



Chapter 1

Introduction

In today Heating, Ventilation, and Air-conditioning (HVAC) business, Thailand is one of the South East Asia major manufacturers that supply HVAC products to the world market. Thailand exports air conditioning more that 2 million units, which have approximate, value over 10 billion Baht in 1999. The value of the export is at the top 20 level export products of this country. Due to the advantages on lower wages, tax advantages and lower production cost, foreign investors from USA, Europe and Japan use Thailand as the major production base for the mini-split (small unitary) air conditioning systems, large unitary and Air Handling Unit (AHU) since 1980s.

Air Handling Unit (AHU) is one of the Engineering Systems products, which local manufacturing facilities can easily bring the imported designs in for local production. In 1990s, market demands in Double Skin AHU for high quality Air Handling Unit (AHU) is increased by the expansion of high-technology production facilities and the consumer's concerned of Indoor Air Quality (IAQ). Double Skin Air Handling Unit (AHU) is imported from production base in USA, Europe, Japan, Australia, and Malaysia to serve the demands. High competition and selling price-cutting in the market force the local manufacturers to locally produce AHU by using the imported design. The imported designs are not hundred percents compatible to the local customer demands and local manufacturing limitation.

This thesis study is the improvement of the existing imported AHU design to meet the Thai customer demands in high quality Double Skin AHU for using and manufacturing in Thailand.

In this chapter, the history of HVAC industries, the background of air conditioning industry, AHU market environment and the problems of current AHU design will be discussed

1.1 History of Heating Ventilation and Air Conditioning Industries in Thailand

The air-conditioning industries businesses in Thailand are started in the period of Vietnam War, introduced by American Military. By the influence of the American Industries Standards on the measurement system I-P unit, Thai air conditioning engineers are more familiar with the I-P unit, codes, standards and practices of American. The I-P unit becomes the Thailand industrial standard references of the HVAC and Air Conditioning systems since then.

Starting from 1970, the air conditioning industries is continuously expanding consecutively. Market value is increased more than ten folds when comparing the market value of 1990s to the 1970s. Thousands of air conditionings are installed in the buildings, factories, public facilities and residential facilities. Air conditioning systems become parts of Thai people life.

The great expansion of the economic in 1990s drives many air conditioning companies to invest in manufacturing facilities in Thailand for local and Southeast Asia regional market demands. Production technology and product designs of various models of air conditioning equipment are transferred to local manufacturing facilities. Supply chains of air conditioning industries in Thailand are successfully developed. The industry's improvement makes Thailand become the world air conditioning supplier.

1.2 Air Conditioning Industrial Market Segmentation, by product

In general, Air Conditioning Industries can be divided into following segments according to product type:

1.2.1 Unitary Product

Unitary product or sometime refereed as "mini-split" is the most well known air conditioning equipment to the market. It ranges from the consumer product mini-splits to the medium range (50 ton) of the cooling/heating capacity. The unitary product defined by its system construction characteristics, where the completed air conditioning system is supplied in single packaged. The air conditioning set is fully equipped with the matched condensing unit, fan-coil unit, control, and monitoring equipment. The packaged system have limited variations in components, customers only choose the available cooling/heating capacity provided by the manufacturers.

1.2.2 Engineering Systems Products

Totally different from the unitary products, the engineering systems products are very flexible in designing and varying the functions, applications, and capacities. The air conditioning in the engineering systems products can be customized to condition the air for each specific customer's requirement. Specific air conditions such as temperature, humidity, air cleanliness and etc can be achieved by the integration of various engineering systems equipment together. Due to its flexibility, the engineering system products are not come in packages, instead the HVAC engineer need to individually select the equipment to serve each specific function and integrate together to meet the systems requirements.

Generally, the engineering system product can be divided into three major groups according to equipment function as, "Water-Side", "Air-Side" and

"Control & Monitoring". Since the whole air conditioning systems are comprising of various of components, the air conditioning suppliers are mostly focus on the products that they are expert with in each groups of equipment.

For example, the "Water-Side" general equipment are, Water Chillers, Pumps, Piping, Cooling Tower, Water Treatment systems and etc. The air conditioning suppliers will be supply only the water chillers, to complete the systems the contractors need to purchase other equipment that match to systems requirement from other suppliers for installation.

The common engineering system products that air conditioning suppliers supply to the market are:

✓ *"Water-Side" Water Chillers Products*

For Thailand application where the heating is not a requirement, the water chiller is used to chill the water that supplied into the systems. Chilled water is pumped through the piping networks to the Air Handling Unit (AHU) or other equipment. The heat exchanged between the chilled water and the AHU and other equipment increased the chilled water temperature to a certain degree. The water is circulated back to chillers to complete the cycle.

The circulated chilled water that running back to water chiller is exchanging the heat with the refrigerant. The water temperature is lowered before released back to the piping network. The water is circulated to the AHU and equipment for new cycle. The rate of heat exchanged depends on the chilled water flow rate, time of heat exchanging and design of the exchanged temperature/energy. After the water exchange the heat with the refrigerant at the chiller, the refrigerant is warmer and need to be cooled down in the refrigerant cycle.

Refrigerant in the chiller need to be cooled down, two major cooling methods are air-cooled and water-cooled. Air-cooled chillers use the fan to draft the air through the heat exchanger, commonly coil-fin type, to cool down the refrigerant. The water-cooled chillers use another water circuit and the cooling tower to cool down the refrigerant.

✓ *"Air Side" Air Handling Unit Products*

AHU is the key components that treat the air to the set requirement in the systems. Air in the controlled environment is drawn through the AHU by the fan and conditioned by the stages of AHU components. Dirt is removed from the air by means of filters. Heat is rejected out or introduced in to the controlled environments by the heat exchangers. Humid can be introduced or rejected to the specific level by usage of humidifiers and de-humidifiers. Each specific customer demands on air condition can be achieved by the proper selected

The air handling unit construction is simple. The equipment is enclosed with the airtight sheet metal box with openings for water supply and return connection, air inlet and air outlet. The box is insulated to achieve the closed environment for thermal controlled and heat transfer between internal and external. Equipment and components is typically internally installed in series. The AHU can be classified according to the unit wall construction as single skin and double skin AHU.

✓ ***Single Skin Air Handling Unit***

The single skin AHU constructed by the simple sheet metal box that internally insulated with insulation material. Typically fiberglass insulation with the surface treated or covered with the aluminum foil to protect the fiber loosen. The fiberglass is adhered to the internal surface of the sheet metal box by means of adhesive and anchors. Alternated materials for insulation are foam, synthetic rubber and mineral wool. The single skin air handling is the most common for the market. It is very easy to manufacture and has low manufacturing cost. The single skin AHU is used in the air conditioning systems for more than 50 years.

The major problems of the single skin AHU are the control of indoor air quality (IAQ) and dust particle control. In operation, humidity that penetrated into the porosity of the insulation material, dust accumulated on the insulation surfaces and the germ that grown in the insulation material introduced the poor air quality to the systems. The poor air quality is the major root cause of the "Sick Building Syndrome" symptom that cause the dizziness, flu and nauseous to the people who living in the building. On the other hand, the loosen fiber and insulation particles into the air stream cause the dust particle problems in many high technology industries that required the extreme air cleanliness level in clean rooms.

In correcting the present problems of the single skin AHU the double skin AHU is developed to serve the higher level of customer demands.

✓ ***Double Skin Air Handling Unit***

The development of the double skin AHU is to increase the clean feature of the AHU. In single skin AHU the construction and installation of the insulation material to the unit wall limits the air cleanliness level. Major improvements are made on the wall construction. The insulation is inserted in between two sheet metals, internal and external surface, in the sandwich like structure. The sandwich panels allow the AHU to be internally clean, no insulation contact with the air stream and still thermal insulated the AHU. The benefits of the sandwich panel are: the ability to control the continuous thickness of the insulation, protect the insulation of wearing off, clean internal structure, vary the thickness of the insulation to meet specific thermal insulation requirement and increasing the flexibility of varying the insulation material.

The key success of the double skin AHU design is the minimum thermal bridge or zero thermal bridge that conduct the heat through the sandwich panel wall.

✓ *Control and Monitoring Systems*

In order to operate the multi-equipment systems of HVAC harmonically, control equipment is very important part. The chillers, Air Handling Unit (AHU) pumps, etc will be monitored, controlled to reach the specified condition. The advancement of the computer, computer communication protocol and the high speed data transfer advanced the control and monitoring systems to the automation systems that allow the owner, operator run the systems unattended and optimized.

1.2.3 *Services*

Apart from the product supply the technical support or the service business is one of the key profits making business in the HVAC industries especially for the Engineering Systems products.

The air conditioning systems are not the easily maintain especially the engineering systems that need to synchronize multiple equipment together. Each component needs specific technical knowledge to maintain the systems. Because of the systems complications and the requirements of specific tools, customers cannot easily service the air conditioning equipment by themselves; thus, the market is open for the supplier to service their own products.

1.3 Air Handling Unit Market Segmentation: By Industries' Requirement

In this thesis study, we will focus on the Air Handling Unit (AHU) equipment design development, excluding the smaller unit which refereed as the fan-coil unit. The market background of each market segment will generate the idea of the AHU application requirements.

1.3.1 *Residential Market*

Only small volume of Air Handling Unit (AHU) used in the residential application. Only found in the large resident, where the HVAC systems are designed to be the central systems. In Thailand, the residential market is the market of the small unitary products. The norm of Thai is different from American where the central furnaces/HVAC equipment is installed. There are no specific requirement and the standard of IAQ requirement in the residential segment.

1.3.2 *Commercial, Office Building & Public Building*

Largest Air Handling Unit (AHU) revenue is in this market segment. Most of the Commercial, Office, and Public Building are using the central cooling systems that supply chilled water to the AHU. In common, Air Handling Unit (AHU)

is installed with the chilled water system. Air Handling Unit (AHU) is selected by the system designers to meet the cooling load requirements. The necessary air condition components are added to the Air Handling Unit (AHU) such as, filters, dehumidifier, heat recovery to improve the Air Handling Unit (AHU) performance. In design the HVAC systems, international standards are regulated the design such as ASHRAE¹ 62-89², ASHRAE 52.1-92³. Usually this market segment use the single skin AHU in the HVAC systems, but increasing the IAQ concerned, the double skin AHU is increasing its share. More designers specify double skin AHU with better filtration equipment for office buildings and public buildings.

1.3.3 Hospital & Health Care Industries

Clean and hygienic environment is the basic requirement of facility. The Air Handling Unit (AHU) is used to provide the cleaned air to the hospital facilities. AHU construction must not collecting and growing the germs. The proper selection of Air Handling Unit (AHU) to meet the specific demand of each room requirement is necessary. AHU also plays major roles in recovering and treating the patient. For example, the room for recover the burning skin patient must be very clean, the air cleanliness level should less than 10,000 particle per cu. ft. and the temperature is around 80 Degree Fahrenheit while the operation room need same particle requirement but the temperature is at 70 Degree Fahrenheit.

Variety of Air Handling Unit (AHU) configurations are used in the hospital, ranges from cool air delivery to hot air deliver, the humidity operation ranges from 30 to 95 %RH, depends on each room requirement.

1.3.4 General Industries

Today factories are equipped with air conditioning for control the manufacturing environment. In the general industries, the cooling and dehumidifying is one area that Air Handling Unit (AHU) is used. The better air quality is increasing the performance of the staffs, help cooling the machine and ventilating the pollution.

¹ American Society of Heating Ventilation and Air Conditioning Engineers

² ASHRAE. 1989. Ventilation for acceptable indoor air quality. ANSI/ASHRAE standard 62-1989

³ ASHRAE 1992. Gravimetric and dust-spot procedures for testing air cleaning devices used in general ventilation for removing particulate matter. ANSI/ASHRAE Standard 52.1-1992

1.3.5 High Technology Industries

The high technology industries are the group of the industries that the operation environment needs to be strictly controlled. Those industries are:

- ✓ Electronics Parts Production
- ✓ Semiconductor Industries
- ✓ Aerospace Industries
- ✓ Film & Printing
- ✓ Pharmaceutical

Most of the case the high-technology industries require the minimum fluctuation in air volume, temperature, and humidity in controlled environment. In each industry, there is different amount of air circulation rates and air cleanliness levels requirements. Air Handling Unit (AHU) is playing a major role to deliver and control room environment.

The Air Handling Unit (AHU) that selected for this application must very reliable, since the controlled air environment is necessary to the production process and cannot be failed. The failures in the control air environment will effect the machines; product outputs and will cost the facility owner a large amount of money. In common, the Air Handling Units (AHU) in high technology industry facilities are running 24-hours minimum shutdown over each annum. Not only the reliability of the systems are the major requirement but also a long mean time to maintenance.

1.3.6 Textile Industries

Special designed Air Handling Unit (AHU) is used in the textile industries because of high humidity requirement of operation environment. The cooling coil is not commonly used. AHU is designed to control the humidity and air temperature by using the air washer. The dust particle that generated in the textile operation is large, heavy and can easily clogged the duct and air ventilation systems, special design filters that aim to remove the lint from the air stream is used instead of general HVAC air filters.

1.3.7 Food Processing Industries

To ensure the food processing environment is cleaned and hygienic, the food processing facility required the very specific AHU to fit into the systems. Most of the AHU for food processing application will have the stainless steel parts and equipment so the rusting is almost impossible. The internal of AHU must be cleanable and germ free. Material that contact to air stream or within the operation area should toxic free. There are variety requirements of Air Handling Unit (AHU) for food industries, depended on the type of food that produced in the facility.

1.3.8 Petroleum & Chemical

The Petroleum and Chemical Industries also have strict requirements in Air Handling Unit (AHU) configuration. In some process, Air Handling Unit (AHU) needs to work in high corrosive environment, so AHU parts and components need to be able to withstand the corrosion. The requirements are varied from facility to facility depended on the Air Handling Unit (AHU) operating environment. Most of Air Handling Units (AHU) that supplied to this segment are made to order.

1.4 Major Brand of Air Handling Unit in Thailand Market

The competition for the market share in the Air Handling Unit (AHU) segment is getting tougher. After the economic crisis of ASIA in 1997, market environment is changed from the supplier's market to customer's market. The Air Handling Unit (AHU) suppliers need to improve the current product to meet the customer demands. Each Air Handling Unit (AHU) manufacturers are working to improve their competition edges with various approaches e.g. cost reduction, quality enhancement etc. Following are the list of major Air Handling Unit (AHU) manufacturers/suppliers in Thailand

1.4.1 CARRIER

The world oldest brand of HVAC systems, Carrier is the Thailand market leader in the Air Handling Unit (AHU) due to its low cost approaches. Air Handling Unit (AHU) is manufactured in Thailand by subcontracting company. The local design center is established. Some design improvements are made to suit the local demand and cost reduction.

1.4.2 DAIKIN

Daikin is the only major Japanese Brand Air Handling Unit (AHU) that produced in Thailand. The local factory output is focus to serve Thai market only. The Air Handling Unit (AHU) is tailored design to meet the exact customer demands by the design center in Bangkok Head Quarter. The quality of the manufactured Air Handling Unit (AHU) is very good. The selling price is in the most expensive range compare with local production Air Handling Units (AHU). The market of Daikin Air Handling Unit (AHU) is in the high technology factory market, where customers looking for the high quality, durable, reliable Air Handling Unit (AHU).

1.4.3 ROBATHERM

The only brand that fully imported from German, Robatherm is the best AHU available in the market due to the superb workmanship, modular design, and the quality of material and parts. The fully imported products make Robatherm the most expensive AHU. The high quality parts and equipment that installed in Air

Handling Unit (AHU) is the competitive edges of this brand. German made images increased the customer's perceptions in reliability, durable, and good designs of AHU.

1.4.4 TRANE

Trane's AHU is locally made by own production facility. The product quality and images is ranked at the same level of Carrier and York. Trane have local design center and product development division. There are versions of design improvement that the original American design is adjusted to meet the local demand.

1.4.5 UniAir

The only original local brand, UniAir focus on the medium-low market segment of the Air Handling Unit (AHU) where cost is the most important factor. The AHU quality is fair. UniAir factory is also sub-contractor for other brand AHU.

1.4.6 YORK

One of the big three (Carrier, Trane and York) American brand in Thailand. They used own manufacturing facilities and some local sub contractors to produce air Handling Unit (AHU) to serve Thailand and neighbor country. The product quality is the same level of Carrier and Trane. Range of Air Handling Unit (AHU) is from the low end to the high end, modular structure, and clean room grade. Some high-end model is imported from international production base. Local product design center is not yet established, the AHU produced in base on the international design.

1.5 AHU Market Environment

In the recent study of the reference company⁴ the market size of chilled water coil AHU is at 494 million Baht in 1999, growth from 1998 about 3%. From the study of the Air Handling Unit (AHU) market size in value and volume from 1995 to 1999, the gathered data are displayed in table 1.1 and 1.2. The AHU market value and volume are shown for both single skin AHU and double skin AHU in both tables. The market size is based on the estimated AHU systems sold by the major AHU brand that listed in previous section.

⁴ "Reference company" term is used in this thesis to eliminate the bias and conflict of interest, the reference company providing sponsorship and confidential marketing data to researcher for references.

Air Handling Unit Market Value (By Million Baht)

Year	Single Skin Air Handling Unit Market	Double Skin Air Handling Unit Market	Total Market
1995	523	162	685
1996	600	202	802
1997	1,033	233	1,266
1998	302	176	478
1999	303	191	494

Unit Million Baht

Table 1.1: Air Handling Unit (AHU) market size by market value from 1995-1999

Table 1.1 illustrates the market value of the "Chilled Water Coil Air Handling Unit (AHU)" from year 1995 to 1999. The five years history records shows that the total market of Air Handling Unit (AHU) is sharply dropped from over one billion Bath in 1997 to approximate five hundred million Bath in 1998 due to economic crisis. The market value is starting to increase in the 1999 by the increment of the Air Handling Unit (AHU) market in double skin segments.

Air Handling Unit Market Size (By Volume)

Year	Single Skin Air Handling Unit Market Qty.	Double Skin Air Handling Unit Market Qty	Total Market
1995	4,350.00	1,400.00	5,750.00
1996	4,950.00	1,620.00	6,570.00
1997	8,490.00	1,840.00	10,330.00
1998	2,420.00	1,410.00	3,830.00
1999	2,180.00	1,400.00	3,580.00

Unit: System(s)

Source: Reference Company

Table 1.2: The market size of Air Handling Unit (AHU) market in Thailand 1995-1999

The table 1.2 illustrated the changing of the units sold of the Air Handling Unit (AHU) during 1995 to 1999. The five years record show that the economic crisis in 1997 effects the single skin Air Handling Unit (AHU) segment, due to the stoppage of real estate project in country. The total market volume is deeply dropped by 70%. In contrast, volume of the double skin AHU is not effected much from the economic crisis,

From the table 1.1, graphically presentation of the market share between two segments of Air Handling Unit (AHU) by the quantity of unit sold is displayed in Figure 1.1 as follow:

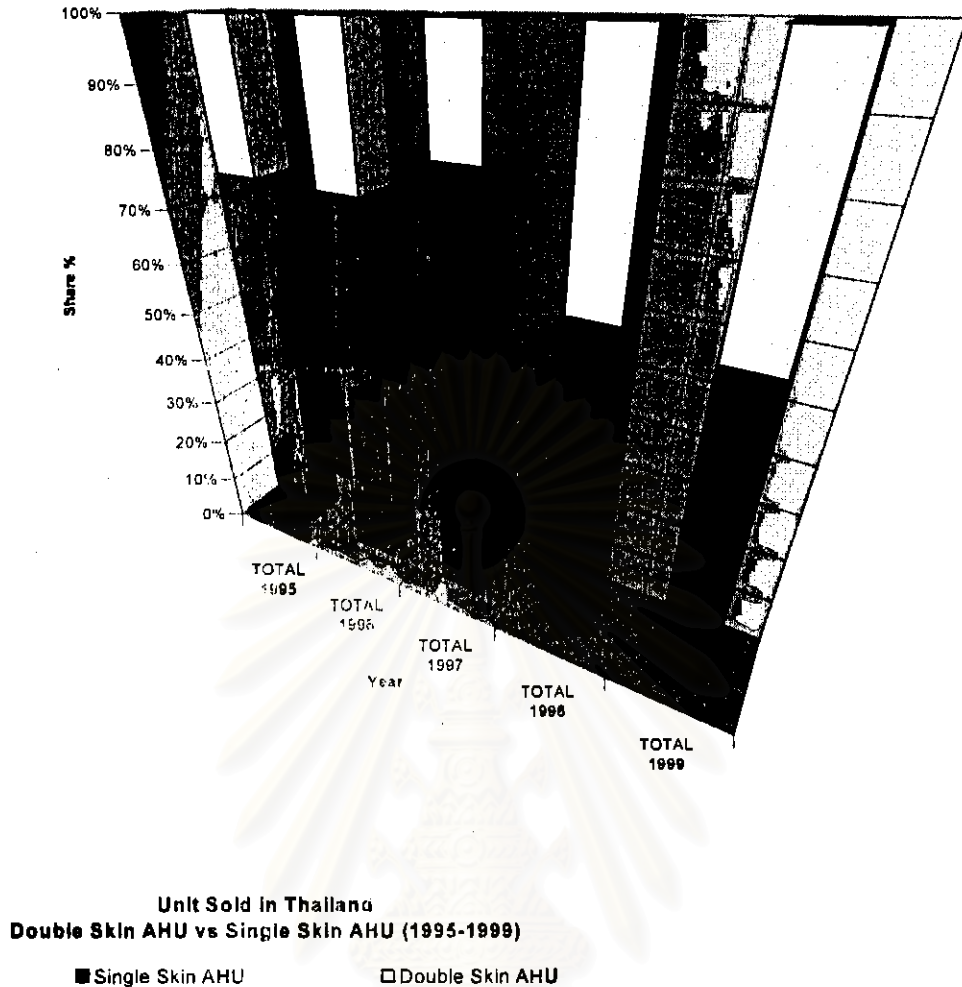


Figure 1.1: The percentage market share between single skin AHU and double skin AHU from 1995 to 1999

Figure 1.1 illustrates the ratio between two types of AHU, the single skin, and double skin. The dark shaded area represents the percentage share of the single skin, while the light shaded area represents the double skin. The percentages share is based on the total AHU market value on each year from 1995 to 1999.

From the graph and tables, we found two interesting issues:

- 1) The data in table 1.2 show that the volume of the double skin Air Handling Unit (AHU) is not fluctuated by economic crisis, which can reflected the real sector of AHU business.

- 2) The trend of the usage of double skin Air Handling Unit (AHU) is increasing. By looking from increased in ratio between single skin and double skin.

1.6 Problems of Existing AHU Design in Thailand

Since the design of Air Handling Unit (AHU) that used for manufactured in Thailand are all imported from design center abroad, USA, Europe and Japan, some parts of design are not appropriate with the local demands and local manufacturing limits. The major problems of current AHU designs that found in Thailand application are:

- 1) *Thermal Transmission Bridge (Thermal Bridge):* The thermal bridge problems cause the thermal transmission from inside of AHU to outside structure. The cold that transferred from inside to outside will cause the condensation at the external structure. Water drops are forming. In some operating environment, the condensation rate is high enough to wet the entire ceiling or machine room floor. The condensation is mostly found at floor, posts, and corners of the Air Handling Unit (AHU).
- 2) *High Precision requirement of some major parts:* The design of Air Handling Unit (AHU) that imported required high precision parts, such as the structures and double skin panels. In practice, those precision requirement parts are manufactured with the high degree of variation. The varied part dimensions cause the AHU structure to be distorted when assembly and effect the whole assembly processes.
- 3) *Other minor problems:* Access Door thermal bridges and air leakage. Fan performance and vibrations, workmanship quality etc.