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Letter to the Editor—Reply to Nelson's Comments

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A suggested revision of the Tsao-Day technology matrix for coking coal is given in Table 1.[3] In addition, the authors specify that lignite coal is used in the direct reduction process for making steel. The direct reduction process is still in the development stage, there were over 240 patented processes in 1951 [1, p. 28], so characterization of a standard fuel for use as a reducing agent seems highly uncertain. Rather than lignite, more readily available fuels such as coke, coke fines (breeze), or other bituminous coal fines are likely to be used in the initial commercial applications (see [6, Chapter 13], [1, p. 29]).

Process analysis models are often an artful blend of economics and engineering. Engineering estimates of input-output coefficients are widely scattered and difficult to obtain. The investigator should, however, reject the single activity representation of the production process where this disregards the essential economics of the situation.

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Reply to Nelson's Comments

Nelson is quite right in saying that the typical byproduct oven uses bituminous coals of various volatile content. Subbituminous coals are not used. The appropriate heading for the second constraint in our model should therefore read "low rank bituminous coals," where "low rank" refers to a proximate analysis of less than 69 per cent of dry fixed carbon and more than 31 per cent of dry volatile matter in the coal. (For a detailed classification of coals by rank, see [48, p. 74] in our paper.) We have checked our work sheets and found that the input coefficient a_{23} was indeed intended to represent the per unit input requirement on this class of low rank bituminous coals. Our apologies to our readers for the incorrect use of the word "subbituminous" in this context.

Regarding Nelson's suggested coefficients, we only wish to refer our readers to the comments we made in §3 of our paper (p. B-606, first paragraph). We think it is obvious to our readers that, in view of the multitude of production methods used in the

[3] A more complete treatment of the problem would necessitate solution of a large scale coal blending linear programming model. For some initial work on this problem, see Trozzo [3].

industry, it is virtually impossible to represent all existing practices accurately with a limited number of coefficients. For an industry-wide analysis, any set of coefficients must be viewed as representing some "average" production methods. Whether one set of coefficients is more representative of the industry-wide production pattern than another set is a question which can only be answered by empirical testing. Since Professor Nelson has not provided us with the results of such tests, we are not in a position to evaluate his suggested coefficients and to make comparisons.

In our paper we have pointed out the experimental nature of the direct reduction process included in the model (p. B-591). Professor Nelson reiterated this point in his comments.

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A Note on Scheduling a Multi-Product Single Machine System for an Infinite Planning Period

In [1], Madigan describes a method for scheduling a number of products on a repetitive basis on a single machine. As a first step he computes the optimal lot size and cost per unit time for each product independently. Secondly, he computes the optimal cycle time for all products combined and the associated cost rate for each product. This assumes that each product is to appear only once in the cycle. After comparing the cost rates calculated for each item in Steps one and two, he then allows selected products to appear more or less frequently than once a cycle so as to lower the total cost. The total cycle length, however, is constrained to be an integer multiple of the cycle time originally calculated in Step two. A further reduction in the total cost can be realized by recalculating the cycle time without this restriction. Letting n_i be the number of times the ith item is to be produced in the total cycle, then the optimal cycle time can be calculated as follows:

$$T^* = [(2\sum_i n_i s_i)/(\sum_i r_i h_i(1 - r_i/p_i)/n_i)]^{1/2},$$

where

s = setup cost,
h = carrying cost per unit time,
r = demand rate,
p = production rate.

For the example given in [1], this relationship yields a total cycle time of 104 days and a cost of 33.35 per day as compared to the cycle time of 86 days and cost of 33.93 per day presented in [1]. The values of n_i are 2, 2, 2, 4, 2, 2, 1, 4, 2 and 2 for $i = 1$, 10, respectively.

Letting T_i be the setup time for the ith item, a necessary but not sufficient condition for feasibility of the cycle time is that

$$T^* \geqq (\sum_i n_i T_i)/(1 - \sum_i r_i/p_i).$$