doing likewise with the normal components, then from Eqs (2), (3), (11), (12), (18) and (19):

$$\left(\frac{\lambda_x}{\lambda_y}\right)_m=\left(\frac{\lambda_x}{\lambda_y}\right)_t\left[\left(\frac{Tu}{Tv}\right)_m\left(\frac{Tv}{Tu}\right)_t\right]^{-7/10}$$

$$\left(\frac{\Lambda_x}{\Lambda_y}\right)_m=\left(\frac{\Lambda_x}{\Lambda_y}\right)_t\left[\left(\frac{Tu}{Tv}\right)_m\left(\frac{Tv}{Tu}\right)_t\right]^{-7/10}$$

Now, for truly isotropic turbulence[15], $(\lambda_x/\lambda_y)_t=\sqrt{2}$, $(\Lambda_x/\Lambda_y)_t=2$ and $(Tu/Tv)_t=1$. Substitution of these figures, and combining with Eq (A.4), gives

$$\left(\frac{\lambda_x}{\lambda_y}\right)_m=\sqrt{2}\left(\frac{1+k^2}{1-k^2}\right)^{-7/10} \tag{A.5}$$

$$\left(\frac{\Lambda_x}{\Lambda_y}\right)_m=2\left(\frac{1+k^2}{1-k^2}\right)^{-7/10} \tag{A.6}$$

Using the typical value of $k=0.2$ gives $(\lambda_x/\lambda_y)_m=1.34$ and $(\Lambda_x/\Lambda_y)_m=1.89$. Over the usual range $0.1<k<0.3$:

$$1.39>(\lambda_x/\lambda_y)_m>1.25, \qquad 1.97>(\Lambda_x/\Lambda_y)_m>1.76.$$

As a test of the validity of Eq (A.4), a brief series of experiments was undertaken in the wind-tunnel, using the grids described in Table 1. The results of this work are shown in Table A.1, where it has been assumed that $k=0$, and $10<U<20$ m/s.

Table A.1

Grid type	$\frac{x}{d}$	$\left(\frac{\overline{u^2}}{\overline{v^2}}\right)$
SMR	515	1.07 1.13
PR	74	1.08 1.10 1.06
PS	49	1.09 1.10 1.09

A standard DISA P53 x-wire probe was used to obtain the above data, and over the flow velocity range under investigation, the k-factor was experimentally determined to be 0.14 (compare with Ref 72). From Eq (A.4) it is seen that (for truly isotropic turbulence) the expected measured ratio of turbulence energies (ignoring the k-factor) would therefore be 1.08. This latter figure is in remarkable agreement with the figures given in Table A.1, which shows an average figure of 1.09 for $(\overline{u^2}/\overline{v^2})$. Although these rather limited data do not prove that grid turbulence is truly isotropic, the very close agreement of the above figures strongly suggests that it is, at least to within experimental uncertainty.

Book review

The chemical engineering guide to heat transfer

Ed. K. J. McNaughton

This two-volume set is a collection of reprints from *Chemical Engineering* magazine. The reprinted articles date from 1979 to 1985 and cover a very wide range of heat transfer topics including basic equipment such as fired heaters, boilers, refrigeration systems, cooling towers, agitated vessels and dryers. More exotic subjects addressed include heat pipes, hydraulic turbines, solar ponds and microwave dryers. There are also topics which some heat transfer engineers might regard as 'gatecrashers' namely steam traps, steam tracing and insulation.

The main emphasis, however, is on heat exchangers and, especially, shell and tube heat exchangers.

The two substantial, well printed, solidly bound, quarto sized volumes are entitled respectively 'Plant Principles' and 'Equipment', titles which are rather vague and, as it turns out, somewhat irelevant as regards the contents. However, the amount of material is too large for one volume and I suppose the editor had to find a title of some sort for each of the resulting two. Classifying such a large and diverse range of articles must, in fact, be quite a difficult task but classify them he does, fairly successfully, under six headings in each volume namely, Heat Exchangers, Shell & Tube Equipment, Design, Heat Recovery, Steam and Cost and, in volume 2, Boilers, Cooling, Heating & Insulation, Condensers, Dryers and Other Equipment.

Those familiar with 'Chemical Engineer' magazine will know that it specializes in articles of an intensely practical nature written by practising engineers who are anxious to share many years of hard, and often painful, experience with colleagues. Prospective readers looking for good heat transfer science will, therefore, be disappointed. Indeed, the articles in this collection which fall down flattest are those where the authors are attempting to be at their most scientific. Examples of this include several articles on calculating multipass log mean temperature difference which are largely taken up by the tedious algebra found in many standard texts.

Sympathy, however, must be extended to the many Hewlett Packard HP-67 buffs contributing to the book who laboured long and hard programming up thermal design methods from Kern and others only to find their efforts overtaken by the mid-eighties generation of personal computers and associated sophisticated software.

Where the books really do score, however, is in the collected experience of specialists who, over the years, have had to select, design, buy, construct, operate and troubleshoot all kinds of heat exchangers and other equipment. Much of this hands-on experience is never written down except in magazine articles and is most unlikely to be found in the more academic texts.

Also hard to find elsewhere and very useful are the articles on cost estimation. Although the information contained in these is now a few years out of date the application of a judicious factor to account for recent, mercifully small, rises in costs should render these estimation methods still very helpful.

This one is, then, very much for the practising engineer in the oil and gas industry and probably more for the operating company generalist rather than the contracting/manufacturing specialist.

Chris Norman
Harwell Laboratory,
Oxfordshire, England

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