EXPERIMENTAL AND COMPUTATIONAL SYUDY OF STRESSES ON OUTDOOR PIPING OF DOMESTIC AIR CONDITIONER

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ABSTRACT

Piping is a system of pipes used to transfer fluids from one location to another. Refrigerant piping system is used in the air-conditioner to transfer heat from one place to the other place by the refrigerant. One major requirement in refrigeration piping design is to provide adequate flexibility for absorbing the thermal expansion or contraction of the pipe. Piping system shall be designed to be free from high stress originated from thermal stress during operation to prevent product short life cycle and failure. Extensive researches and studies on the design parameters affecting the piping stress are required in order to achieve distinctive and economical piping system design.

The current work is to study the effects of pipe wall thickness, temperature difference between pipe suction temperature and ambient temperature, and pipe length on piping stress. First of all, experimentations are performed to study the effects of these three parameters on pipe stress. Test result indicates that the thicker wall thickness does not reduce the thermal expansion or contraction stress. It only unfavorably increases the forces and moments in the pipe and consequently causes higher stress in adjacent pipe region. An increase in the temperature difference between pipe suction temperature and ambient temperature increases the thermal contraction stress due to higher degree of thermal contraction. Longer pipe length reduces the thermal contraction stress for the reason that it provides better flexibility for absorbing the thermal contraction.

Finite element analysis is then used to predict the stress level of pipe in one of the test conditions and it is validated by the experimental result. The simulated stress result is below 16% in error compared to experimental test data.

Subsequently, finite element methodology is employed to predict the effect of five different pipe lengths on stress. It can be observed from the simulation that the pipe stress reduces with increasing pipe length. This result is compatible with the test result and theory.

ABSTRAK

Sistem paip merupakan satu system yang digunakan untuk memindahkan cecair dari satu lokasi ke lokasi lain. Sistem paip penyejukan digunakan dalam penyaman udara untuk memindahkan haba dari satu tempat ke tempat lain dengan penyejuk. Satu keperluan utama dalam reka bentuk paip penyejukan adalah memberikan fleksibility yang mencukupi supaya paip dapat menyerap pengembangan atau pengecutan terma paip. Rekabentuk bagi setiap sistem paip harus dipastikan bebas daripada tekanan yang tinggi disebabkan oleh pengembangan atau pengecutan terma untuk mengelakkan kitaran hayat produk yang pendek dan kegagalan semasa dalam operasi. Penyelidikan meluas terhadap parameter paip diperlukan supaya sistem paip dapat direka dengan prestasi yang optimum dan kos yang rendah.

Tesis ini bertujuan untuk menganalisa pengaruhan ketebalan dinding paip, perbezaan suhu antara ambien dan sedutan paip, dan kepanjangan paip yang berlainan terhadap tekanan paip. Pertama sekali, eksperimen dijalankan untuk mengkaji kesan ketiga-tiga parameter itu terhadap tekanan paip. Keputusan eksperimen menunjukkan bahawa penambahan ketebalan dinding paip tidak mengurangkan tekanan terma paip tetapi sebaliknya akan meningkatkan daya dan momen dalam paip. Peningkatan daya ini akan menyebabkan tekanan tinggi pada system pipe. Perbezaan suhu antara sedutan paip dan ambient yang lebih tinggi akan meningkatkan tekanan pengecutan terma dan ini disebabkan oleh pengecutan yang lebih tinggi. Peningkatan kepanjangan paip akan mengurangkan tekanan pengecutan terma kerana ia memberi fleksibility yang lebih baik bagi paip untuk menyerap pengecutan terma.

Simulasi seterusnya digunakan untuk menganalisa tekanan paip dan disahkan oleh keputusan eksperimen. Keputusan simulasi telah disahkan oleh keputusan eksperimen dengan kesilapan yang kurang daripada 16% terhadap tekanan paip.

Simulasi kemudiannya digunakan untuk menganalisa kesan lima kepanjangan paip yang berbeza terhadap tekanan. Ia diperhatikan bahawa tekanan paip menurun apabila kepanjangan paip meningkat. Keputusan simulasi ini adalah serasi dengan keputusan eksperimen dan teori.

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σ	Stress	kg/mm^2
F	Force	N
A	Cross sectional area	mm^2
ε	Strain	mm/mm
ΔL	Change in length	mm
L	Length	mm
E	Modulus of elasticity	N/mm^2
e	Expansion rate	mm/mm
s	Axial stress	N/mm^2
D	Inner diameter of pipe	mm
t	thickness	mm
S	Thermal expansion rate	N/mm^2
r	Mean radius of the pipe	mm
T	Torque	Nm
θ	Angle	radian
G	Shear modulus	N/m^2
J	Polar moment of inertia	m^4
M	Bending moment	Nm

MPa	Megapascal
%	Percentages
g	acceleration of gravity (ft/s^2)
k_x	Translational located at pipe suction outlet x direction
k_y	Translational located at pipe suction outlet y direction
k_z	Translational located at pipe suction outlet z direction
kv_x	Translational located at pipe suction inlet x direction
kv_y	Translational located at pipe suction inlet y direction
kv_z	Translational located at pipe suction inlet z direction
psig	Pound force per square inch gauge
FSI	Fluid Structure Interaction
RTD	Resistance temperature detector
AHU	Air handling units
DB	Dry bulb
WB	Wet bulb
FE	Finite element
N	Newton
Sec	Seconds
DOF	Degree of freedom