# PROSIDING SEMINAR NASIONAL TEKNIK MESIN VI

"Penemuan dan Inovasi Teknik Mesin dalam Pengembangan Industri Nasional".
Surabaya, 16 Juni 2011



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**SAMBUTAN KETUA JURUSAN**
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ASEAN *China Free Trade Agreement* (AC-FTA) yang sudah diberlakukan sejak 1 Januari 2010 merupakan suatu opsi kerjasama di bidang ekonomi yang memberikan peluang sekaligus ancaman. Langkah yang harus diambil pemerintah dan berbagai kalangan baik perguruan tinggi maupun dunia industri adalah bagaimana mengelola peluang itu dengan sebaik-baiknya.

Dalam rangka meningkatkan daya saing bangsa untuk menghadapi AFTA serta AC-FTA tersebut, kolaborasi antara perguruan tinggi/lembaga penelitian dan pelaku bisnis (industri) harus dapat terjalin dengan baik dan saling mendukung satu dengan lainnya. Selama 5 tahun berturut-turut, Seminar Nasional Teknik Mesin (SNTM) telah diselenggarakan dengan baik untuk meningkatkan sinergi antara perguruan tinggi, lembaga peneliti dan industri dalam bidang riset dan pengembangan.

Di tahun 2011 ini, SNTM VI diselenggarakan sebagai salah satu acara dari rangkaian kegiatan *"Petra Golden Jubilee"* yaitu perayaan Dies Natalis ke-50 Universitas Kristen Petra. Dengan semangat yang baru di ulang tahun emas Universitas Kristen Petra, maka SNTM semakin berupaya untuk mewujudkan kualitas penelitian yang unggul dalam bidang Teknik Mesin dan Otomotif. Kegiatan ini diharapkan dapat memberikan kontribusi positif terhadap pengembangan industri nasional. Dengan demikian maka tantangan perdagangan bebas dapat dijawab melalui kemampuan bangsa dalam menciptakan produk-produk penelitian dan rekayasa yang mampu menyaingi atau bahkan melebihi kualitas produk-produk luar.

Akhir kata, semoga pelaksanaan Seminar Nasional Teknik Mesin VI ini dapat meningkatkan kolaborasi antara perguruan tinggi/lembaga penelitian dan industri dalam rangka meningkatkan daya saing bangsa menghadapi era global. Terimakasih atas partisipasi dari para peneliti baik dari perguruan tinggi/lembaga penelitian dan industri dalam seminar nasional ini.

Selamat berseminar, Tuhan memberkati.

Surabaya, 16 Juni 2011
Ketua Jurusan

Fandi D. Suprianto, ST., MSc

**SAMBUTAN KETUA PANITIA**
**SEMINAR NASIONAL TEKNIK MESIN VI**
**JURUSAN TEKNIK MESIN**
**UNIVERSITAS KRISTEN PETRA**

Puji dan syukur kami panjatkan kepada Tuhan, karena hanya dengan berkat dan pimpinanNya, maka Seminar Nasional Teknik Mesin VI dapat berjalan dengan baik. Seminar Nasional Teknik Mesin VI ini merupakan agenda tahunan yang dilakukan oleh Program Strudi Teknik Mesin Universitas Kristen Petra. Hingga tahun ke-6 seminar ini tetap diadakan karena pada setiap tahun penyelenggaraannya, selalu diikuti oleh banyak peserta. Hal ini menunjukkan bahwa forum diskusi antar peneliti, akademisi dan profesional ini sangat diperlukan.

Tema seminar nasional yang diangkat kali ini adalah "Penemuan dan Inovasi Teknik Mesin dalam Pengembangan Industri Nasional". Dengan tema ini diharapkan Seminar Nasional Teknik Mesin VI mampu menjadi forum diskusi yang menjembatani kerja sama antara peneliti, akademisi dan praktisi sehingga hasil-hasil penelitian yang dilakukan dapat sejalan dengan kebutuhan pengembangan industri nasional.

Undangan untuk Seminar Nasional Teknik Mesin VI ini dilamar oleh lebih dari 65 pemakalah, yang sebagian besar masih didominasi oleh akademisi, baik dari perguruan tinggi negeri maupun suasta, yang berasal lebih dari 7 provinsi di Indonesia. Dari 65 makalah tersebut, 48 diantaranya direkomendasikan oleh *reviewer* untuk dipresentasikan. Pada tahun mendatang, kiranya seminar nasional ini dapat diikuti oleh kalangan yang lebih luas sehingga hal ini juga dapat menjadi forum untuk membangun dan meningkatkan kerjasama antara peneliti dan praktisi di industri, serta menambah wawasan baru bagi para peserta.

Akhir kata kami ingin menyampaikan terima kasih yang sebesar-besarnya kepada para *reviewer*, pemakalah, dan semua panitia yang telah berkontribusi, berpartisipasi dan memberikan dukungan sehingga Seminar Nasional Teknik Mesin VI ini dapat berjalan dengan baik dan lancar.

Selamat berseminar.

Surabaya, 16 Juni 2011
Ketua Panitia

Ir. Joni Dewanto, MS

# KATA PENGANTAR

Kerjasama antara perguruan tinggi dan industri dalam bidang penelitian merupakan suatu strategi yang perlu dibangun dan dilestarikan dalam rangka mendorong terciptanya inovasi produk dalam negeri untuk meningkatkan kemampuan industri nasional. Dengan demikian, peran para peneliti dan praktisi yang serasi melalui pertukaran informasi perkembangan penelitian nasional menjadi suatu kebutuhan yang tidak dapat dihindari yang selaras dengan upaya peningkatan daya saing bangsa. Pada kesempatan ini, Jurusan Teknik Mesin Universitas Kristen Petra untuk yang keenam kalinya kembali mengadakan even tahunan melalui Seminar Nasional Teknik Mesin VI sebagai media untuk tujuan tersebut.

Seminar Nasional Teknik Mesin VI ini mengambil tema "Penemuan dan Inovasi Teknik Mesin dalam Pengembangan Industri Nasional". Sebuah tema dengan jangkauan bidang keilmuan yang meliputi: Disain Produk, Energi Terbarukan, Konversi Energi, Material Teknik dalam Permesinan, Mesin dan Peralatan Industri, Metrologi Industri, Otomasi dan Robotika Industri, Proses dan Sistem Manufaktur, dan Rekayasa Otomotif. Melalui proses seleksi, sejumlah 48 (empat puluh delapan) *e* direkomendasikan oleh *reviewer* untuk dilanjutkan sebagai *full paper*. Sebanyak 3 (tiga) *full paper* tidak dikirimkan sehingga prosiding ini hanya memuat 45 (empat puluh lima) makalah terpilih karya para peneliti dari perguruan tinggi, dari lembaga penelitian universitas, dan dari lembaga penelitian pemerintahan. Seluruh naskah terpilih tersebut dipetakan ke dalam Bidang Studi Disain, Bidang Studi Konversi Energi, dan Bidang Studi Manufaktur.

Melalui presentasi seluruh makalah terpilih tersebut, diharapkan media tahunan ini dapat dimanfaatkan oleh para peserta seminar untuk berpartisipasi aktif dalam diskusi ilmiah hasil-hasil penelitian dan pengalaman praktis di lapangan. Kiranya segenap upaya yang telah dilakukan ini berguna bagi pengembangan penelitian dan penguasaan ilmu dan teknologi dalam bidang terkait di Indonesia dan bermanfaat bagi peningkatan kemampuan industri nasional dalam menghadapi era pasar global.

Selamat membaca.

Surabaya, 16 Juni 2011
Tim Editor

**DAFTAR ISI**

# PERFORMANCE TEST ON VAC SYSTEM OF UPS BUILDING

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*Abstract*

***This paper explains performance test on a VAC system of an UPS building. The UPS building under consider has size 8m x 2.4m x 2.7m and consists of two rooms that are UPS room with area 5.76 $m^2$ and Battery room with area 13.44 $m^2$. Air within both the UPS and Battery room shall be conditioned to maintain the temperature and pressure of air inside at 22 $^oC$ and 15 Pa, approximately. The existing VAC system consists of duct split type with cooling capacity 5.3 kW (18.000 Btu/h) and air flow rate 900 CMH. During running test, pressure of the UPS room around 2 Pa and the recorded temperature of UPS and Battery room is 23 and 33 $^oC$ at the day time, respectively; it means both the room temperature and its pressure are not meet to the specification and indicates that the performance of the VAC system is not so good condition. Therefore, both the performance test shall be carried out and the cooling load needs to be reviewed or recalculated. The Performance test and the recalculated cooling load have been done; it shows that the cooling load of the UPS building is 7 kW (24.000 Btu/h) and the air flow required is 1100 CMH (650 cfm). Moreover, the temperature digital located on the wall is not represented the room temperature. The difference temperature between thermometer digital located on the wall and sling psychrometer used to measure the room temperature is 2 – 5 $^oC$. Also, the air flow from the UPS room to the battery room is inadequate due to low pressure flow in between. To meet the specification required; it is recommended to upgrade both the cooling load capacity and air flow of the AC unit, and to provide a fan or blower to boost the air flow from the UPS room to the Battery room.***

*Keywords :Battery room, UPS room, Air Conditioning*

## 7. INTRODUCTION

This paper explains performance test on a VAC system of an UPS building. Figure 1 below illustrates schematically the VAC system of UPS building. The UPS building under consider has size 8m x 2.4m x 2.7m and consists of two rooms that are UPS room with area 5.76 $m^2$ and Battery room with area 13.44 $m^2$. Air within both the UPS and Battery room shall be conditioned to maintain the temperature and pressure of air inside at 22 $^oC$ and 15 Pa, approximately. The existing VAC system consists of duct split type with cooling capacity 5.3 kW (18.000 Btu/h) and air flow rate 900 CMH. During running test, pressure of the UPS room around 2 Pa and the recorded temperature of UPS and Battery room is 23 and 33 $^oC$ at the day time, respectively; it means both the room temperature and its pressure are not meet to the specification and indicates that the performance of the VAC system is not so good condition. Therefore, both the performance test shall be carried out and the cooling load needs to be reviewed or recalculated

## . METHODOLOGY

The review and recalculate of the cooling load, and also the performance test have been done to improve the performance of VAC system with the methodology as following:

A. To review and recalculate the cooling load:
   a. To review design condition such as temperature and relative humidity of ambient, indoor requirement and properties of the UPS building, and also procedure of cooling calculation.
   b. To recalculate the cooling load based on the update information for the ambient condition.

B. To carry out the performance test by measuring the following parameters:
   a. Ambient condition such as temperature and relative humidity.
   b. Temperature, relative humidity and pressure inside the UPS building.

c. Both temperature and air flow discharged by the supply air diffuser.

The location of measurement is shown on figure 2 below, schematically. It consists of three locations at the out side of UPS Building (1, 2, and 3), two locations in the UPS room (4 and 9) and four locations in the battery room (5, 6, 7, and 8).

The measurement of TWB and TDB has been done for all points of measurement from point 1 until point 9, while for the measurement of air flow velocity; it has been carried out on point 8 and 9. Moreover, the pressure difference between the UPS and battery room is measured by a differential pressure indicator.

The instrumentations that are used to measure the performance parameters of the VAC system are listed below:

- Sling psychrometer
- Anemometer
- Differential pressure indicator
- Pocket thermometer
- Micro pressure gauge

The measurement has been done every 30 minutes, approximately and it had taken during two days.

## 9. RESULT AND DISCUSSION

***RESULT***

The detail measurement records are shown in the appendix and the summary is shown in Figure 3 below.

During two days measurement, it is obtained that the minimum temperature in the battery room and the UPS room is 27 Celsius and 17 Celsius, respectively. The maximum temperature in the battery and the UPS room is 31 Celsius and 23 Celsius. It should be noted that the battery room temperature is still greater than the requirement

***DISCUSSION***

a. Figure 4 and 5 below show the trend of ambient temperature and relative humidity of air with respect to time. The ambient temperature increases gradually with time and the maximum temperature is achieved at a range peak time for about 13.30 – 15.30 pm. It has been recorded during two days measurement that the maximum temperature for ambient is 37 C when the day clear at the peak time. Otherwise, the relative humidity is decrease gradually with time during two days measurement.

b. With two AC units are running, the temperature of UPS and battery room is 17 C and 31 C, respectively at the peak time. While for only one AC unit is running, the temperature UPS battery room is 22 C and 29 C, respectively at the peak time.

c. During measurement, the relative humidity of ambient varies from 38 % until 89 %, while for the UPS room is below 60 % and for battery room is below 50%.

d. Differential pressure between UPS and battery room is only 2 Pa. The pressure of battery room is almost equal with the ambient pressure.

e. Total air flow discharges the SAD is 900 CMH thus, one AC unit can supply air to the UPS building with 16 ACH.

f. Based on the critical ambient condition, where TDB = 37 C and RH = 46.5%; and indoor condition at 22 C and RH 50%, the cooling load of the UPS building is 7.0 kW (24.000 Btu/h) and flow rate required is 1100 CMH (650 cfm).

g. The maximum and minimum temperature recorded in the battery room is 31 C and 28 C, respectively. This value is too high for the air conditioned room and need to improve to get the temperature around 22 C.

h. The air flow resistance gives a large contribute for cooling process in the battery room so the cooled air flow is not enough to absorb heat generated inside the battery room. Therefore the temperature of battery room is still high enough. Also blade angle louvers pointing downward instead of upward.

i. Less air flow flowing into the battery room is also caused by circulation of air in the UPS room. The air flowing into the battery room is less because some air will flow back to the FCU through the RAG.

## 10. CONCLUSION AND RECOMMENDATIONS

***CONCLUSION***

For two days measurement, it can be summarized as follows:

a. The maximum temperature of ambient condition is 37 C.
b. The maximum and minimum temperature in the UPS room is 20 C and 17 C.
c. The maximum and minimum temperature in the battery room is 31 C and 26 C.
d. The differential pressure between the UPS and battery room is 2 Pa.
e. The maximum air flow discharges diffuser is 0.25 cms (900 CMH, estimation)
f. The maximum air flow discharges louver is 0.20 cms (715 CMH, estimation)
g. The temperature difference between Tb and the digital thermometer on the wall in the battery room is 1 - 2 Celsius.
h. The temperature difference between Tu and the digital thermometer on the wall in the UPS room is 3 - 5 Celsius.

***RECOMMENDATION***

To improve the performance of VAC system of the UPS building, some actions below shall be done:

*Alternative I*

a. To provide a new adjustable blower equipped by VSD for boosting the cooled air from the UPS room to the battery room so that the battery room meets adequate supply of cold air from the UPS room to cool or absorb the heat generated in the room.
b. To run the two AC units in day time and only one AC unit in the night time is running.
c. To provide a controller (smart relay) that manages the sequence operation of two AC units so the cooling load can be handle by two AC units. The controller will manage the sequence of ac units as follows: one ac unit will run for 24 hours while other units will run for 12 hours (06:00 – 18.00) during the day in turn.
d. To relocate the temperature sensor from return side to battery room.
e. To modify the angle of louver blade. It shall be pointed upward instead of downward.
f. To provide a fan in the UPS room to boost the cooled air from the UPS room to the battery room.

*Alternative II*

a. To upgrade the AC unit in both the cooling capacity and the external static pressure. To achieve 22 C and 15 Pa inside the UPS building, it requires the AC unit with the minimum cooling capacity 7 kW, 1100 CMH in flow rate and 200 Pa in ESP.
b. To relocate the temperature sensor from return side to battery room.
c. To modify the angle of louver blade. It shall be pointed upward instead of downward.
d. To provide a fan in the UPS room to boost the cooled air from the UPS room to the battery room.

## 11. NOTATION

AC : Air Conditioning
ACH : Air Change per Hour
CMH : Cubic Meter per Hour
CU : Condensing Unit
ESP : External Static Pressure
FCU : Fan Cooling Unit
SAD : Supply Air Diffuser
RAG : Return Air Grille
RH : Relative Humidity
TDB : Dry Bulb Temperature
TWB : Wet Bulb Temperature
UPS : Unintterubtible Power Supply
VAC : Ventilation, Air Conditioning
VSD : Variable Speed Driver

## 12. REFFERENCES

[1] ASHRAE 1999 Application Handbook, Chapter 3, Commercial and Public Building.

[2] ASHRAE 1999 Application Handbook, Chapter 11, Industrial Air Conditioning.

[3] ASHRAE 1999 Application Handbook, Chapter 28, Ventilation of the Industrial Environment.

[4] Battery room guideline by EXIDE Technologies.

[5] National Fire Protection Association, NFPA 76, Fire Protection for telecommunication facilities.

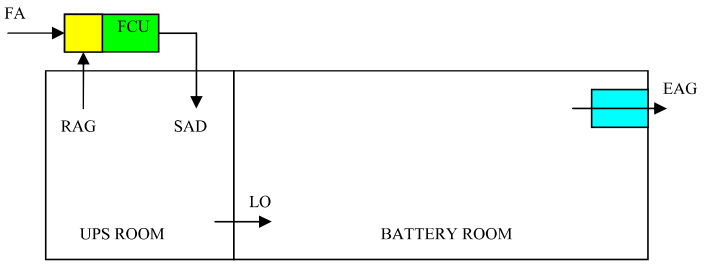

Figure 1 VAC system of UPS Building

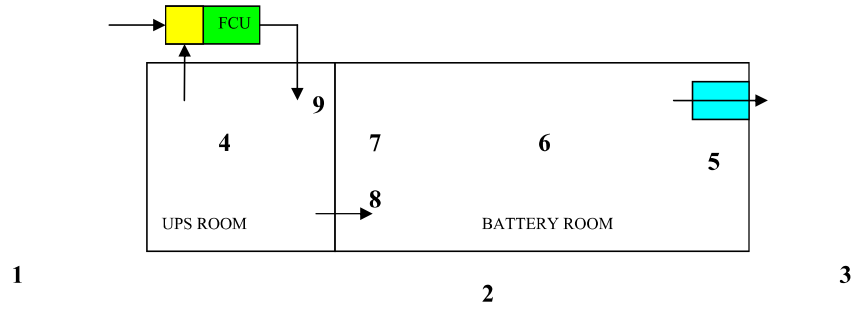


Figure 2 Measurement locations

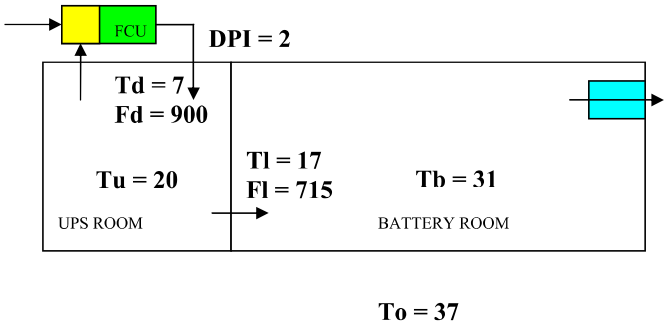


Figure 3a Measurement result: day clear, 2 AC units running.

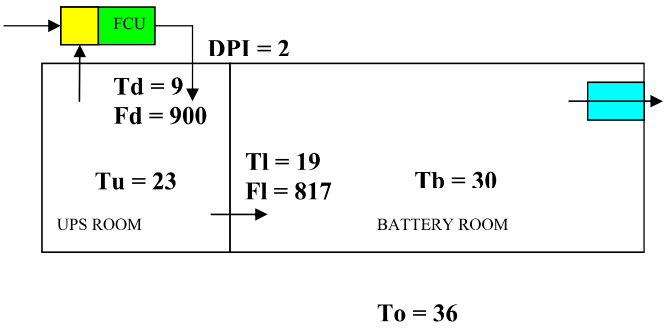


Figure 3b Measurement result: day fog, 1 AC unit running.

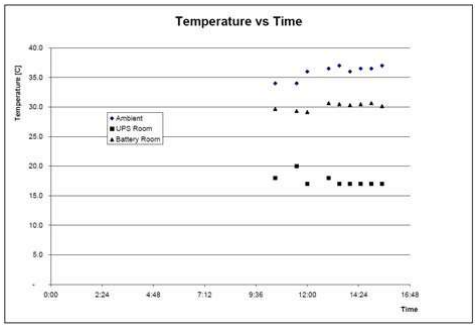


Figure 4a Temperature vs time t
Day clear, 2 AC units running

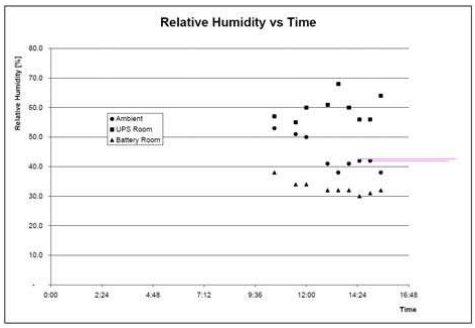


Figure 5a Relative humidity vs time t
Day clear, 2 AC units running

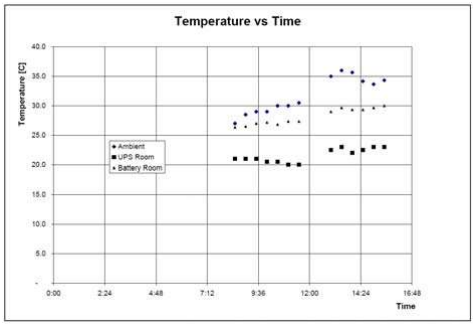


Figure 4b Temperature vs time t
Day fog, 1 AC units running

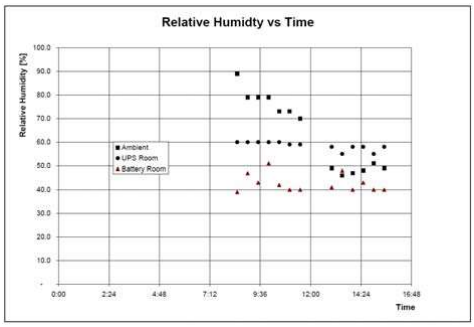


Figure 5b Relative Humidity vs time t
Day fog, 1 AC units running