Extractor Líquido-Líquido

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Extracción Líquido-Líquido

Example 10.3 A feed with a flowrate of 1000 $kg \cdot h^{-1}$ contains 30% acetic acid by mass in aqueous solution. The acetic acid (AA) is to be extracted with isopropyl ether to produce a raffinate with 2% by mass on a solvent-free basis. Equilibrium data are given in Table 10.1[1,8].

Table 10.1 Equilibrium data for acetic acid–water–isopropyl ether[1,8]. (Reproduced from Cambell H, 1940, *Trans AIChE*, **36**: 628 by permission of the American Institute of Chemical Engineers).

Mass fraction in water phase			Mass fraction either phase		
Acetic acid	Water	Isopropyl ether	Acetic acid	Water	Isopropyl ether
0.0069	0.981	0.012	0.0018	0.005	0.993
0.0141	0.971	0.015	0.0037	0.007	0.989
0.0289	0.955	0.016	0.0079	0.008	0.984
0.0642	0.917	0.019	0.0193	0.010	0.971
0.1330	0.844	0.023	0.0482	0.019	0.933
0.2550	0.711	0.034	0.1140	0.039	0.847
0.3670	0.589	0.044	0.2160	0.069	0.715

Promedio:

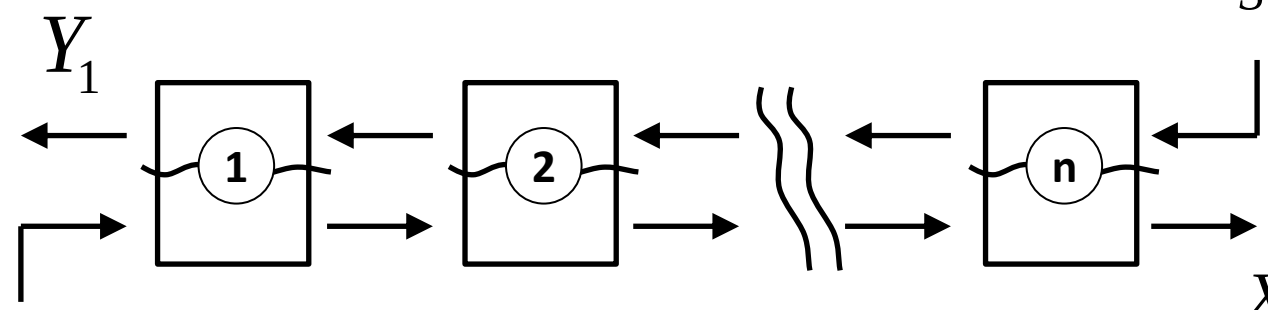
$$K = 0.3218$$

Ajuste lineal:

$$K_i = 0.3618\,X_i + 0.2566$$

Smith, R. (2005). Chemical Process: Design and Integration (Chichester, West Sussex, England ; Hoboken, NJ: Wiley).

Ejemplo: Extracción de AA



$$S = 2500\ \frac{kg\ isopropyl}{h}$$

$$Y_1$$

$$Y_{in} = 0\ \frac{kg\ AA}{kg\ isopropyl}$$

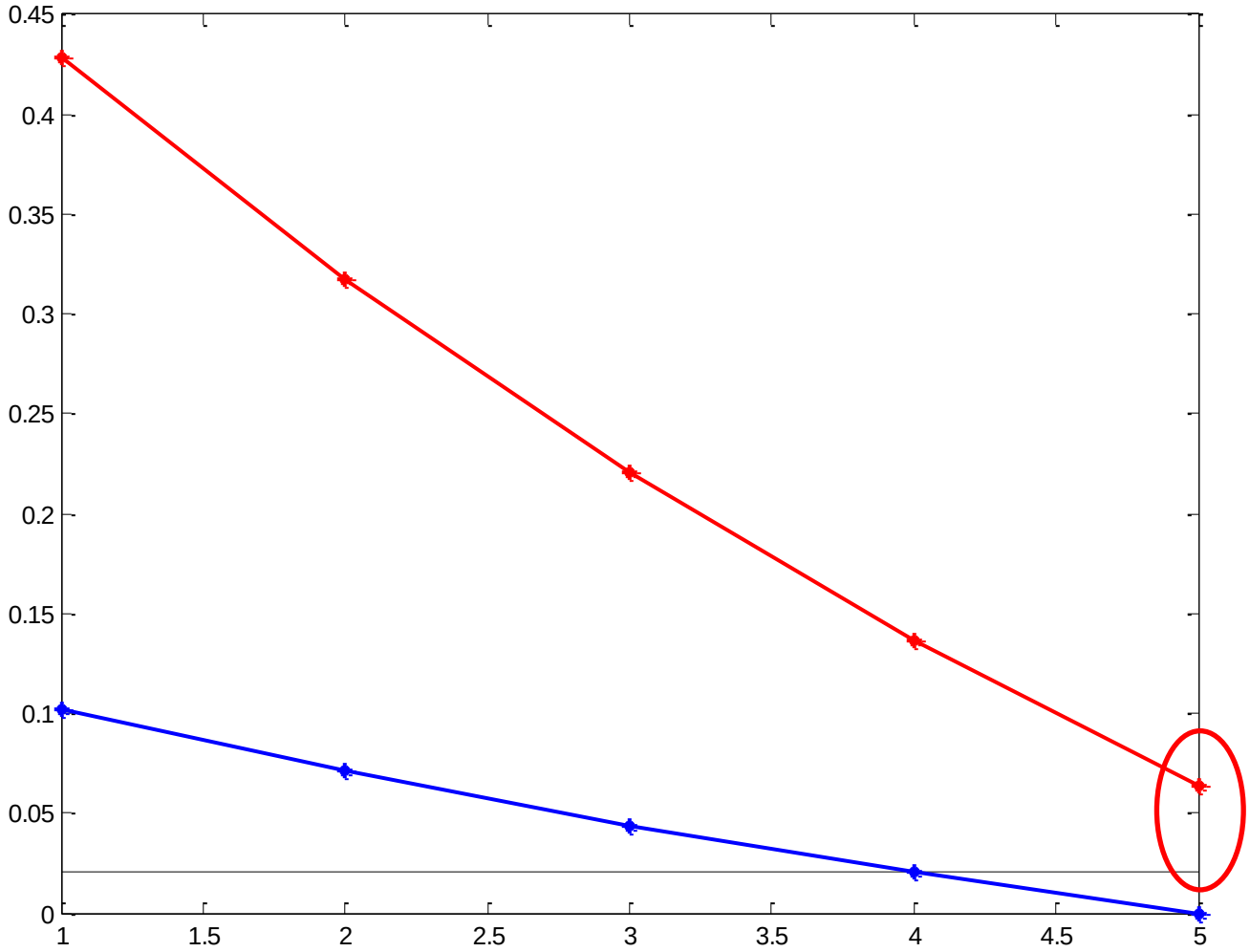
$$X_n \leq 0.0204$$

$$W = 700\ \frac{kg\ agua}{h}$$

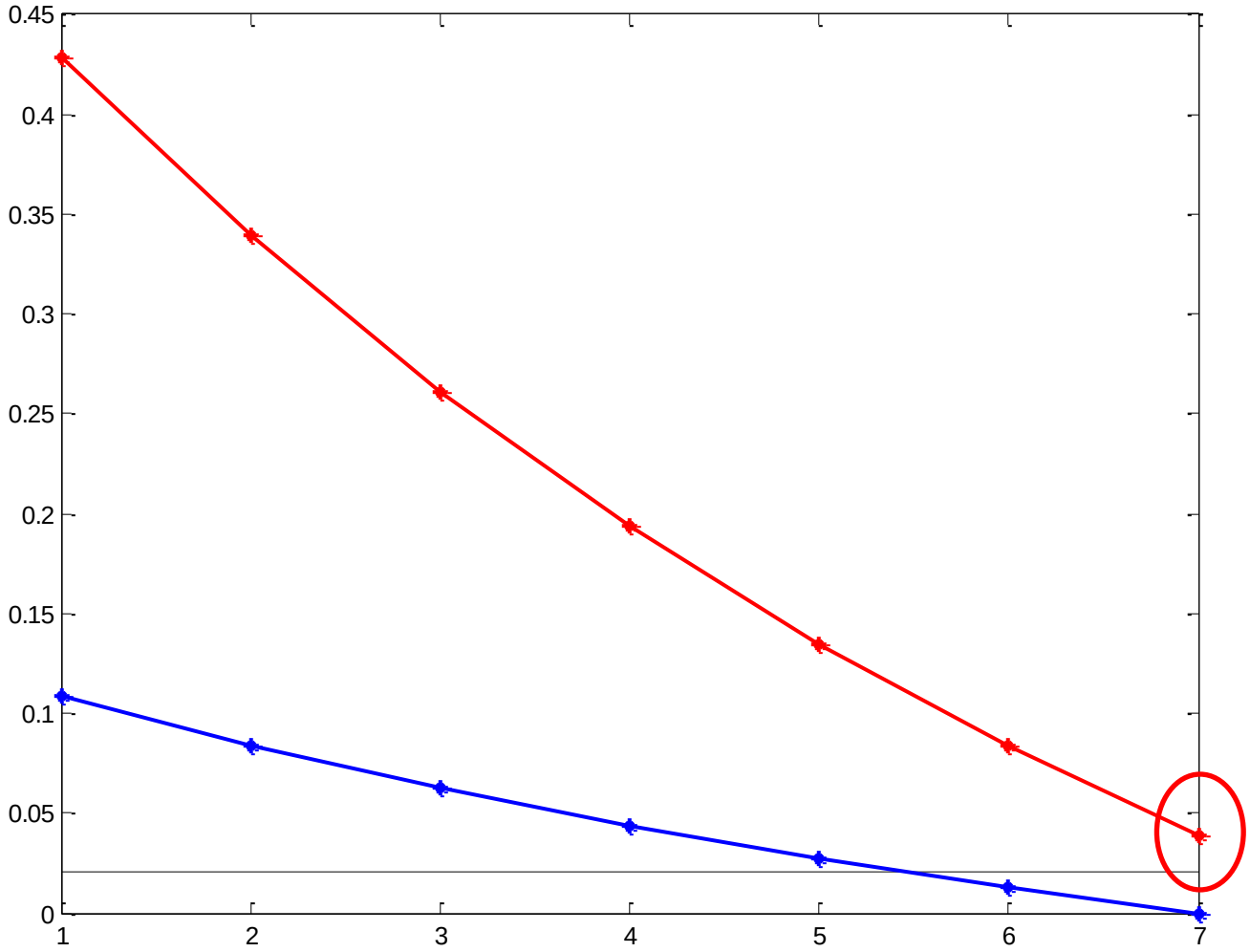
$$X_{in} = 0.4286\ \frac{kg\ AA}{kg\ agua}$$

$$K = 0.3218$$

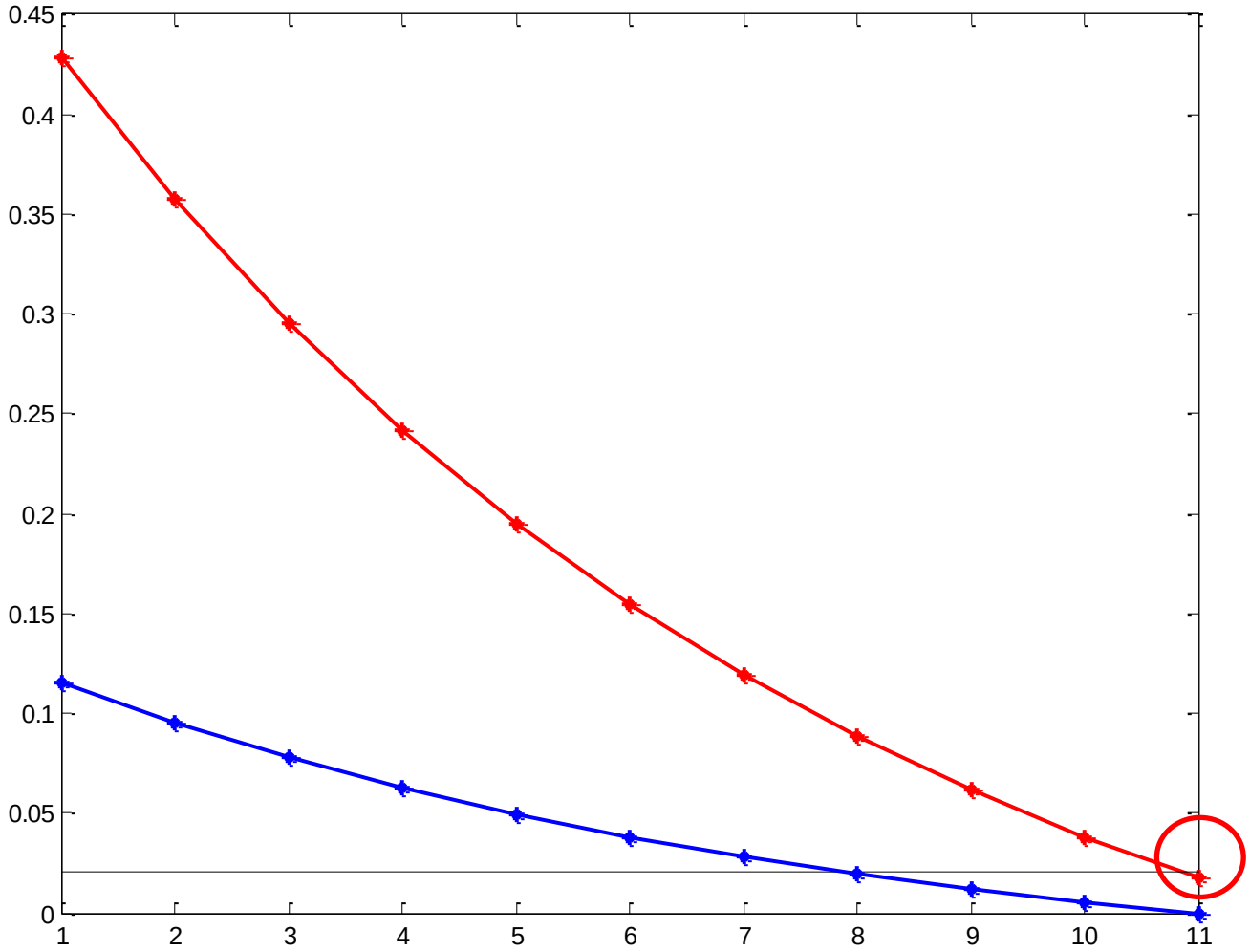
Ejemplo: 4 etapas



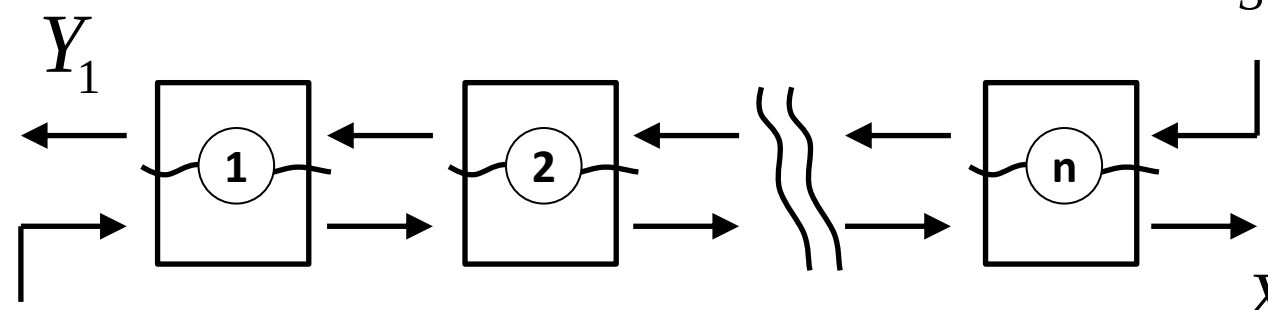
Ejemplo: 6 etapas



Ejemplo: 10 etapas



Ejemplo: Extracción de AA



$$S = 2500\ \frac{kg\ isopropyl}{h}$$

$$Y_{in} = 0\ \frac{kg\ AA}{kg\ isopropyl}$$

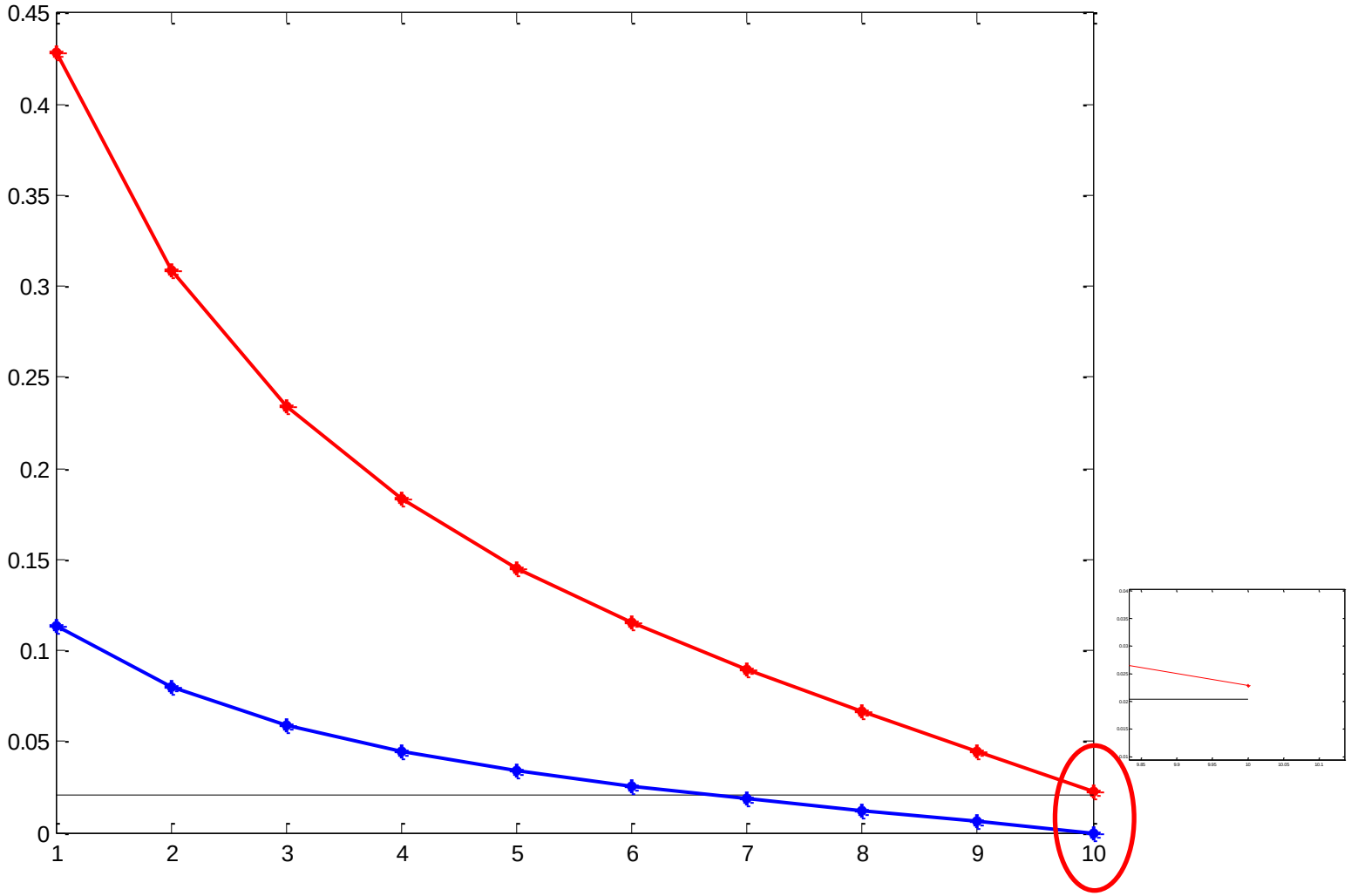
$$X_n \leq 0.0204$$

$$W = 700\ \frac{kg\ agua}{h}$$

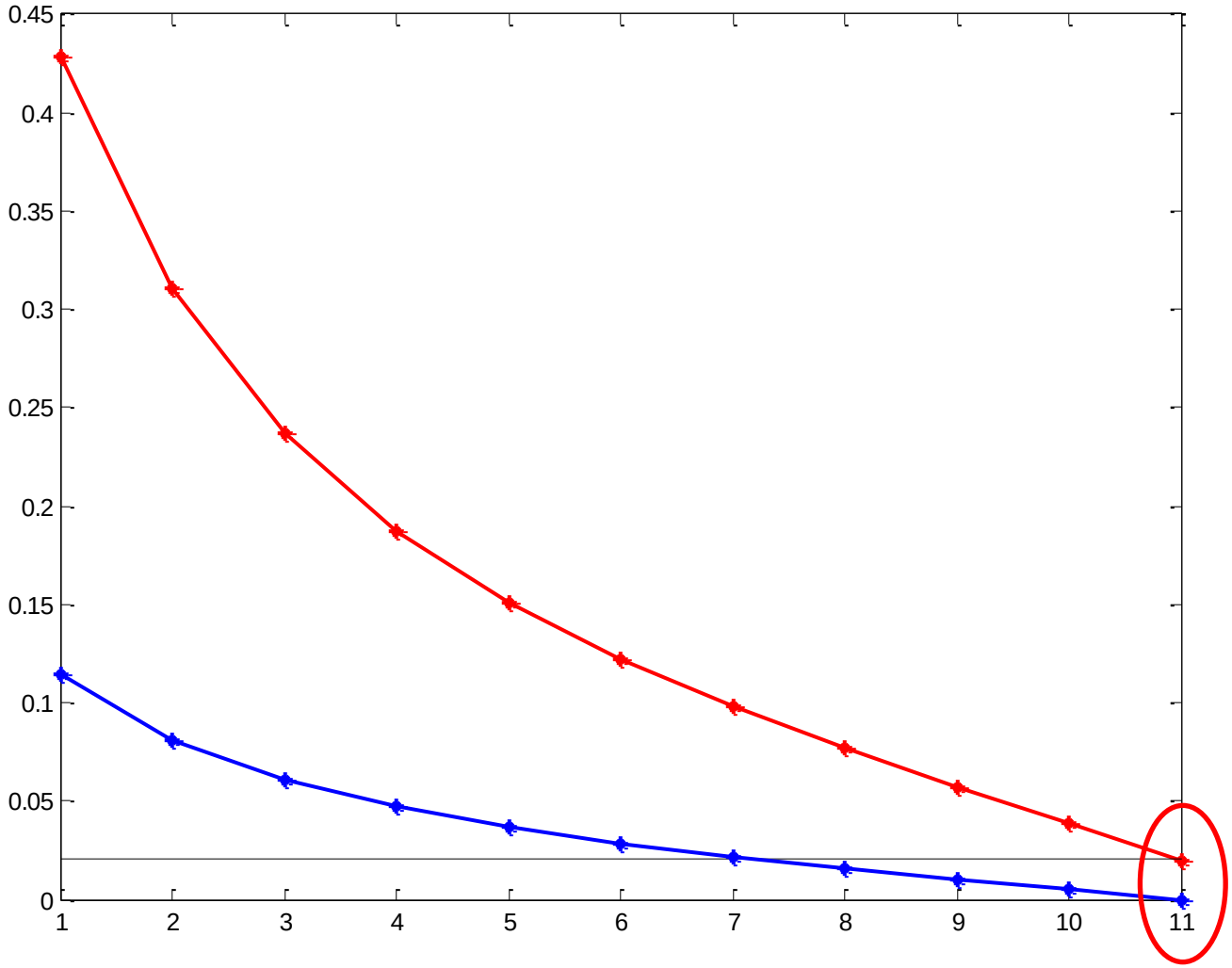
$$X_{in} = 0.4286\ \frac{kg\ AA}{kg\ agua}$$

$$K_i = 0.3618\,X_i + 0.2566$$

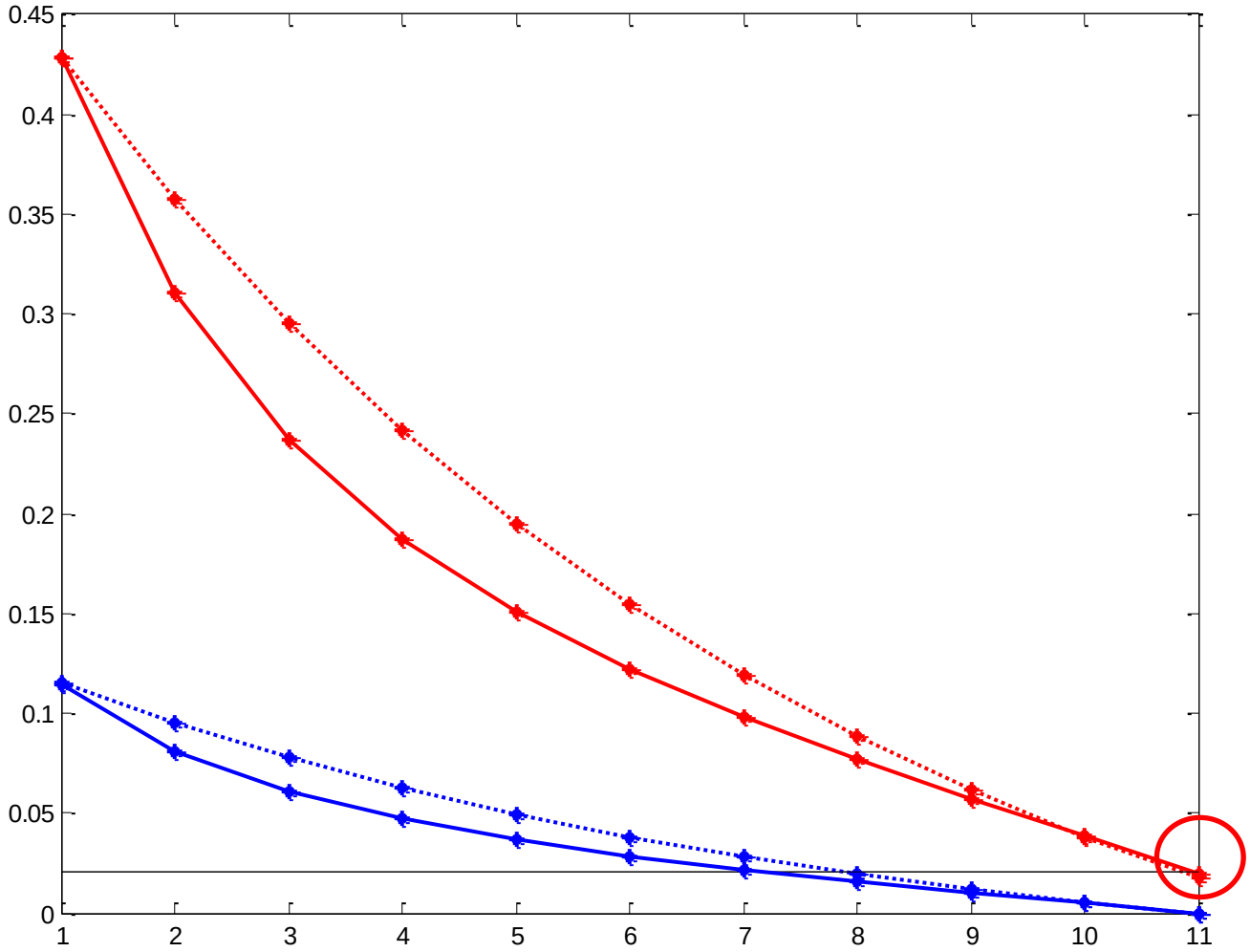
Ejemplo: 9 etapas (chi variable)



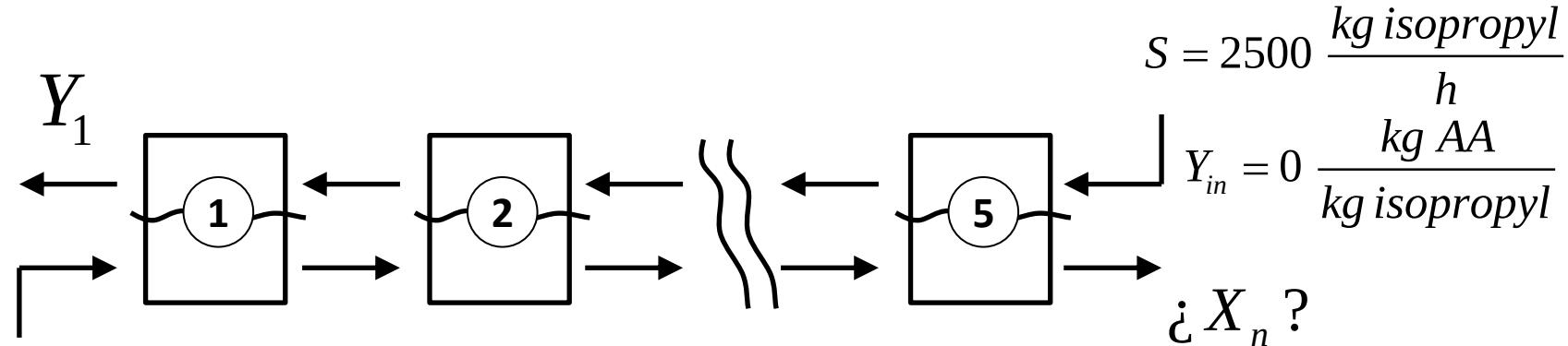
Ejemplo: 10 etapas (chi variable)



Ejemplo: Comparación



Ejemplo: Extracción de AA



$$W = 700 \frac{kg\ agua}{h}$$

$$X_{in} = 0.4286 \frac{kg\ AA}{kg\ agua}$$

$$K_i = 0.3618\,X_i + 0.2566$$

Modelado Matemático No Lineal

Suponemos las composiciones de cada etapa

$$\left(X_1, X_2, X_3, X_4, X_5\right)$$

Calculamos el chi de cada etapa

$$\chi_i = \frac{S\left(0.3618 X_i + 0.2566\right)}{W}$$

Resolvemos utilizando Thomas y obtenemos una solución

$$\left(X_1, X_2, X_3, X_4, X_5\right)^*$$

Comparamos la solución con los valores propuestos

$$\left(X_1, X_2, X_3, X_4, X_5\right) \quad \text{Vs} \quad \left(X_1, X_2, X_3, X_4, X_5\right)^*$$

Si no son similares repetimos la operación pero con

$$\left(X_1, X_2, X_3, X_4, X_5\right) = \left(X_1, X_2, X_3, X_4, X_5\right)^*$$

Modelado Matemático No Lineal

```
--> error = sqrt(sum((x-xi).^2));
```

```
xi  =            A  =

  0.4286        -2.470241    1.3382486    0.           0.           0.
  0.32645   →    1.          -2.3382486    1.2062562    0.           0.
  0.2243         0.           1.          -2.2062562    1.0742638    0.
  0.12215        0.           0.           1.          -2.0742638    0.9422714
  0.02           0.           0.           0.           1.          -1.9422714

x  =             error  =

  0.2667348      0.2558243
  0.17209
  0.112459
  0.0707679
  0.0364356
```

```
xi  =            A  =

  0.2667348     -2.261088    1.1387934    0.           0.           0.
  0.17209   →    1.          -2.1387934    1.0617416    0.           0.
  0.112459       0.           1.          -2.0617416    1.0078708    0.
  0.0707679      0.           0.           1.          -2.0078708    0.9635086
  0.0364356      0.           0.           0.           1.          -1.9635086

x  =             error  =

  0.2986169      0.0776258
  0.2165442
  0.154959
  0.1021374
  0.0520178
```

```
xi  =            A  =

  0.2986169     -2.3022843   1.1962347    0.           0.           0.
  0.2165442 →    1.          -2.1962347    1.1166578    0.           0.
  0.154959       0.           1.          -2.1166578    1.0484046    0.
  0.1021374      0.           0.           1.          -2.0484046    0.983643
  0.0520178      0.           0.           0.           1.          -1.983643

x  =             error  =

  0.2934083      0.0199159
  0.2064055
  0.143201
  0.0922373
  0.046499
```

Modelado Matemático No Lineal

Matemática Superior Aplicada

UTN

```
xi  =          A  =                                                    x  =         error  =

  0.2986169      -2.3022843    1.1962347    0.           0.           0.            0.2934083    0.0199159
  0.2165442  →    1.          -2.1962347    1.1166578    0.           0.      →     0.2064055
  0.154959       0.           1.          -2.1166578    1.0484046    0.            0.143201
  0.1021374      0.           0.           1.          -2.0484046    0.983643      0.0922373
  0.0520178      0.           0.           0.           1.          -1.983643      0.046499
```

```
xi  =          A  =                                                    x  =         error  =

  0.2934083      -2.295554     1.1831339    0.           0.           0.            0.2939532    0.0038642
  0.2064055        1.         -2.1831339    1.1014647    0.           0.            0.208079
  0.143201   →     0.           1.          -2.1014647    1.0356124    0.      →     0.1455437
  0.0922373      0.           0.           1.          -2.0356124    0.9765119     0.0944136
  0.046499       0.           0.           0.           1.          -1.9765119     0.0477678
```

```
xi  =          A  =                                                    x  =         error  =

  0.2939532      -2.2962581    1.1852964    0.           0.           0.            0.2939694    0.0005861
  0.208079         1.         -2.1852964    1.1044918    0.           0.            0.2079055
  0.1455437  →     0.           1.          -2.1044918    1.0384244    0.      →     0.1451941
  0.0944136      0.           0.           1.          -2.0384244    0.9781514     0.0940409
  0.0477678      0.           0.           0.           1.          -1.9781514     0.0475398
```

Modelado Matemático No Lineal

Matemática Superior Aplicada

UTN

xi =

0.2939496
0.2079053
0.1452237
0.0940821
0.0475669

A =

-2.2962534	1.1850719	0.	0.	0.
1.	-2.1850719	1.1040784	0.	0.
0.	1.	-2.1040784	1.0379961	0.
0.	0.	1.	-2.0379961	0.9778917
0.	0.	0.	1.	-1.9778917

x =

0.2939496
0.2079053
0.1452237
0.0940821
0.0475669

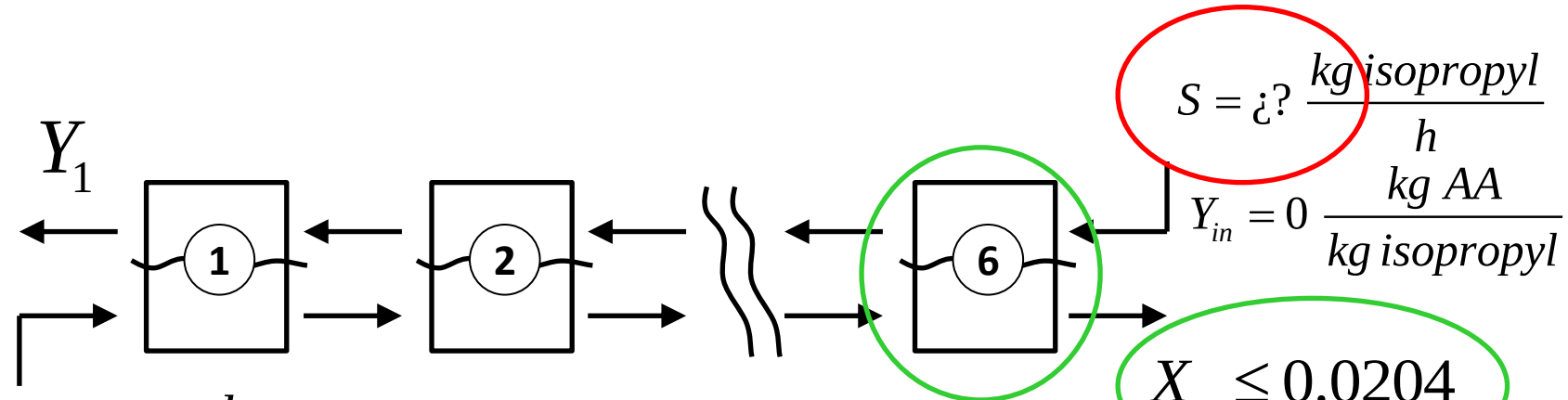
error =

3.259D-08

Modelado Matemático No Lineal

```
W=700;
xin=0.4286;
S=2500;
yin=0;
n=5;
b=zeros(n,1);
b(1)=-xin;
xi=linspace(xin,0.02,n)';
chi = S*(0.3618*xi + 0.2566)/W;
error =1;
while error > 1e-6
A = diag(ones(1,n-1),-1) + diag(-(1+chi),0) + diag(chi(2:n),1);
x = Thomas(A,b);
error = sqrt(sum((x-xi).^2));
xi = x;
chi = S*(0.3618*xi + 0.2566)/W;
end
```

Ejemplo: Extracción de AA

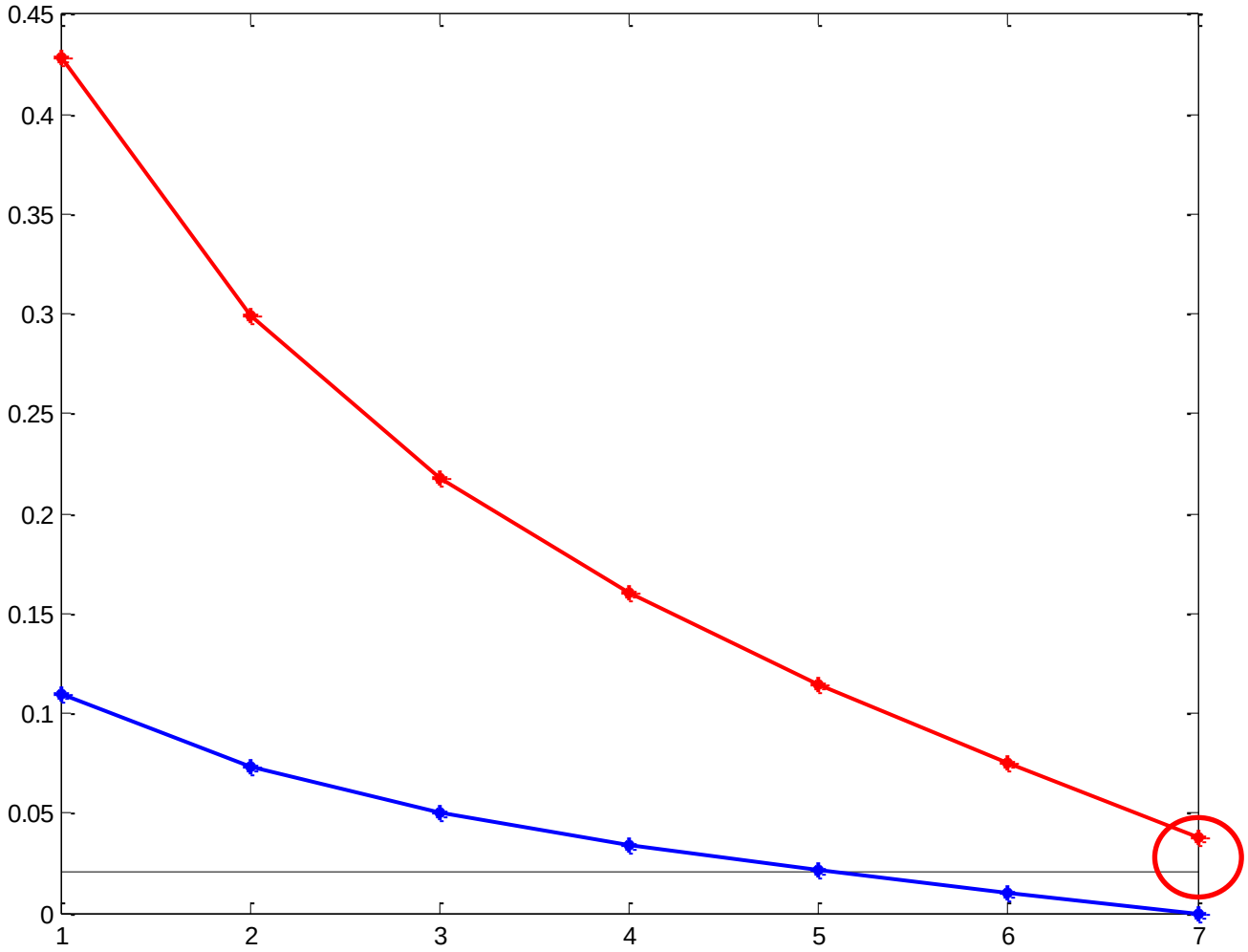


$$W = 700\,\frac{kg\ agua}{h}$$

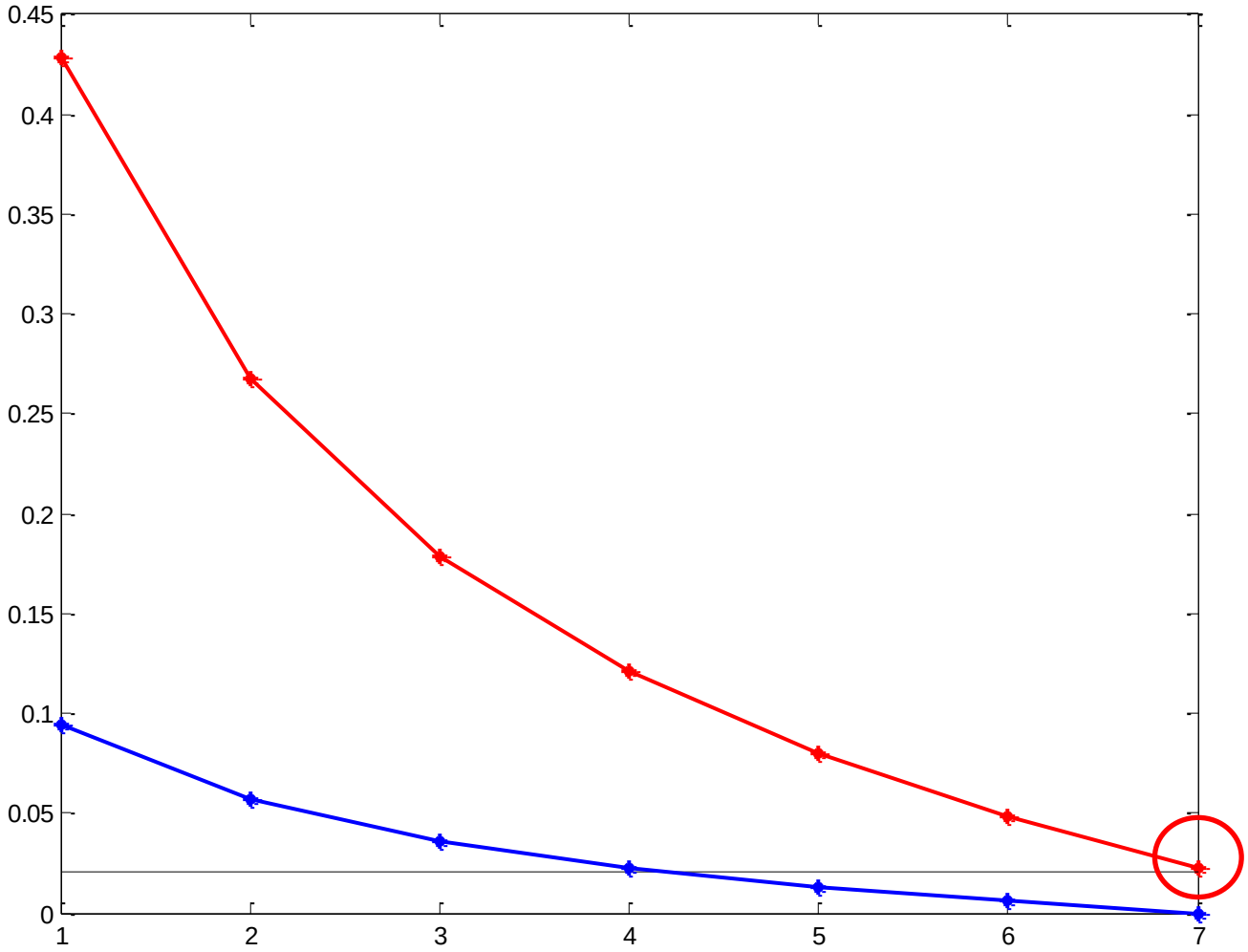
$$X_{in} = 0.4286\,\frac{kg\ AA}{kg\ agua}$$

$$K_i = 0.3618\,X_i + 0.2566$$

Ejemplo: S=2500



Ejemplo: S=3000



Ejemplo: S=3200