Study of Thermal Conductivity of Hydrogen-argon Mixture at Different Temperatures for Thermal Insulation Pipes in Petroleum Industry

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【Abstract】In this paper, through the study of thermal conductivity of hydrogen- argon mixture at different temperatures for thermal insulation pipes in petroleum industry, a good method for determining the thermal conductivity of other gas mixture at different temperatures has been provided.

【Key words】Thermal conductivity; Hydrogen; Argon; Gas mixture

0 Preface

In common sense, vacuum is the best way for thermal insulation, so it is used for the thermal insulation pipes in petroleum industry. However, the Hydrogen under the high pressure in the oil drills can gradually penetrated through steel wall into the vacuum space to destroys the thermal insulation and reduce the lifetime of the pipe. A way was introduced to reduce the effect of penetrated Hydrogen to extend the lifetime, by pre-filling high pressure Argon, a low thermal conductivity gas. This paper introduces how to calculate the thermal conductivity of the gas mixture.

1 The calculation formula of thermal conductivity of single-component gas

Thermal conductivity of gas varies with the change of temperature at atmospheric pressure, and it can be calculated by the following formula[1-2]:

$$\lambda=\frac{R}{M}\left[\frac{15}{4}+1.32\left(\frac{C_P}{R}-\frac{5}{2}\right)\right]\eta\times418.7 \tag{1}$$

$$\eta=\frac{26.693\sqrt{MT}}{\sigma^2\Omega*}\times10^{-6} \tag{2}$$

Neufeld et al. proposed an empirical equation which is convenient for computer application:

$$\Omega*=\frac{A}{(T*)^B}+\frac{C}{\exp(FT*)}+\frac{E}{\exp(ET*)}+G(T*)^B\sin\left[S(T*)^W-H\right] \tag{3}$$

$$T*=\kappa*T/\varepsilon \tag{4}$$

In which: A =1.16145, B =0.14874, C =0.52487,D =0.77320,E = 2.16178, F=2.43787,G=-6.435×10^{-4}, H=7.27371,S=18.0323, and W=-0.76830, ε/κ(Ar) = 93.3(K), ε/κ(H_2) = 59.7(K).

heat capacities (C_p) of Ar and H_2 at constant pressure vary with the temperature from 298.15K to 1500K can be found in the book of "CRC Handbook of Chemistry and Physics".

Besides[3],"CRC Handbook of Chemistry and Physics" have provided the coefficient of viscosity of H2 and Ar range in temperature from 100K to 600K, results show that the calculations of η are in good agreement with the values measured experimentally.

Above all, the coefficient of thermal conductivities (λ) of H_2 and Ar can be calculated with the change of temperature at atmospheric pressure.

ε maximum energy of attraction between colliding molecules, ergs;
κ Boltzmann's constant, 1.38×10^{-16}ergs·K^{-1};
λ coefficient of thermal conductivity, W/(m*K);
R gas constant, 1.98726 g-cal/(g-mole)(K);
M molecular weight, g/g-mole;
C_p heat capacity at constant pressure, g·cal/(mol)(K);
η coefficient of viscosity, g/(cm)(sec);
T absolute temperature, K;
σ distance potential parameter,Å, σ(Ar)=3.542, σ(H_2)=2.827;
Ω*reduced collision integral.

2 Comparison of experimental and calculated values of thermal conductivities (λ) of H_2 and Ar

E. Bich et al.[4] have provided the thermal conductivity of Argon vary with the change of temperature at atmospheric pressure (experimental value):

Tab. 1 thermal conductivity of Argon vary with the change of temperature

T (K)	λAr (W/(m*K))
270	0.01627
280	0.01678
290	0.01729
300	0.01779
320	0.01876
340	0.01972
360	0.02065
380	0.02156
400	0.02244
420	0.02331
440	0.02416
460	0.02499
480	0.02580
500	0.02660
550	0.02855
600	0.03041
700	0.03395

M. J. Assael et al.[5] have provided the thermal conductivity of H_2 varies with the change of temperature at atmospheric pressure (experimental value):

By the above figure, it can be found that the calculated results are matches for the experimental data very well. At the same time, the calculated results of Hydrogen can be obtained by external polation for the temperature above 400K.

3 Effect of pressure on thermal conductivity of Ar[3]

According to this table, it can be seen that the influence of pressure on the thermal conductivity of argon is very small. When the pressure increased from 0.1 MPa to 1.0 MPa, the thermal conductivity of argon at 260K increased by only 3.16%, and with the increase of temperature, this value is reduced: the thermal conductivity of argon at 380K increased by only 1.38% when the pressure increased from 0.1 MPa to 1.0 MPa. So, it will not introduce too much error if the thermal conductivity at atmospheric pressure instead of the thermal conductivity at 1.0 MPa is used.

Tab. 2 Thermal conductivity of H_2 vary with the change of temperature

T (K)	λH_2 (W/(m*K))
270	0.1716
280	0.1768
290	0.1819
300	0.1869
310	0.1918
320	0.1965
330	0.2012
340	0.2057
350	0.2101
360	0.2144
370	0.2186
380	0.2226
390	0.2266
400	0.2304

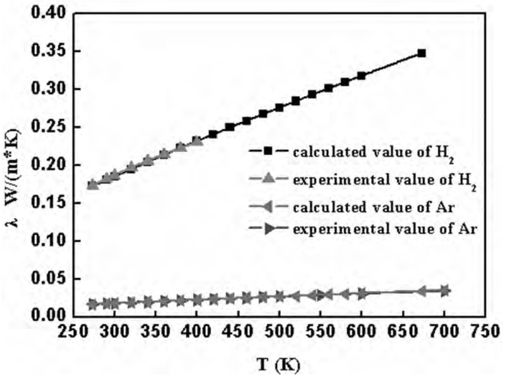

Fig.1 Thermal conductivity of H_2 and Ar variation with temperature under atmospheric pressure

Tab. 3 Effect of pressure and temperature on the thermal conductivity of Ar

P(MPa)) T(K)	0.1	1	10
260	0.0158	0.0163	0.0214
280	0.0169	0.0173	0.0218
300	0.0179	0.0183	0.0223
320	0.0189	0.0192	0.0229
340	0.0199	0.0202	0.0235
360	0.0208	0.0211	0.0242
380	0.0217	0.022	0.0249

4 Thermal conductivity of H_2–Ar mixtures containing different mole fraction of H_2

Brokaw [6] have proposed a simple correlation for therma conductivities of gas mixtures, for a dual system:

$$\lambda_m = q\lambda_{mL} + (1-q)\lambda_{mR} \tag{5}$$

In which, $\lambda_{mL} = y_1\lambda_1 + y_2\lambda_2$ (6) and $\frac{1}{\lambda_{mR}} = \frac{y_1}{\lambda_1} + \frac{y_2}{\lambda_2}$ (7), and the factor q changes with the light component in the mixture composition, and its value can be found by the following table, in which it is assumed that "a" represents the mole fraction of light constituent:

Tab. 4 Factor q as a Function of a

a	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.90	0.95	1.0
q	0.32	0.34	0.37	0.39	0.42	0.46	0.50	0.55	0.61	0.69	0.74	0.80

Through the above formula and the thermal conductivities of pure Hydrogen and pure Argon, the thermal conductivity of H_2–Ar mixtures can be calculated.

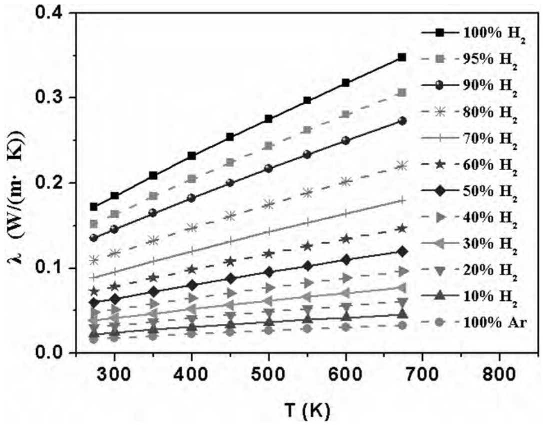

Fig.2 The thermal conductivity of H_2–Ar mixtures

Tab. 5 Thermal conductivity of Hydrogen–Argon mixtures at 0℃[7]

Mole fraction of H_2	λm(Experiment W/(m*K))	λm(Brokaw W/(m*K))	Error (%)
0	0.01633	0.01642	0.55
0.09	0.02303	0.022153	3.81
0.18	0.03057	0.028726	6.03
0.4	0.05276	0.04794	9.14
0.6	0.07830	0.07282	7.00
0.802	0.11305	0.10907	3.52
1	0.16915	0.17193	1.64

By comparing the λ of experimental values and Brokaw, it is found that the calculation accuracy of Brokaw empirical formula can meet the requirement.

If the mole fraction of Hydrogen is not very high, the λ of mixture is much lower than that of pure Hydrogen. In this case, the effect of penetrated Hydrogen can be reduced very much by pre–filling Argon. If the Mole fraction of H_2 is less than 0.40, the thermal conductivity of mixture is less than 31% of pure Hydrogen, the thermal insulation pipes is still can be used in this case. And the lifetime of the pipe is much extended.

5 Conclusions

Through the calculation of the thermal conductivity of H_2–Ar mixtures at different temperatures, a good method for determining the thermal conductivity of other gas mixture at different temperatures has been provided.

High pressure Argon can be pre–filled in the thermal insulation space to extend the lifetime of the thermal insulation pipe by reducing the effect of penetrated Hydrogen. S

【References】

[1]Svehla R. A., Estimated viscosities and thermal conductivities of gases at high temperatures[R].NASA–R132,1962.

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情景模式在高校商务英语口语教学中的应用

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【摘 要】商务英语作为基于特定目标的重要英语分支，其不仅涉及了与特定商业情景有关的专有术语、表达模式等及语法规则等语言知识，也包括了在商务环境中须应用的听说读写等各项互动技能。而基于商务工作的实践特性，说的地位尤为突出。本文探讨了情景教学模式对进一步提高高校商务英语口语教学效率的作用，以及其在目标确定、内容安排、模块设计及效果评估中应注意的问题。

【关键词】情景模式；商务英语口语

听、说、读、写包括译，作为英语技能的五个基本技巧具有高度相互关联性，但对于商务英语的学习者而言却并非同样重要。Ellis & Johnson 列出了作为商务英语学习者须掌握的表达技能：口语表达的自信与流畅；组织信息的技巧；足够准确的传递信息而不会给听者造成模糊和压力；具备听懂快速、复杂和不完善演讲主要论点的策略；具备理清与检验模糊信息的能力；应对他人表达的反应速度；清晰的发音与表达；具备应对文化选择合适语言与行为的能力。其中大部分与口语技能相关。与此同时，在 Holden(1993)设计的一份调查问卷中，当涉及到在日本工作对英语语言技能需要的 10 个项目，其中 8 项与口语相关。尤其是随着国际经济一体化的迅速发展，商务英语口语的地位日渐凸显。与此形成强烈对比的是，中国高校毕业生“哑巴英语”的现象仍然十分突出。市场对商务英语人才的要求与高校英语口语教学效果之间的矛盾敦促高校商务英语口语的教学者寻求更高效的模式来大力改进与提高教学效果。情景式教学模式因其有机的结合了商务应用环境与商务英语语言知识，而成为高校英语口语教学的新的突破。

1 基于需求分析的商务英语口语教学目标的设置

商务英语口语，作为一门“实用性”极强的课程，其教学目标设置必须建立在需求分析的基础之上。“作为一门 ESP 的分支学科，需求分析对商务英语的重要性远胜于科技英语，因为学习者需求之间存在巨大的差异”(Dudly-Evan &St John, 1996:2)。商务活动涉及领域繁多，如市场营销、银行、会计、物流、国际贸易，而不同领域的从业人员对商务英语的无论是语言上还是商务常识上需求都有明显差异。因此教师首先应针对学生做出目标情景分析（target situation analysis）和学习情景分析（learning situation analysis）。前者明确了学习者的内容：如具体的语言知识、技能，语言应用的主体、地点、时机，以及相关商务常识等。后者分析了与学习过程密切相关的主观因素，如学习者的态度、个性、动机等。经过这样的需求分析后的课程设计，才有可能既在内容上满足学习者日后工作的实际需求，又在方法上因材施教，切实提高教学实际效果。更为关键的是定期检验需求分析并灵活做出调整。

2 情景教学内容、资料及难度的选择

商务英语教学的主要原则是将教学内容与学习者需要紧密结合。“学习者的学习动机通常有两种基本类型：一是将语言习得作为一种工具或手段，如为将来找到一份工作；二是学习者希望其能融入所学语言群体的文化之中并顺利成为其中一份子”(Brown, 1994)。不同高校学习者的主体需求类型有所不同，作为湖南商学院这样更侧重培养实践人才的地方本科院校，学生的主体类型应归属于第一种，因而情景教学内容的选择将主要与将来的工作环境有关。其中口语教学的内容将主要包括：如何做正式与非正式的演讲；如何在工作中下达指令与做出展示；如何做出描述与解释；如何访问企业及接待来访者；如何参与讨论与（正式或非正式）会议；如何主持会议；如何谈判；如何面试等等。而将一系列商贸活动进行模块化设计是情景教学的一个有效方式。

在教学资料的选择上，除了包括上述主题的教材，补充材料也很重要，这是学生课堂学习延伸到课外学习的重要载体。其中多媒体教学资料效果最为突出。“人们辨识语言信息平均需要 2.8 秒，而辨识图片图像信息只要 0.4 秒“（Gao,2007）。尤其是在商务环境中，非语言信息远比语言信息更重要。本科院校学生大多没有商务工作的实践经验，多媒体尤其是视觉化的学习资料不仅使学习更生动，也使得学生更直观的理解商务工作环境中的语言及非语言信息。

而在教学内容难度的选择上应遵循“跳起来可以摘到桃子”的原则。如果学习者的水平为 i，则学习内容的难度可设定在 i+1。教学内容的难度与学习者水平之间的差异可以经由情景资料与学习者的经验来弥补，从而激发学习者的挑战欲望，改进学习效果。也就是说太难与太简单的内容都不利于实现教学效果的最大化。

3 情景教学模式遵循的几个原则

情景教学模式是对以往以教师为中心的讲授式教学模式的突破，其强调了学生在课堂中的中心地位。但如果从整个教学的过程来看，教师在教学目标设置、教学内容选择、教学安排设计、及教学效果评估各个环节上反而面临了更大的挑战。在情景式教学实践中，教师自身缺乏相关工作经验与教学时间极其有限成为了教学效果不佳的重要原因。而从学生角度而言，传统的中国初高中英语教学模式使得许多学生，尤其是来自教育资源相对缺乏的地区的学生，既缺乏必要的口语表达技能，也缺乏当众口语表达的信心与勇气，这也是教学安排实施不顺利的重要原因。

为此，教师在实施情景教学模式时，应注意遵循几个原则。首先在课程设计时要将学习者的需要作为首要考虑的因素。通过实践调查，将学生将来工作的实际场景融入其中。其二，选择丰富而具有针对性的情景教学手段，如问题回答、课堂讨论、案例分析、角色扮演等，从而使得教学不再停留在单纯的语言教学而是将语言学习与社会活动紧密结合，充分展现语言学习的实用性。其三，在情景教学模式中教师承担多样化的功能。不仅是情景教学内容的设计者、学生参与学习的激励者与引导者，还是学生学习效果的评估者。也许在传统的教学模式中，教师也有类似功能，但情景式教学模式的灵活性与复杂性将对教师功能的多样性提出更大的挑战。

【参考文献】

[1]严明.高校双语教学理论与实践研究[M].黑龙江:黑龙江大学出版社,2009(7).
[2]唐静.商务英语口语课程中外贸活动模块化仿真教学的开发[J].现代商贸工业,2012(11).

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[2]Ting Horng Chung, Mohammad Ajlan, Lloyd L. Lee, and Kenneth E., Generalized multiparameter correlation for nonpolar and polar fluid transport properties [J].Industrial & Engineering Chemistry Research , 1988,27(4): 671-679.
[3]David R. Lide,CRC Handbook of Chemistry and Physics 90th edition[M].USA: The Chemical Rubber Co. Press,2010.
[4]E. Bich, J. Millat, E. Vogel, The Viscosity and Thermal Conductivity of Pure Monatomic Gases from Their Normal Boiling Point Up to 5000 K in the Limit of Zero Density and at 0.101325 MPa [J].Journal of Physical and Chemical Reference Data, 1990,19(6):1289-1305.
[5]M. J. Assael, S. Mixafendi, William A. Wakeham., The Viscosity and Thermal Conductivity of Normal Hydrogen in the Limit of Zero Density [J].Journal of Physical and Chemical Reference Data, 1986,15(4):1315-1322.
[6]Richard S. Brokaw, Estimating thermal conductivities for non-polar gas mixtures-simple empirical method[J].Industrial and Engineering Chemistry,1955,47 (11):2398-2400.
[7]Richard S. Brokaw, Approximate Formulas for the Viscosity and Thermal Conductivity of Gas Mixtures[J].The Journal of Chemical Physics, 1958,29(2):391-397.

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