.79	751.9	0.17
30	14.7	227	4.15	0.79	753.1	0.37
45	14.4	225	4.12	0.79	744.3	0.55
60	13.4	225	4.11	0.80	740.3	0.73
75	14.8	228	4.04	0.80	740.9	0.93
90	14.3	226	4.08	0.80	743.1	1.10
105	14.2	225	4.07	0.80	736.2	1.31
120	14.4	226	4.05	0.80	739.9	1.50

The calculation results

The following data calculations from table 1 are carried out manually, then they will be carried out using Ms Excel. For further calculations the author used the MS Excel program and immediately entered the results into table 6

Table 7. PSE, COP and EER calculation results

No	Measurement			Calculation			
	SE (°C)		E	PSE	kW/ton	COP	EER
	Beginning	End	(kWh)				

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1.	30.2	22.1	1.05	8.1	0.663	5.30	18.10
2.	17.9	25.1	0.25	-7.2	0.158	22.27	76.00
3.	29.7	16.4	1.99	13.3	1,257	2.80	9.55
4.	30.3	14.3	2.01	16.0	1,269	2.77	9.45
5.	30.7	16.6	1.57	14.1	0.992	3.55	12,10
6.	28.2	14.4	1.50	13.8	0.947	3.71	12.67

Discussion

In the following, the author will make an analysis and discussion in the form of a comparison between the measurement results of TS=27°C the 1st and 2nd.

Figure 1. Comparison of measurement results TS=27°C between 1st and 2nd

From graph 1 it can be seen that the two have different initial SE values. In the next measurement Initial SE = 30.2°C is higher than TS=27°C. While the 2nd measurement initial SE = 17.9°C is lower than TS=27°C. So in the graph from the 1st measurement, SE drops to 17.1°C at 30 minutes after the TS has passed and then rises slowly. Meanwhile, the second measurement is reversed, SE actually rises to 26.30°C in the 15th minute before the compressor works again to cool the SE.

Figure 2. Comparison of measurement results TS=27°C between 1st and 2nd

From graph 2 it can be seen that the compressor working current is due to the effect of the previous initial SE, at 15 minutes in the 1st measurement (I=5.47A), while in the 2nd measurement (I=0.13A).

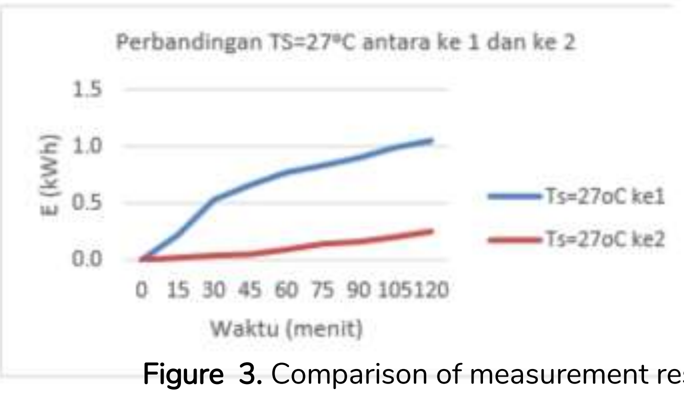

Figure 3. Comparison of measurement results TS=27°C between 1st and 2nd

From Figure 3, it can be seen that the energy consumption graph between the 1st and 2nd measurements has the same pattern. It's just that the value of E is different due to the different initial SE. Results of analysis and discussion of TS=27 measurements°C can represent the analysis and discussion for TS=22°C and TS=27°C. The relationship between energy (kWh) and cooling load (kW/ton). The KW/ton value is obtained from the calculation results as in table 1.4.

Figure 4 Comparison of E (kWh) with cooling load (kW/ton)

From Figure 4 it can be seen that the E value (kWh) is directly proportional to the cooling load (kW/ton).

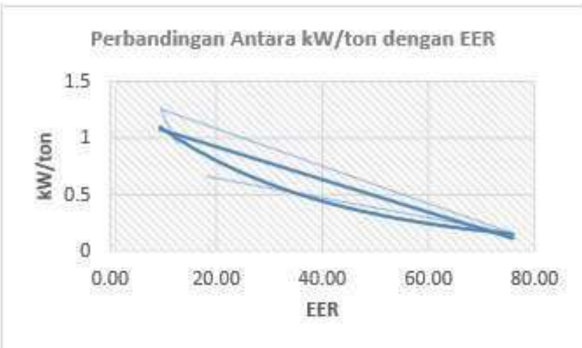

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Figure 5. Comparison of cooling load (kW/ton) with EER

From Figure 5 it can be seen that the cooling load value (kW/ton) is inversely proportional to COP and EER. The greater the cooling load value (kW/ton), the smaller the EER value. The smaller the cooling load value (kW/ton), the greater the EER value.

Figure 6. Comparison between PSE, COP and EER

From Figure 6 it can be seen that the PSE value is inversely proportional to the COP value. From the graph, it can be seen that when the smallest value is PSE = -7.2, COP gets the largest value, namely COP = 22.27. When the largest value is PSE=16.01, the COP value is the smallest, namely COP=2.77.

Figure 7. Comparison of PSE with EER

From Figure 7 it can be seen that the PSE value is inversely proportional to the EER value. From the graph, it can be seen that when the smallest value is PSE=-7.2, EER gets the largest value, namely EER=76. And when the largest value is PSE=16.01, the EER value is the smallest, namely EER=9.45.

CONCLUSION

In this research have SOME of the conclusions ARE: The Reliability of Compressor Motor Performance Based on the analysis conducted an AC compressor motor shows good performance reliability when operating under optimal power quality conditions. The motor works with high efficiency, appropriate power consumption, and maintains a safe operating temperature. An Effect of Power Quality had Poor power quality, such as fluctuating voltage or harmonic distortion, significantly affects the performance of the AC compressor motor. This condition can cause increased motor temperature, decreased efficiency, and even potential damage to the motor. Maintenance and Monitoring: Routine maintenance and monitoring of power quality are essential to ensure that the AC compressor motor operates optimally. The use of a power quality meter can help detect power problems that can affect motor performance and allow for timely preventive action. Power Quality Improvement: Implementation of power conditioning devices, such as harmonic filters or voltage stabilizers, can improve the quality of power received by the compressor motor. This will help maintain stable motor performance and extend its operational life. Energy Efficiency: AC compressor motors operating under good power quality conditions show higher energy efficiency. This not only reduces operational costs but also contributes to the reduction of carbon emissions, which is in line with sustainable environmental initiatives.

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