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煤水浆的雾化与磨损的实验研究

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本煤水浆喷嘴采用内混合式空气雾化喷嘴(图1)。煤水浆通道设计成形状简单的直通道，主流雾化空气高速旋转喷出，在内混合室与煤水浆混合，形成气浆薄液膜，它在内混合室出口处再与次流雾化空气相撞，进一步雾化破碎。

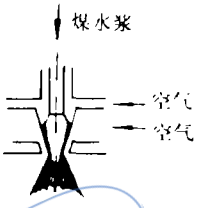

图1 内混合空气雾化喷嘴示意图

实验用煤粉成份为固体碳68.0%，挥发份23.2%，灰分7.8%和硫0.84%。实验用煤水浆按重量比为70%的磨细煤粉、1%的附加剂和29%的水组成。最大煤粒尺寸为250um。混合煤浆可泵压，其粘度甚大，且不为常数，与剪应变有关，属非牛顿流体。煤水浆液雾颗粒尺寸分布用 Malvern ST 2200/3300激光测雾仪进行测量。

1. **影响煤水浆液雾特性之因素**：(1) **空气-煤水浆流量比 $V_{L\text{-}S}$之影响** 图2表明煤水浆液雾索太尔平均直径 SMD 随 $V_{L\text{-}S}$增加而明显减小，但 $V_{L\text{-}S}$大于0.5后却变化不大。(2) **雾化空气压降之影响** 在 $V_{L\text{-}S}$一定的条件下，随 ΔP_L 提高，雾化空气速度增大，液雾明显变细，SMD 显著减小(图3)。对液雾特性影响而言，ΔP_L 的影响要比 $V_{L\text{-}S}$的影响大得多。(3) **煤水浆喷嘴在内混合室中轴向位置之影响** 如图4所示：当用水做实验时，随着中心喷水喷嘴轴向上移，即内混合室有效长度 S 增加，SMD 减小，当 S 增到一定值后，液雾特性变化不大。当用煤水浆做实验时，随着 S 增加，SMD 先减少后增加，有一最佳值。通过透明喷嘴实验观察可知：S 过长或过短，都将引起内混合室中气浆液膜增厚，对雾化不利。

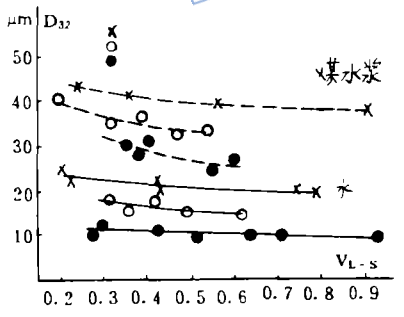

图2 空气-煤水浆流量比与液雾特性关系空气压降 KPa
×200 ○300 ●400

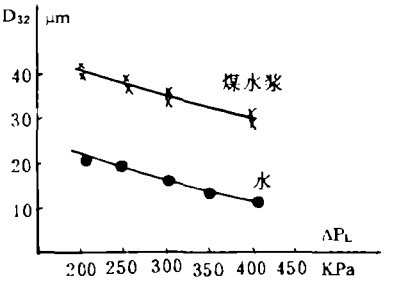

图3 雾化空气压降与液雾特性关系

(4) **煤水浆液雾特性随喷嘴下游轴向距离 L 之变化** 实验中用水和煤水浆分别研究喷嘴下游轴向距离 L 与煤水浆液雾特性关系 (图5)。其变化趋势与文献 [1] 相同 (表1)。从表1

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对比中可见：本文所采用的内混合式空气雾化喷嘴不仅便于煤水浆流动，防止堵塞，而且其液雾特性也优于文献［1］所使用的外混合式空气雾化喷嘴。

表1 液雾特性与喷嘴下游轴向距离关系

介质	水		煤水浆	
气液比	0.3	0.4	0.3	0.2
L mm	SMD (μm)		SMD (μm)	
	文献	本文	文献	本文
100	19	5.9	32	26.8
250	31	21.2	43	39.6

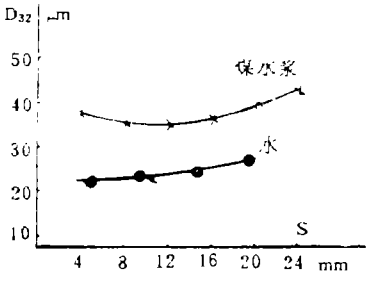

图4 煤水浆喷嘴在内混合室中轴向位置的影响

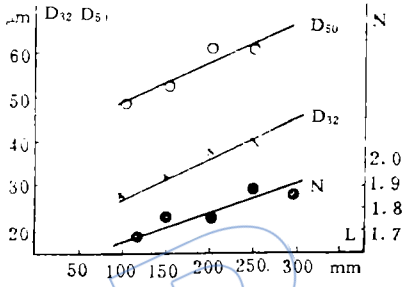

图5 SMD、MMD、N 随喷嘴下游轴向距离 L 之变化关系

2. 喷嘴磨损问题 实验中所用的内混合式空气雾化喷嘴先后进行实验17次，在275个工况下进行了测试，喷嘴净工作时间20个小时左右。实验结束时对喷嘴所有构造尺寸进行了重新测量，结果表明均无改变。实践证明本喷嘴设计中所采取的以下措施正确：选择了较大的煤水浆喷嘴出口直径 D_0，降低了煤水浆流速，从而减少了煤粒子对壁面的冲刷、磨损侵蚀；专门设计了旋转气流所形成的气膜来保护喷嘴的内壁面，防止了煤粒子对它的侵蚀磨损。

3. 实验结果的相关分析 鉴于内混合式空气雾化喷嘴的工作过程与机理，通过无量纲准则分析，利用线性回归分析方法，求出相关系数

$$D_{32}/D_0 = 2.84 \times 10^{-3} \times (L/D_0)^{0.32} \times (\sqrt{W_e}/R_e)^{0.06} \times (1_{L-S})^{-0.15} \times (\Delta P_L/P_a)^{-0.51}$$

将此结果与所有实验测量数据点吻合较好，(图6)。实验结果证明：采用内混合式空气雾化喷嘴，不仅使煤水浆的液雾特性大大改善，且能有利于解决磨损和堵塞等问题。

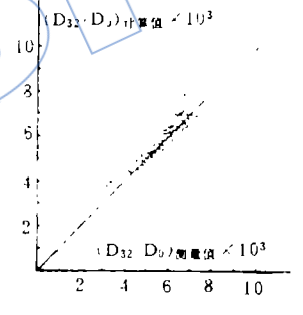

图6 实验结果与相关分析结果对比

就煤水浆的液雾特性而言，空气雾化喷嘴的工作条件影响较大，煤水浆液雾 SMD 随雾化空气压降增加而明显下降。

为了克服煤水浆对喷嘴壁面的冲刷侵蚀和防止由于喷嘴出口处的磨损而导致工作不稳定，建议尽可能增大煤浆出口直径，降低煤浆喷射速度；使用旋转气流所形成的气膜来保护壁面；选用耐磨损材料制造喷嘴；改变空气雾化喷嘴的工作参数，以调节喷嘴工作状态。

参 考 文 献

[1] Meyer·P·L, Chigier·N "Characterization of the Atomization Process in Coal-Water Slurry Sprays" ICLASS-85

EFFECT OF GEOMETRIC PARAMETERS ON INTERNAL PERFORMANCE OF CONVERGENT-DIVERGENT NOZZLE

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ABSTRACT The efect of geometric parameters on internal performance of convergent-divergent nozzle has been investigated experimentally. The relationships of thrust coefficient and wall static pressure distribution to area ratio, divergent angle, convergent angle and throat radius of curvature are presented in this paper.

AN EXPERIMENTAL STUDY ON ATOMIZATION OF COAL-WATER SLURRY AND EROSION OF ATOMIZER

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H. W. Glaser (*University Essen*)

ABSTRACT An internal-mix atomizer has been specially designed for coal-water slurry. The relationships between its slurry spray characteristics and operating parameters have been studied experimentally. High levels of atomization were achieved by the internal-mix atomizer. The protective layer formed by the rotating flow at high speed in the internal-mix atomizer provides a useful means of protection against erosion, corrosion and deposition.

AN EXPERIMENTAL STUDY ON FUEL SPRAY ATOMISING CHARACTERISTICS OF EVAPORATING PIPE ATOMIZER

Sun Yuezhong (*China Civil Aviation Tianjin Training Center*)

ABSTRACT This paper summarizes the test research on the atomizing characteristics of the evaporating pipe atomizer. Among all the factors which affect the fuel atomization, the atomizing air speed is the most important, but the fuel-air-ratio and geometrical parameters have certain effects on it as well. The distance of the fuel atomization shortens with the increase of the atomizing air speed.

AN EXPERIMENTAL INVESTIGATION ON HEAT TRANSFER IN ROTATING COOLANT CHANNELS

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(*Nanjing Aeronautical Institute*)

ABSTRACT This paper deals with a facility and an experimental technique for researching the heat transfer of coolant channels in the rotating turbine blade, and presents the preliminary results of the convective coefficient of the flow parallel to the axis in the rotating conditions. The results show that the effect of rotating on heat transfer is highly enhanced by centrifugal and Coriolis forces. In the conditions of the present tests ($Re=6.4\times10^4$, $n=1000$rpm.), the Nusselt number in the rotating state in about 20 percent higher than that in the stationary case.