热电联产热、电按质分摊数学模型的建立及修正方法

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[摘要]　在“热电联产热电分摊新概念”[1]的基础上，从热量法入手，建立热、电分摊的数学模型，完善了实际焓降法的推导过程，导出了热量法与实际焓降法之间的关系，使实际焓降法的概念更清楚、物理意义更明确。为克服热量法和实际焓降法的缺点，引入了热化发电冷源损失按质分摊的概念。

关键词　热电联产　抽汽发电　热、电按质分摊
热化发电冷源损失
中图分类号　TM621.4

1　引言

对于热电联产的厂家，其热经济指标的制定比火力发电厂、供热锅炉房复杂和困难得多。这不仅是一个技术性的理论问题，而且是一个政策性问题。只有全面反映热电联产的生产特点，合理地制定热经济指标，才能促进热化事业的发展，充分发挥热电联产的优越性，提高热电厂的热经济效益。为此，人们进行了不懈的探索和研究，至今为止，虽有多种热、电分摊法，但在实际应用中却没有一种是令人满意的。

本文就热电联产，热、电按质分摊数学模型的建立及修正方法，谈谈自己的浅见，供同行参考。

2　数学模型的建立

2.1　热量法

热量法建立在热力学第一定律基础上，从热量利用的角度来分配总热耗量，即按热、电所用热量的比例来进行热、电分摊。热电厂总热耗量分配如图 1 所示。抽汽对外供热量可表示为

$$Q_r = Q\frac{D_r(i_r - i_h)}{D_o(i_o - i_{fw})} \quad \text{kJ/h} \qquad (1)$$

由式(1)可得热分摊比

$$\alpha_r = \frac{Q_r}{Q} = \frac{D_r(i_r - i_h)}{D_o(i_o - i_{fw})} \qquad (2)$$

式中：Q——热电厂总热耗量，kJ/h；
Q_r——热电厂抽汽对外供热量，kJ/h；
D_o——汽轮机进汽量，kg/h；
D_r——抽汽对外供汽量，kg/h；
i_o——汽轮机进汽焓，kJ/kg；
i_r——汽轮机抽汽焓，kJ/kg；
i_{fw}——锅炉给水焓，kJ/kg；
i_h——热网回水焓，kJ/kg；
α_r——热分摊比。

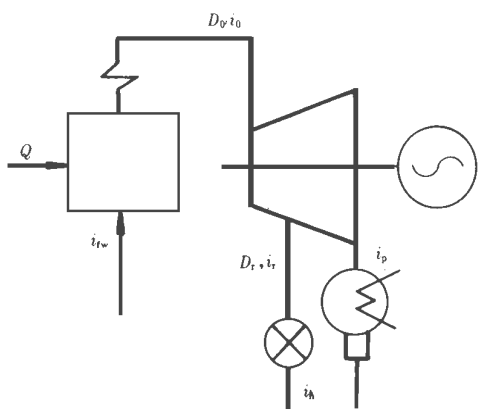

图 1　热电厂总热耗量分配图

2.2　实际焓降法

实际焓降法按供热汽轮机供热抽汽的实际焓降不足与新汽实际焓降的比例分配。如图 1 所示，抽汽对外供热量为

$$Q_r = Q\frac{D_r(i_r - i_p)}{D_o(i_o - i_p)} \quad \text{kJ/h} \qquad (3)$$

由式(3)可得热分摊比

$$\alpha_r = \frac{Q_r}{Q} = \frac{D_r(i_r - i_p)}{D_o(i_o - i_p)} \qquad (4)$$

2.3　实际焓降法与热量法的关系

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由式(2)可得

$$\alpha_r = \frac{D_r(i_r - i_p + i_p - i_h)}{D_o(i_o - i_{fw})} = \frac{D_r(i_r - i_p)}{D_o(i_o - i_{fw})} + \frac{D_r(i_p - i_h)}{D_o(i_o - i_{fw})} \quad (5)$$

式中:第一项为抽汽焓降不足热分摊比,第二项为抽汽发电(或热化发电)和抽汽焓降不足冷源损失热分摊比。

由此可见,热量法把抽汽部分的冷源损失全归热,热电联产的好处全归电。显然是不合理的,为了照顾热、电双方利益,将抽汽部分的冷源损失按质分摊,引入抽汽焓降不足系数 β, $\beta = \frac{i_r - i_p}{i_o - i_p}$ (6)

于是,将式(5)改写为

$$\alpha_r = \frac{D_r(i_r - i_p)}{D_o(i_o - i_{fw})} + \frac{D_r(i_p - i_h)}{D_o(i_o - i_{fw})} \cdot \beta = \frac{D_r(i_r - i_p)}{D_o(i_o - i_{fw})} + \frac{D_r(i_p - i_h)(i_r - i_p)}{D_o(i_o - i_{fw})(i_o - i_p)} = \frac{D_r[(i_o - i_p)(i_r - i_p) + (i_p - i_h)(i_r - i_p)]}{D_o(i_o - i_{fw})(i_o - i_p)} = \frac{D_r(i_r - i_p)(i_o - i_p + i_p - i_h)}{D_o(i_o - i_{fw})(i_o - i_p)} = \frac{D_r(i_r - i_p)(i_o - i_h)}{D_o(i_o - i_{fw})(i_o - i_p)}$$

令 $i_h = i_{fw}$,导出实际焓降法热分摊比

$$\alpha_r = \frac{D_r(i_r - i_p)}{D_o(i_o - i_p)} \quad (7)$$

实际焓降法考虑了抽汽焓降不足对热能质量利用的不利因素,注意了不同参数的质量差别,克服了热量法的缺点,但因热化发电的冷源损失和不可逆损失并没有分摊给对外供热量,对电能生产没有给以应有照顾,挫伤了热电厂生产电能的积极性。[1]

3 实际焓降法的修正方法

为使热、电双方得益,引入热化发电冷源损失按质分摊的概念,于是热分摊比可修正为

$$\alpha'_1 = \frac{D_r(i_r - i_p)}{D_o(i_o - i_{fw})} + \frac{D_r(i_p - i_h)\beta}{D_o(i_o - i_{fw})} + \frac{D_r(i_p - i_h)\beta(1-\beta)}{D_o(i_o - i_{fw})} \quad (8)$$

式中:第一项为抽汽焓降下足热分摊比,第二项为抽冷焓降不足冷源损失热分摊比,第三项为热化发电冷源损失热分摊比。

经整理,并令 $i_h = i_{fw}$,可得

$$\alpha'_r = \frac{D_r}{D_o}\left[\frac{i_r - i_p}{i_o - i_p} + \frac{(i_p - i_{fw})(i_o - i_r)(i_r - i_p)}{(i_o - i_{fw})(i_o - i_p)^2}\right] \quad (9)$$

4 结论

(1)本文在文献 1 的基础上,从热量法入手,建立了热分摊比的数学模型,完善了实际焓降法的推导过程,导出了热量法与实际焓降法的关系,使实际焓降法的概念更清楚、物理意义更明确。

(2)为克服热量法和实际焓降法的缺点,引入了热化发电冷源损失按质分摊的概念,对实际焓降法进行了修正,修正后的实际焓降法使热、电双方得益,正确反映了热电厂热、电两种产品的质量差别,较为适用。本方法如能在热电建设及热电厂运行管理中推广使用,定能调动热、电双方的积极性,推动热化事业的发展,激励热用户改造用热过程,降低用汽压力,促进热电厂热经济性的不断提高。

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无运动部件的泵

这是一种新型的泵,由于结构上没有运动部件,泵的安全性、可靠性较高,寿命可高达十年以上。

该泵原仅为核工业中的核燃料的输送而设计,由于这种泵的结构简单,安全可靠,使得它的应用范围扩大。这种泵主要应用在核工业中核燃料,生物液体,腐蚀性强的液体,接近沸点的液体等的输送。 (刘伟 供稿)

变工况下汽轮机反动度的统一表达式＝**A Unified Expression of Steam Turbine Reaction Degree under Off-design Operating Conditions**[刊, 中] / Li Weite(North China Electric Power University) //Journal of Engineering for Thermal Energy & Power. —1999, 14(1). —47 ~ 50

This paper discusses the unified expression of steam turbine reaction degree under off-design operaling conditions and a variety of factors exercising an influence on such a degree. Also addressed is the problem of total increment character of the reaction degree variation, etc., giving a relatively comprehensive and concise explanation to the contents of the reaction degree. **Key words**: steam turbine, off-design operating condition, degree of reaction

热电联产热电按质分摊数学模型的建立及修正方法＝**The Establishment of a Mathematical Model for Cogeneration Heat and Electricity Apportionment according to Quality and a Correction Method**[刊, 中] / Jing Youyin(North China Electric Power University) //Journal of Engineering for Thermal Energy & Power. —1999, 14(1). —51 ~ 52

On the basis of a "new conception of cogeneration heat and electricity apportionment" and proceeding from a calorimetric method a mathematical model for heat and electricity apportionment is set up, thus significantly improving the derivation process of actual enthalpy drop method and finding out the relationshiip between the calorimetric method and actual enthalpy drop method. This leads to a more lucid concept of the actual enthalpy drop method and its more clarified physical meaning. To overcome defects of the calorimetric method and actual enthalpy drop method introduced is a concept of the apportionment according to quality of thermification power generation cold source loss. **Key words**: cogeneration, steam extraction power generation, apportionment of heat and electricity according to quality, thermification power generation cold source loss

多媒体技术在汽轮机调速培训系统中的应用＝**The Application of Multi—media Technology in Steam Turbine Speed Governing Training system**[刊, 中] /Zhao Hong, Sun Zhaoqiang, Weng Yiwu(Harbin No. 703 Research Institute) //Journal of Engineering for Thermal Energy & Power. —1999, 14(1). —53 ~ 55

Multi-media technology is employed in a steam turbine speed governing training system. A brief description is given of the development and realization of a multi-media teaching software for the steam turbine speed governing training system. **Key words**: computer, multi-media, teaching and training

键合图方法在气动系统中的应用＝**The Use of Bonded Diagram Method in an Aerodynamic System**[刊, 中] / Li Yan, Zhou Yunlong, et al(North China Electrical Power University) //Journal of Engineering for Thermal Energy & Power. —1999, 14(1). —56 ~ 59

Under the assumption that working medium can meet ideal gas state equation and by the use of a dual-channel pseudo bonded diagram method sought out was the description method for an aerodynamic system C field, R field and aerodynamic. I element. With respect to the gas charging process of a gas tank and the speed governing circuit of a cylinder outlet throttling a simulation and experiment was conducted. **Key words**: power output bonded diagram, pseudo bonded diagram, aerodynamic system, dynamic simulation, C field, R field, I element

燃气—蒸汽联合循环无旁通烟囱的分析＝**An Analysis of the Condition under Which No Bypass Stack is Provided for the Gas-Steam Combined Cycle Power Plant**[刊, 中] / Yao Tingsheng, Zhuang Jianneng, Wu Laigui (Shenzhen Dapeng Power Plant) //Journal of Engineering for Thermal Energy & Power. —1999, 14(1). —60 ~ 62

The features of a gas-steam combined cycle power plant without a bypass stack are analyzed. It is pointed out that during the start-up of such a plant there will be a thermal shock to a heat recovery boiler. The need for the installation of a bypass stack should be determined based on the actual operation conditions of the power plant. What is proposed in the paper may serve as a reference guide to designers of combined cycle plant schemes and operating personnel of such plants. **Key words**: combined cycle, bypass stack, analysis