



BRAND COMPARISONS FOR INDUSTRIAL AIR CONDITIONING SYSTEMS USING TECHNICAL PROPERTIES USING LEAN SIX SIGMA TOOLS

Jamal Musthafa K M* Shreedharan J Sathish S** SanjayKumar S*** Hari Narayanan U******

**Director, Mastrolee Engineering And Management Consultants, Coimbatore.*

***Mechanical Engineer, Park College of Engineering and Technology (2013-2017).*

****Mechanical Engineer, SNS College of Technology(2013-2017).*

*****Mechatronics Engineer, Sri Krishna College of Engineering and Technology (2013-2017).*

Abstract

The air conditioning is the next big bloom in the Indian industrial sector.As everyone requires human comfort which is 24 degree Celsius, the need for AC systems have inclined at a faster rate. There are multiple brands available in the market for commercial products (non-residential air conditioning). The cost for non-residential products is quite a high. This paper gives a clear solution of various brands available in the market with respect to their technical specification of the product, with a survey from customer point of view to select the best brand. This paper is a techno-management paper which deals with technical specifications of air conditioning equipment and the objective is to create awareness among people to show the quality, performance and power consumption factors using lean six sigma tools.

Introduction

There are numerous number of HVAC (Heat Ventilation and Air Conditioning) industries available in India which are providing their systems with certain technical specifications. We are about to make a brief study on the techniques along with the reviews of the customers to find the best brand.

The brands Daikin, Voltas, Mitsubishi, Hitachi, Haier, LGand Ogeneral are seemed to the leading brands in India. This paper makes the study on these brands in respect to their technical specifications and customer reviews and we suggest the best brand in these brands. After which the best brand is viewed to find out the problems in the system and analyzing the problems and are provided with the solutions to the problems using lean six sigma tools’

Define Phase

VOC (Voice of Customer): To identify the best brand.

CTS (Critical to Satisfaction): Cost, Quality, Warranty, Energy Efficiency ratio (EER), DB level, Service.

CTQ (Critical to Quality): Low maintenance cost, Relative Humidity control, quick cooling, and Power consumption.

VOC to CTQ:Identify best brand based on technical properties.

VOD (Voice of Design): Large condensing coil, Compressor Efficiency.

DO (Defect Oppurtunities): Refrigerant gas leakage, Electric shock, Short circuit, compressor failure, Fan failure.

Target: selecting the best brand.

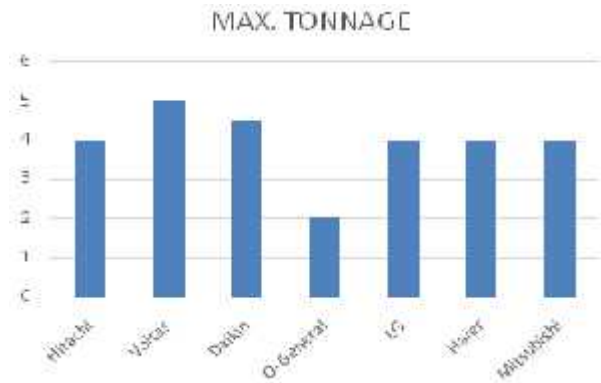
Consumer Product Review

	Voltas	O - General	LG	Mitsubhishi	Hitachi	Haier	Daikin
What three brands you recall immediately?							
Which brand consumes less electric power?							
Which brand provide quick cooling?							
Which brand provides better services?							
Which brand provides varieties of models?							
Which brand is less noise?							
Cost							
Life							

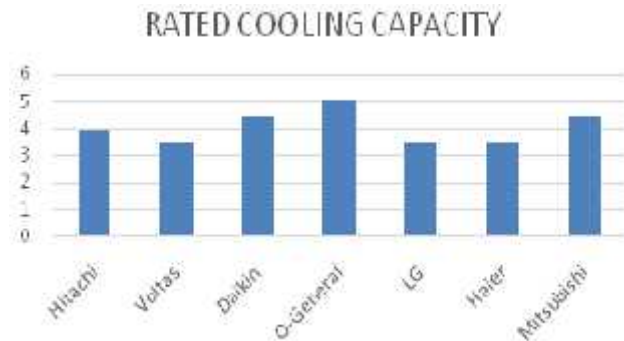
Measure Phase

Brands	Max. Tonnage	Rated Cooling Capacity	Air Flow	Warranty	Cost	Noise	Quality and Performance	EER
Hitachi	4	4	4	2	3	3.5	4	4
Voltas	5	3.5	3.5	3.5	4	3	3.5	3.5
Daikin	4.5	4.5	4.5	4.5	3.5	4.5	4.5	4.5
O-General	2	5	5	4.5	2	5	5	5
LG	4	3.5	3.5	5	4	5	3	3
Haier	4	3.5	3.5	4	5	3	3	3
Mitsubishi	4	4.5	4.5	4.5	2	4.5	4.5	4.5

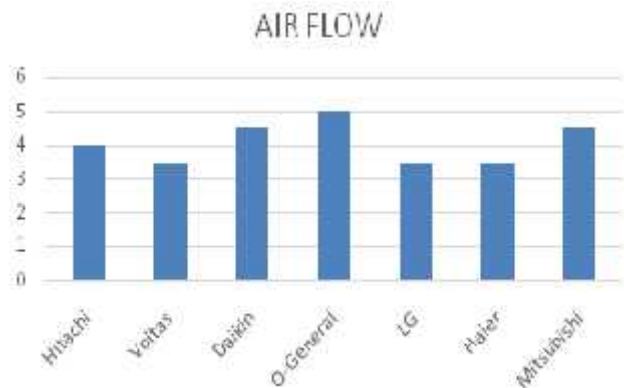
Brands	Max. Tonnage
Hitachi	4
Voltas	5
Daikin	4.5
O-General	2
LG	4
Haier	4
Mitsubishi	4



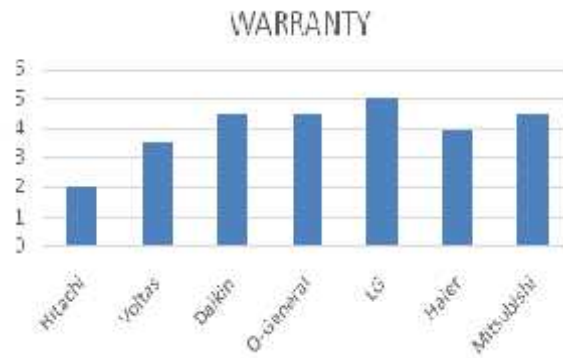
Brands	Rated Cooling Capacity
Hitachi	4
Voltas	3.5
Daikin	4.5
O-General	5
LG	3.5
Haier	3.5
Mitsubishi	4.5



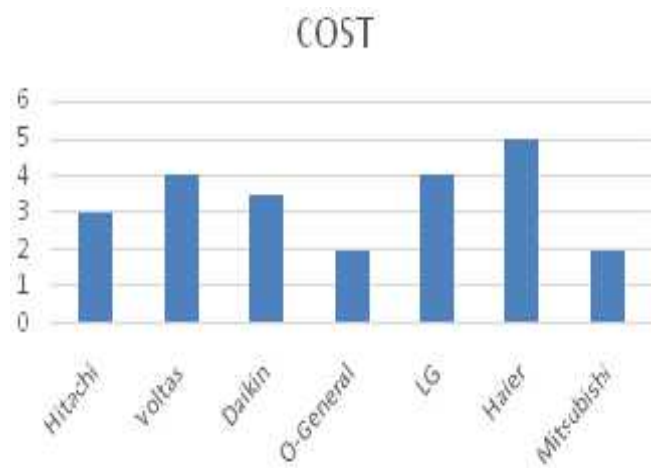
Brands	Air flow
Hitachi	4
Voltas	3.5
Daikin	4.5
O-General	5
LG	3.5
Haier	3.5
Mitsubishi	4.5



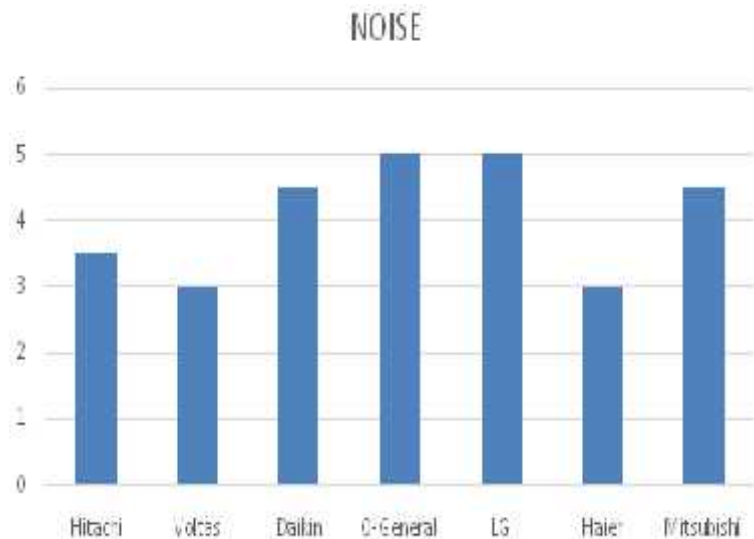
Brands	Warranty
Hitachi	2
Voltas	3.5
Daikin	4.5
O-General	4.5
LG	5
Haier	4
Mitsubishi	4.5



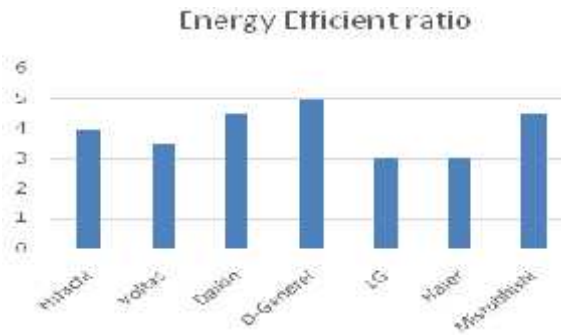
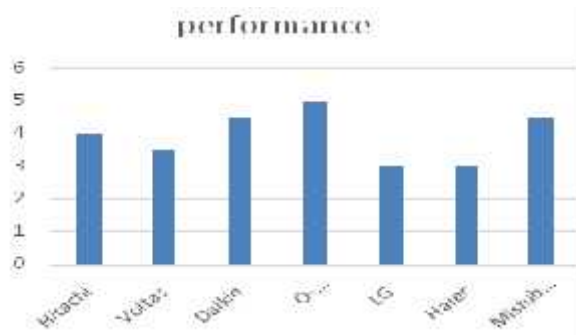
Brands	Cost
Hitachi	3
Voltas	4
Daikin	3.5
O-General	2
LG	4
Haier	5
Mitsubishi	2



Brands	Noise
Hitachi	3.5
Voltas	3
Daikin	4.5
O-General	5
LG	5
Haier	3
Mitsubishi	4.5



Brands	Performance	Energy Efficient Ratio
Hitachi	4	4
Voltas	3.5	3.5
Daikin	4.5	4.5
O-General	5	5
LG	3	3
Haier	3	3
Mitsubishi	4.5	4.5



Analysis Phase

The analyze phase is used to find the statistical analysis of the problem under study. In this phase, using certain tools we find the cause of the things which are slowing down the process consequently helping to suggest a method to bring improved effectiveness in the process.

LG Vs Daikin

LG leaves the race since it lost its EER ratio.

NEWS RELEASE



Attention: Consumer, environment writers

LG COMPENSATES CONSUMERS OVER MISLEADING ENERGY RATINGS

Up to \$3.1 million will be available in rebates for eligible consumers who bought five popular LG Electronics Australia Pty Ltd air conditioner models that did not comply with the energy efficiency values claimed on rating labels.

"LG sold more than 15,000 mislabelled air conditioners", Australian Competition and Consumer Commission Chairman, Mr Graeme Samuel, said today.

"LG will also implement new testing procedures to ensure that the energy efficiency of its air conditioners matches the performance indicated by their stated energy efficiency star rating and, where applicable meet, "minimum energy performance standards".

LG has given court-enforceable undertakings to the ACCC after it raised concerns about the accuracy of energy claims on the five models.

The ACCC investigation followed a complaint by the Australian Greenhouse Office. Check tests conducted on behalf of the Department of Energy, Utilities and Sustainability in New South Wales, and Energy Safe Victoria, found that:

- the actual cooling output of a number of models of air conditioners sold by LG between particular dates was less than 90 per cent of the rated output
- the energy consumption of some of the affected models was more than the rated power consumption, and
- the energy efficiency ratings of the affected models were lower than that claimed by LG, and that of one model was lower than that required by the relevant Minimum Energy Performance Standards (MEPS).

As a result, it is likely that the five air conditioner models use more electricity and, accordingly, cost more to run than would be the case if those air conditioners complied with the values stated on the relevant energy labels.

The ACCC and LG have agreed an estimate of the potential difference in operating costs that may be experienced in respect of each of the five models. LG will compensate purchasers of affected models for the potential increase in operating costs as set out below.

Consumers who purchased these models between the dates listed below and who relied on representations made by LG in relation to the cooling capacity, power consumption or efficiency of that air conditioner should contact LG on 1800 506 154. Consumers will need to provide LG with their contact details, together with proof of purchase or other evidence reasonably establishing their ownership of an affected model within the next six months.

Daikin Vs Mistibushi





This graph shows that mitsubishi has high Noise content on comparison with daikin

Daikin Vs Haier

Haier is a Chinese brand which uses Mitsubishi’s compressor as its own compressor.

Daikin Vs Toshiba

DAIKIN TECHNOLOGY – COMPRESSOR

DAIKIN ↓ (DC Inverter + Constant Speed) Scroll Compressor	TC ↓ Twin Rotary with DC Inverter
	
Scroll Compressor	Rotary Compressor
Higher Efficiency. Due to lesser moving parts. Also low operational noise. Lesser vibration. Because of Uniform load distribution. Enhanced Compressor Life. Due to easier lubrication. Less maintenance is required.	Relatively low efficiency, because of more rotating parts. Higher operating noise. More vibration. Due to one point of contact. Lubrication of Vane Tip is difficult. Severely related to compressor life. Because of complex design, means more parts that can fail, so regular maintenance is required.

This graph shows that Daikin has good compressor efficiency than Toshiba

Daikin Vs Samsung

DAIKIN BENEFITS – DESIGN FLEXIBILITY

DAIKIN ↓ High Combination Ratio → 50 – 200%	SM ↓ Combination Ratio → 50 – 130%														
<ul style="list-style-type: none"> Outdoor unit Cost Saving by installing less use unit to same system Power saving advantage at diversified operation 															
<p>Conditions of indoor unit connection capacity</p> <table border="1"> <tr> <td>Applicable indoor units</td> <td>Other indoor unit number</td> </tr> <tr> <td>Single indoor unit</td> <td>200%</td> </tr> <tr> <td>Double indoor units</td> <td>150%</td> </tr> <tr> <td>Triple indoor units</td> <td>100%</td> </tr> </table> <p>Connection capacity 50% - 200% 200%</p>	Applicable indoor units	Other indoor unit number	Single indoor unit	200%	Double indoor units	150%	Triple indoor units	100%	<table border="1"> <tr> <td>Applicable indoor units</td> <td>All Models</td> </tr> <tr> <td>Single indoor unit</td> <td rowspan="3">130%</td> </tr> <tr> <td>Double indoor units</td> </tr> <tr> <td>Triple indoor units</td> </tr> </table>	Applicable indoor units	All Models	Single indoor unit	130%	Double indoor units	Triple indoor units
Applicable indoor units	Other indoor unit number														
Single indoor unit	200%														
Double indoor units	150%														
Triple indoor units	100%														
Applicable indoor units	All Models														
Single indoor unit	130%														
Double indoor units															
Triple indoor units															

Daikin Vs Voltas

Voltas is a brand made from PRC (Public Republic of China) and marketed in India through TATA Pvt limited.

Voltas control system is a common Control system used for all brands manufactured under Gree manufacturing company located in china.

DAIKIN has their own plant in Neemrana at Rajasthan.

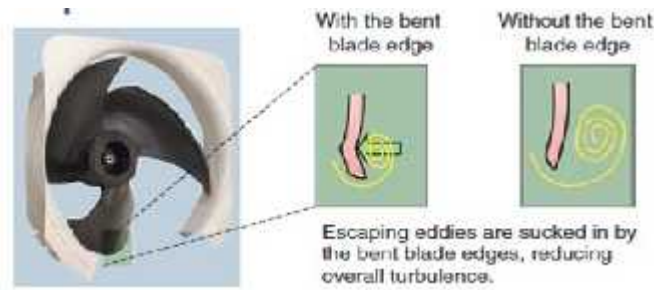
Daikin does not use any Chinese components in their system.

Problems Faced in Daikin

The blades

The fan blades of the outdoor fan are susceptible to damage from any debris that enters the cabinet, such as rocks, sticks, gravel, even tree branches. If the blades of the fan become bent, they will start to strike the edges of the fan casing, leading to an alarming clanging noise, the fan will cause more internal damage to the system if it is allowed to continue running.

Failure in blades will be due to failure in the shaft connecting fan motor and the blades. The length to diameter ratio of the shaft must exactly meet torsional as well as bending.



Broken, Bent Fan Blades

Cracked Fan Top- Severe Damage

Tree Branch Caught Between Fan Blades And Top Grille



Smashed Fan and Crushed Tubing

The Motor

Older air conditioners used fan belts to connect the fan motor to the fan, and the fan belts could break. More recent fans use direct motors. Motors can wear down from overuse, layers of dirt, or loss of lubrication in their moving parts, and this extra stress will eventually cause the motor to overheat and fuse its wiring together. A motor that burns out will need to have a professional replace it in order to get the fan operating once more.

Fmea Chart

Potential Failure Mode & Effects Analysis

Process/Product:		Dialo India Reconditioning system								FMEAD			
FMEAD Team:		Metro Use Engineering and Management Consultant											
Prepared By:		Metro Use Engineering and Management Consultant											
Row Number	Process Step or Product Function	Potential Failure Mode	Potential Effects of Failure	Severity (1-10)	Priority			Current Controls	Detection (1-10)	Risk Priority Number (RPN)	Recommended Action	Responsible and Target Completion Date	Action Taken
					Potential Cause(s) of Failure	Occurrence (1-10)	Detection (1-10)						
1	fan motor	fan blades crushing	Impover Heat Transfer	10	Bending of shaft of fan blades	5	replacement of blades	5	100	change the length / diameter etc	change the air shaft length as per possible	change the air shaft length possible	

5Y Analysis

- Why - noise is produced in ODU – due to vibration in ODU
- Why - due to vibration in ODU - failure in fan blade
- Why - failure in fan blade - failure in shaft
- Why - failure in shaft – provided Length/Diameter ratio is not perfect

Design Calculation

POWER = 2 NT/60 in KW.

T=POWER*60/2 N

Where,

N=3000 rpm

POWER=58.0208KW

T=58.0208*10³/314

T=184.78Nm

CASE (1)

L=6.5cm = 65mm = 65*10⁻³m

d= 1.5cm

r=0.75cm =7.5 mm =75*10⁻³m

F=10N

M_b=force * perpendicular distance
=10*65*10⁻³

M_b=0.650Nm

M_t=T=184.78Nm

= column Factor = [(1/1-0.0044 (1 / r)]

l/r=65*10⁻³/75*10⁻³

l/r=8.67

= [(1/1-0.0044*8.67)]

= 1.04

M = (M_b)² + (M_t)²

M = (0.650)² + (1.04*184.78²)

M = 188Nm

CASE (2)

L=6cm = 60mm = 60 *10⁻³m

d= 2 cm

r=1cm =10 mm =10*10⁻³m

F=10N

$$M_b = \text{force} * \text{perpendicular distance}$$

$$= 10 * 60 * 10^{-3}$$

$$M_b = 0.60 \text{ Nm}$$

$$M_t = T = 184.78 \text{ Nm}$$

$$= \text{column Factor} = [(1/1 - 0.0044) (1/r)]$$

$$l/r = 60 * 10^{-3} / 10 * 10^{-3}$$

$$l/r = 6$$

$$= [(1/1 - 0.0044 * 6)]$$

$$= 1.35$$

$$M = (M_b)^2 + (M_t)^2$$

$$M = (0.6)^2 + (1.35 * 184.78)^2$$

$$M = 214.69 \text{ Nm}$$

This shows that case 1 is smaller than case 2 thus we could prove that the bending movement of shaft of the fan can be reduced by using case 2, where length can be reduced and diameter of the fan's shaft is increased.

- When l/d ratio is undergoing variation the fan's shaft quality can be improved.
- To eliminate the entry of the dust particles, a honeycomb mesh is suggested to be fixed at the ODU.

Few Cases of noise were reported in 5.5 TR (FD65DSV16) & 11.0TR (FD130DSV16) from the market because of following reason

- > Wrong installation and ducting practices
- > Humming noise in the motors.

Counter Action:
 On product side we took the following actions

- > Change in motor supplier (in 5.5 TR and 11 TR)
- > Twin Shaft with single motor (same as in 8.5TR model) keeping the same Airflow (in 11 TR)

Old Combination (11 TR)



New combination (11 TR)



Implementation: 5.5 TR - Febraury'16 Sales
11 TR - December'15 Sales

Control Phase

On the brief analysis of the brands, Daikin has been shortlisted as the best brand with few problems in its system. The problems are diagnosed and the solutions to the problems are proposed in this paper which will provide an effective result. The implementation of the proposed solution enhance the quality of the Daikin system further.