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LEAST COST FLOCCULATION OF CLAY MINERALS BY POLYELECTROLYTES

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TECHNICAL NOTE

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by

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Chakravarti (1) has proposed a graphical method for obtaining the optimum value of flocculant dosage which is essentially a method of minimizing the total cost of solid-liquid separation. This method was based on the assumption that the general shape of the thickening/cost curves (thickening cost vs reagent cost) is one of decreasing negative slope. When this is the case, the sum of coordinates of a point on this curve is a minimum when the gradient is -1. This point corresponds to minimum total thickening cost (cost of reagent + cost of thickening) (Fig. 1).

Further examination of this technique in our laboratory led us to believe that the assumption that the general shape of the thickening cost curves is one of decreasing negative slope does not always hold true especially in the case of high molecular weight synthetic organic flocculants. The systematic shift of the interface height - elapsed settling time curves at different flocculant dosages shown by Chakravarti (Fig. 2) does not appear in practice to exist for our systems. The relative positions of such curves are very often as shown in Figure 3, which represents the average result of 4 independent determinations carried out by us under conditions similar to those stated by Chakravarti.

It is apparent from Figure 3 that as dosage increases, the initial settling rate of the flocculated pulp also increases. This is generally accepted as being caused by increased floc size. However, hindered settling begins at the transition zone, evidently because particles are in closer proximity, reducing open passages between individual flocs. Later the compaction or compression zone occurs where the flocs are in still closer contact with each other, forming a network or structure where mechanical support is predominant. It was suggested that this starts to happen below a critical dilution of 4 (2). In this case, further settling depends on the pressure of the overlying mass, the strength of the network and the availability or probability of formation of escape routes for entrapped water. Settling proceeds until a point is reached at which any further increase in the pressure exerted by the overlying solids is transmitted directly to the walls of the settling column (3).

It is agreed that the higher the flocculant dosage, the larger will be the average floc size, at least up to the point where the optimum flocculant dosage is applied; all other parameters being equal, the size of the floc would clearly determine its settling rate. Large flocs exhibit a higher porosity (interfloc plus capillary voids) in their final sediment. The greater portion of this voidage is most probably attributable to the existence of capillaries; flocs are not rigid structures and interfloc voids could be filled by distortion of the floc shape caused by their collapse under pressure. Higher sediment volumes as being due to higher porosities have been previously reported by Dell and Sinha (4) as a result of higher flocculant dosages.

Chakravarti constructed the thickening cost curves (Fig. 1) from the interface height-elapsed time curves (Fig. 2) by drawing a line parallel to the time axis at a height corresponding to the desired dilution. The intersections of this line with the settling curves at various dosages give the respective times required to thicken to this dilution. When thickening time was plotted against reagent dosage a curve of decreasing gradient was obtained (Fig. 1).

The same procedure was applied to our settling curves (Figure 3), but in this case various heights or dilutions were chosen to illustrate the limitation of such a method. Seven lines parallel to the time axis were drawn representing dilution of 8, 6, 5, 4, 3.4, 2.8 and 2.5 cc/g; the initial dilution being 10 cc/g. Elapsed settling time corresponding to the intersections of these lines with the settling curves were plotted against corresponding dosages, as shown in Figures 4a and 4b.

The resulting curves were not of a decreasing negative slope and an attempt to find a point of minimum sum of coordinates on the curves would result in the establishment of two points; X at a lower dosage and Y at more than double that dosage. It could also be argued that dosages represented by point Z would be more economical than those represented by point Y at the same settling cost. Exceptions to the above conclusion can be observed from Figures 4a and 4b where only a single point of minimum sum (X) can be established and the shape of the curves are of decreasing negative slope. Another exception also exists at a dilution of 2.5 cc/g where most of the curve shows a decreasing positive slope.

Despite some apparent anomalies in the relative positions of the curves in Figure 3, the fact still remains that application of Chakravarti's method appears limited to cases where:

(1) very low dosages of the synthetic flocculant are employed;

(2) coagulation rather than flocculation is the predominent mechanism;

(3) low thickening ratios (high dilution) are contemplated.

When high molecular weight synthetic flocculants are used, which is currently the common industrial practice, we believe therefore that the method does not necessarily predict the optimum economic flocculant dosage.

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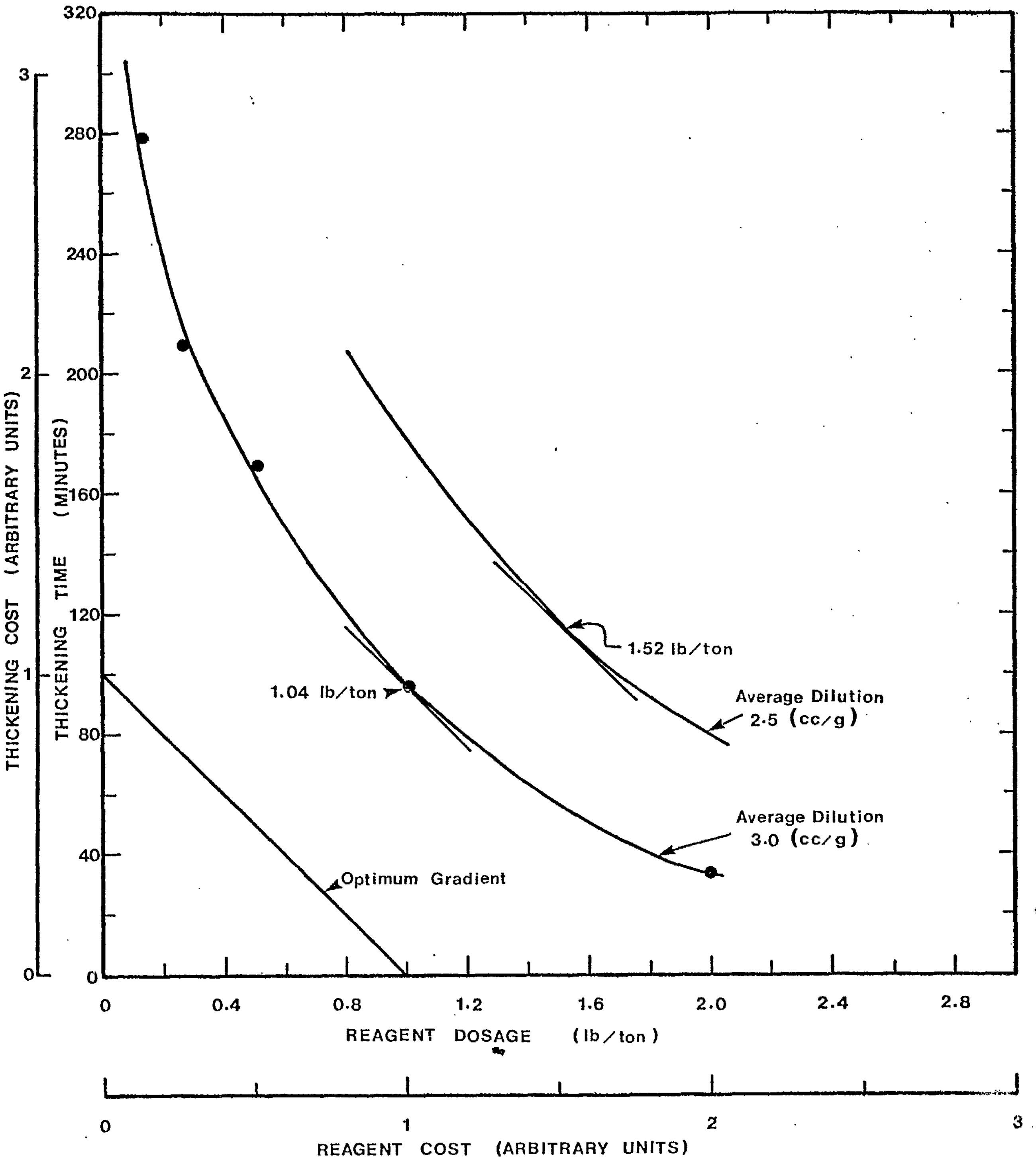

Fig. 1 - Process Diagram and Cost Scales
(after A. Chakravarti, ref. (1))

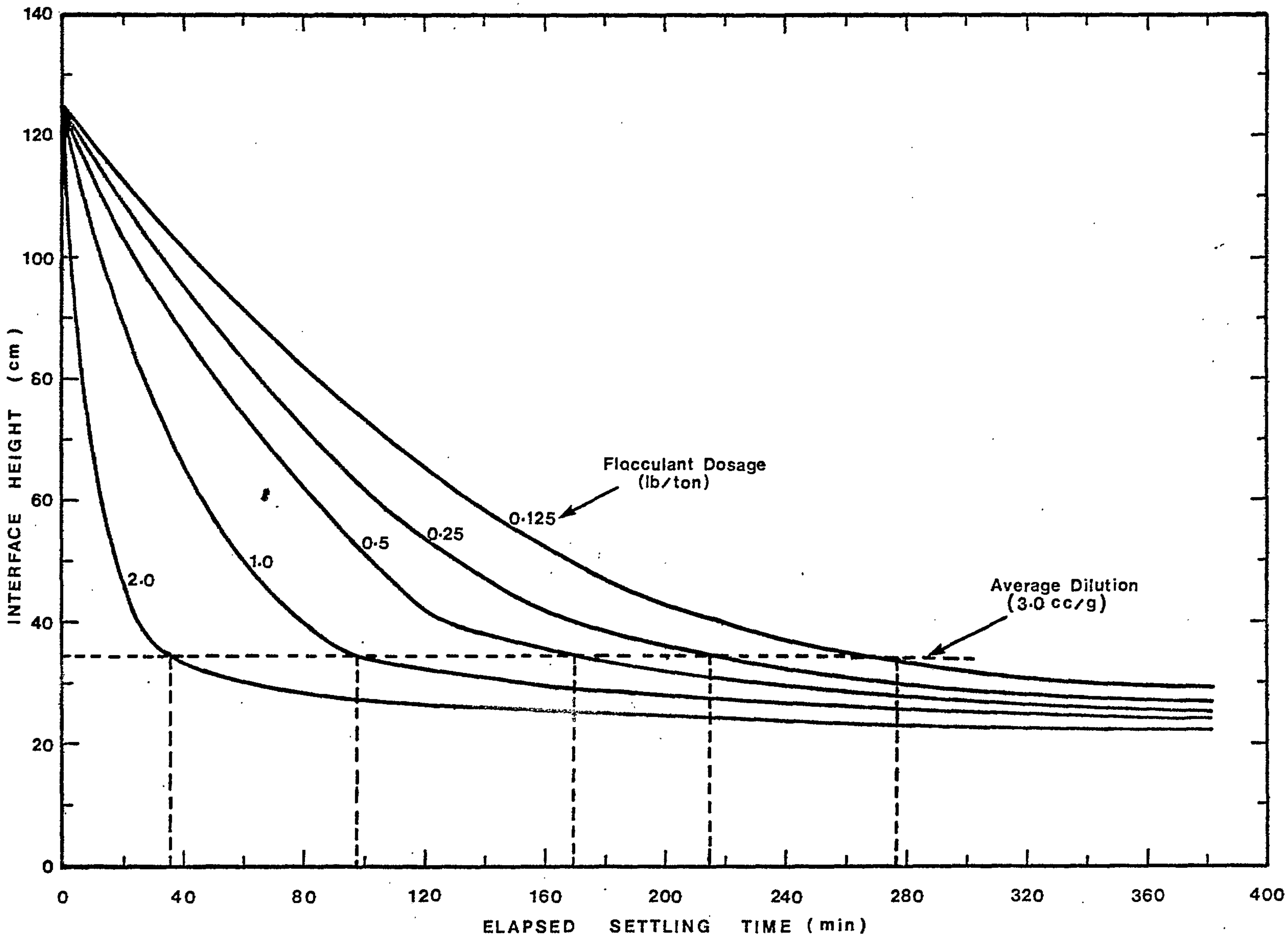

Fig. 2 - Batch Settling Curves (after A. Chakravarti, ref. (1))

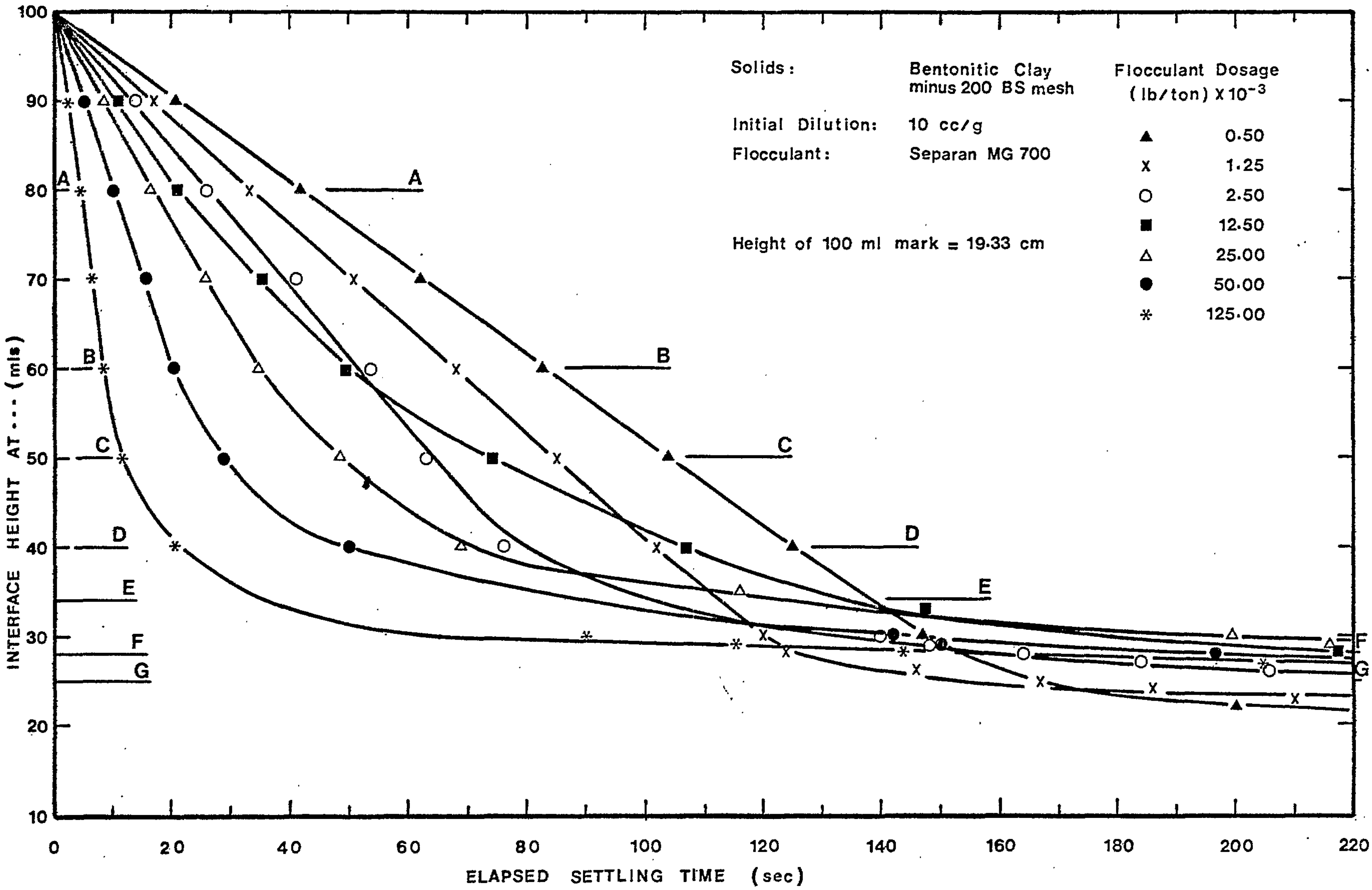

Fig. 3 - Batch Settling Curves
(by author)

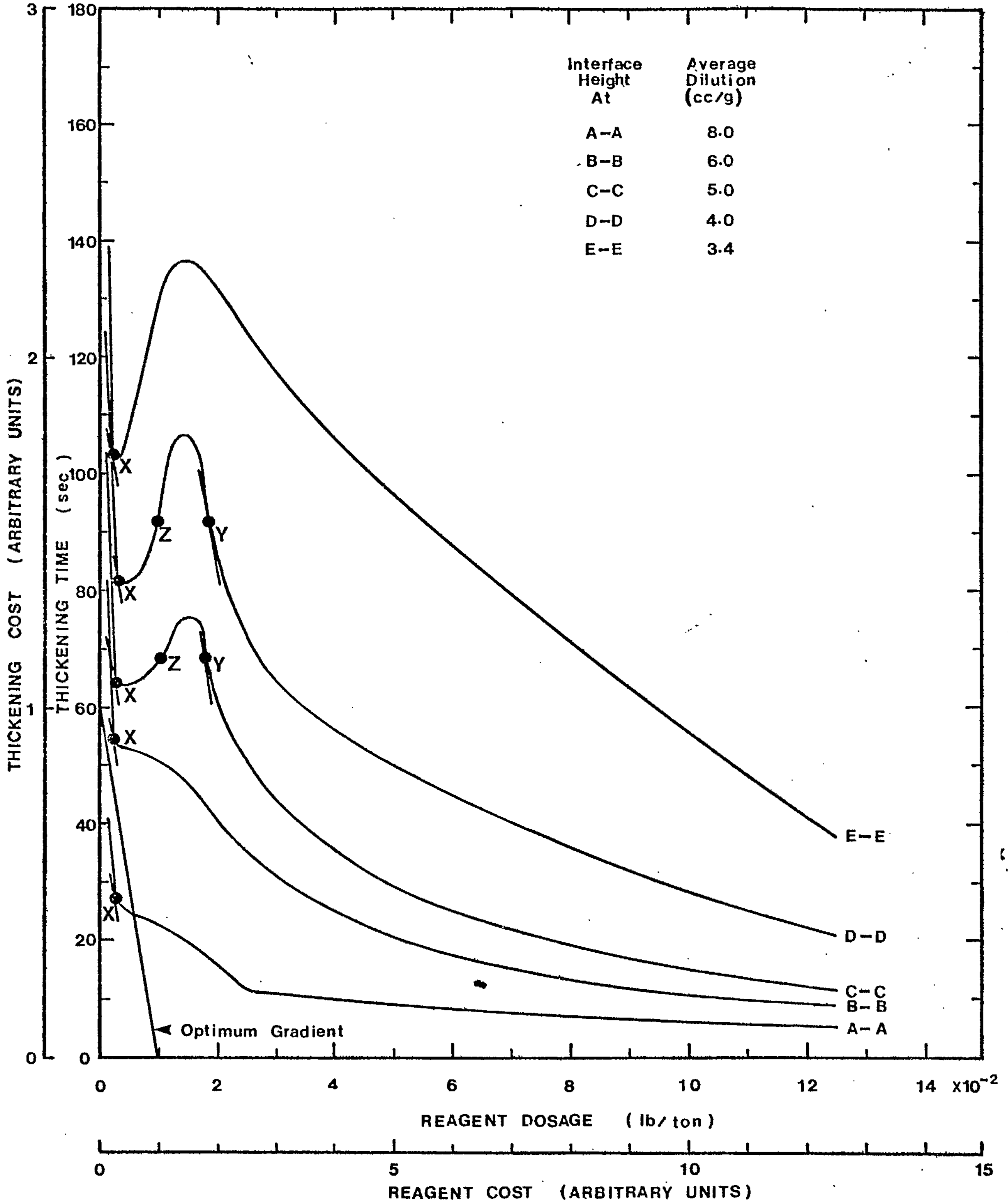

Fig. 4a - Process Diagram and Cost Scales

(by author)

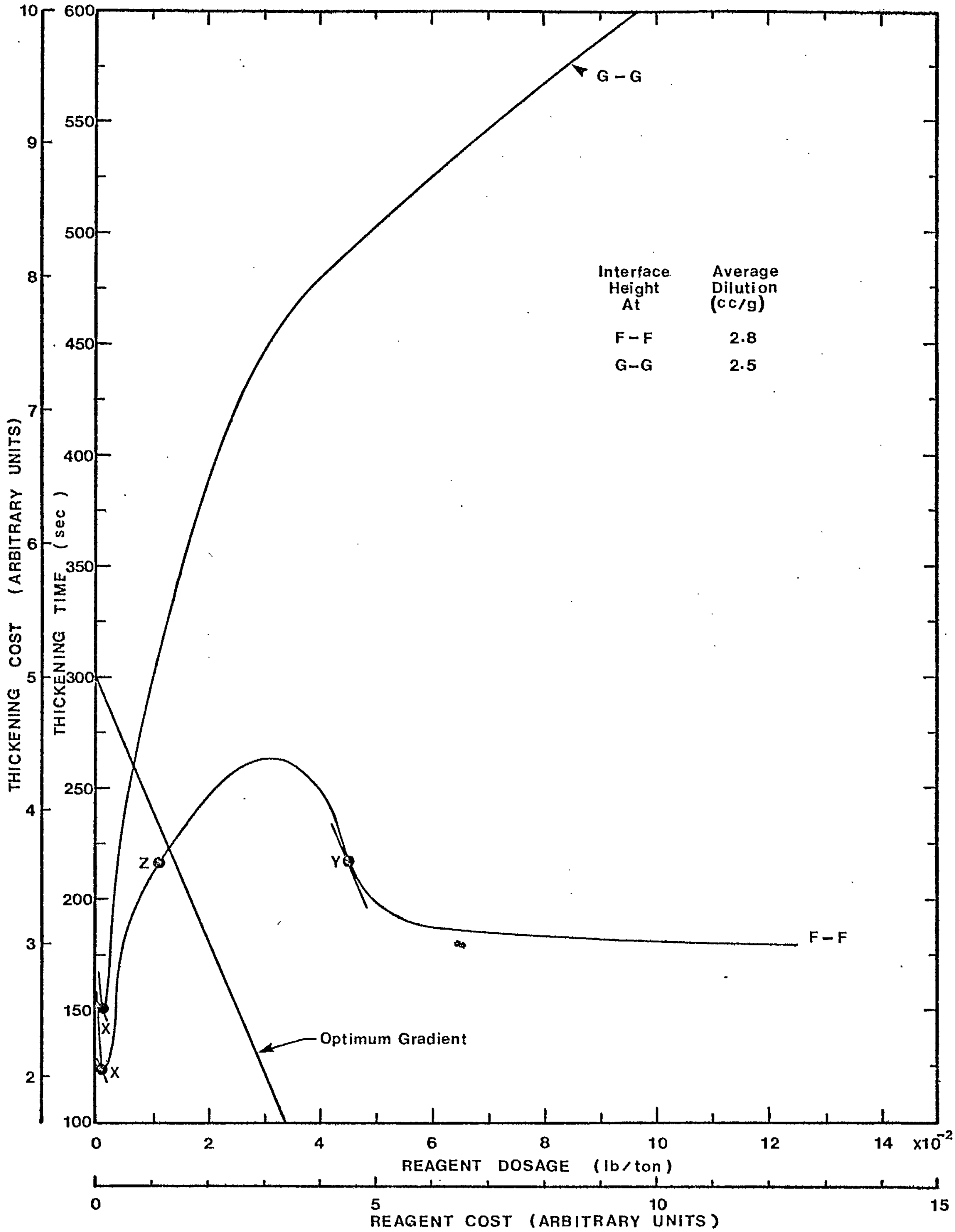

Fig. 4b - Process Diagram and Cost Values (by author)