what other meaning Dr Kotas offers. The comment that 'this relationship (between energy degrading and both internal irreversibility and changes in unavailable energy) is never put to the test...' is ludicrous. Any engineer will tell you that if two separate effects are identifiable in a process, they can be combined additively; it is not necessary to test anything but simply to use one's God-given common sense. I also refute most emphatically the statement 'The fallacy of this treatment...', since it is not at all necessary for the temperatures at which heat is transferred to be the same. Quite simply, a process with combined heat and work interactions is divided into two composite processes, one with work interactions only (including friction), and the second with heat transfer only. This heat transfer can be thought of as occurring very rapidly after the work interaction (and therefore under entirely different conditions compared with the real combined process) provided that the same end state is reached. There is no mystery about this; the procedure is well-explained in the text. By adopting such a simple technique, this complex subject becomes at last amenable to simple mathematical treatment. Dr Kotas seems to have missed this important point.

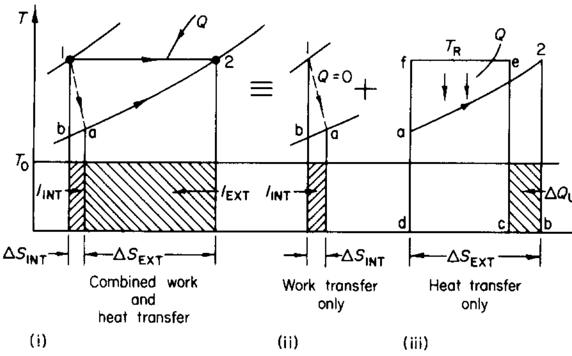
D. F. Moore
Department of Mechanical Engineering
University College, Dublin

Reviewer's reply

I will, for once, agree with Dr Moore that there is no satisfactory English language book available currently that would deal in a comprehensive way with the practical applications of the Second Law to thermal plant analysis. Unfortunately, I do not believe that his book fills this gap. The treatment of this important subject which he has presented, in spite of his claims, is neither simplified nor reliable. My impression of this book is that it is more likely to confuse than inform those potential readers who are new to this subject.

The point of criticism in my review of his book to which Dr Moore takes particular umbrage is that concerning his technique of replacement of an actual process with two component processes. To answer his rhetorical arguments may I be permitted to prove my point by applying his technique to a special case for which the answer is simple and well-known. Fig 1 shows the analysis of an isothermal expansion process presented in exactly the same way as that of a more general expansion process shown in Figure 6.4 in Dr Moore's book. Both the symbols and nomenclature used are his. Let us assume that the heat transfer to the expanding fluid occurs at a temperature, T_R, only marginally higher than that of the fluid so that the irreversibility associated with the heat transfer is negligible. The process will be assumed to suffer some irreversibility due to internal fluid friction. According to Dr Moore, the actual process 1–2 can be split up into two component processes 1-*a* and *a*-2 and the irreversibility, or the energy degrading as he prefers to call it, of the actual process is equal to the sum of the internal irreversibility I_{int} of the adiabatic work transfer process and the irreversibility of the isobaric heat transfer process which, again, he calls by his own name of increase in unavailable energy and denotes by ΔQ_{unav}. This relationship can be written as (expression (6.5) in Dr Moore's book) follows:

$$E.D._{combined} = I_{int} + \Delta Q_{unav} \tag{1}$$



Combined work and heat transfer (i)

Work transfer only (ii)

Heat transfer only (iii)

Fig 1 Analysis of an isothermal expansion process following Moore's presentation and nomenclature

A reference to Fig 1 (iii) will show that even with reversible heat transfer (ie $T_{SYSTEM} = T_R$), Dr Moore's technique will give $\Delta Q_{unav} > 0$, which is obviously wrong. If, further, the frictional dissipation is reduced so that, in the limit, $I_{int} = 0$, the total 'energy degrading' in such an obviously fully reversible process will still be found to be greater than zero according to this technique. It is obvious that we cannot assume as Dr Moore does, 'that if two separate effects are identifiable in a process, they can be combined additively'. The arguments which Dr Moore is offering in support of his technique such as 'Any engineer will tell you'..., do not carry much weight in a properly conducted scientific debate, a view with which I am sure most engineers and scientists would agree.

With regard to '*external irreversibility*', my definition of it is that it is that part of the total irreversibility associated with a given process, which occurs outside the system. The quantity which Dr Moore calls external irreversibility is shown in Fig. 1(i) as I_{ext}. This quantity will be seen to be neither external nor any kind of irreversibility. And, incidentally, on the question of arbitrary nomenclature, another concept which Dr Moore 'invented' and to which he gave his own special name is *gross irreversibility*, defined on page 135 in his book. This will be found to be nothing else but the old familiar concept of *reheat*, which 'as any engineer will tell you', is not wholly an irreversibility and the qualifying word 'gross' will not change this fact.

The lesson, which in my view, is to be learnt from this case is that new, untried ideas should not be put directly into a book, but the author should try to publish them first so that he gets the benefit of the associated process of refereeing and criticism.

T. J. Kotas
Department of Mechanical Engineering
Queen Mary College, University of London

Note added in proof: Dr Moore contends that the example given above is flawed, not his combination technique. Further discussion will appear in the next issue.