USE OF A NEW MODEL TO REPRESENT HYDROCYCLONE CORRECTED-EFFICIENCY CURVES

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MAIN USES OF HYDROCYCLONES

- Classification (e.g. closed grinding circuits extremely efficient at fine separation sizes)
- De-sliming (clarification)
- De-gritting
- Thickening
- Sorting

Hydrocyclone geometrical characteristics

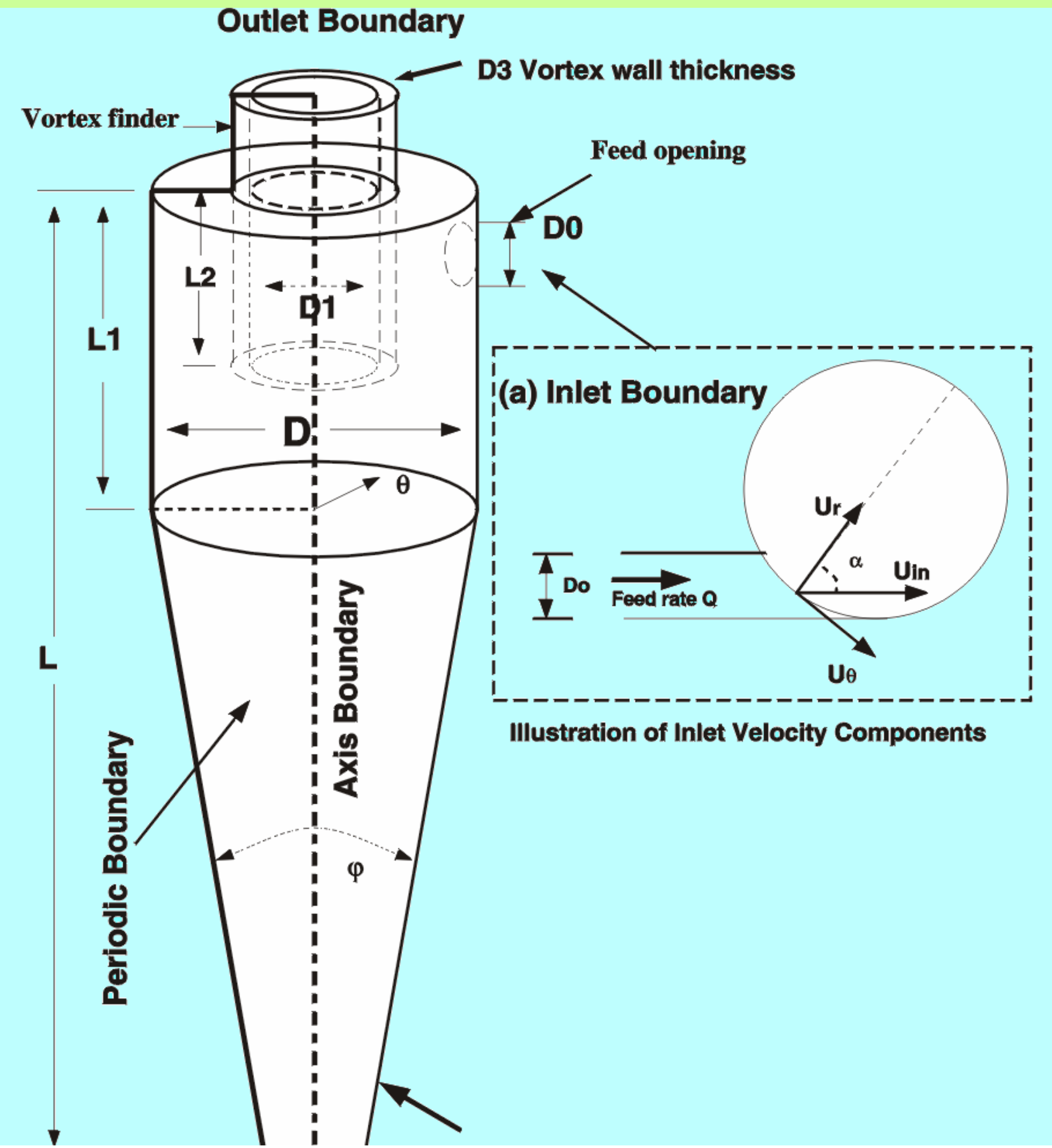
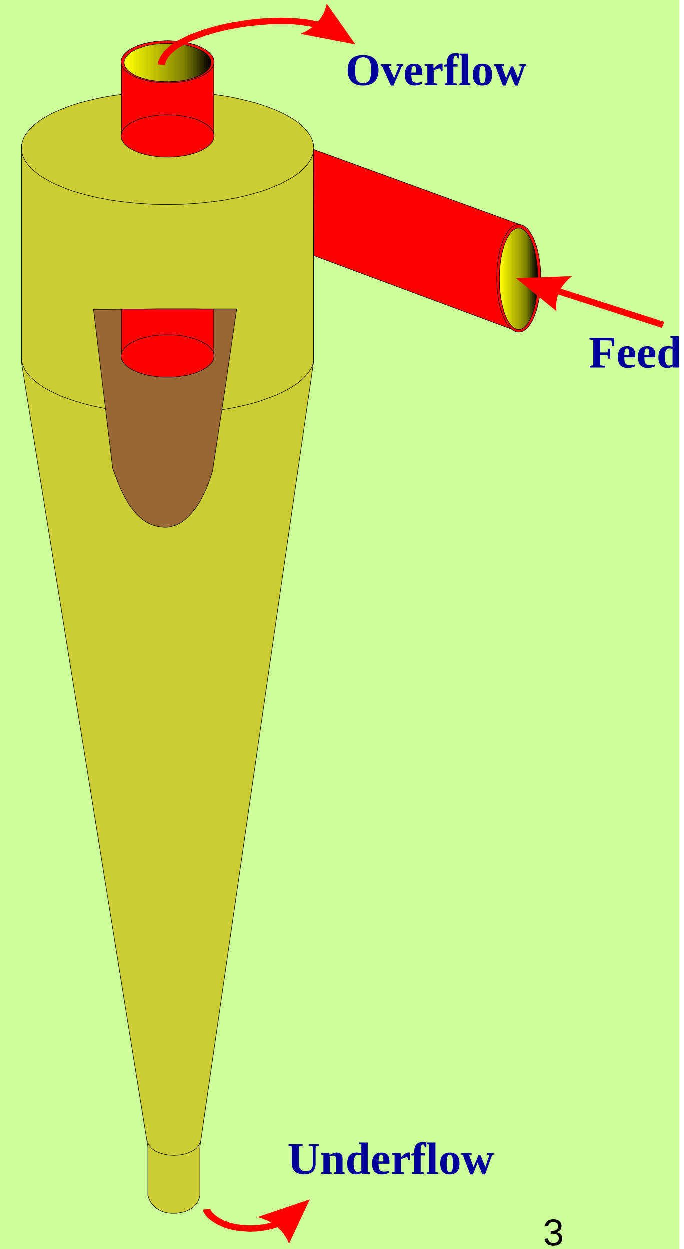
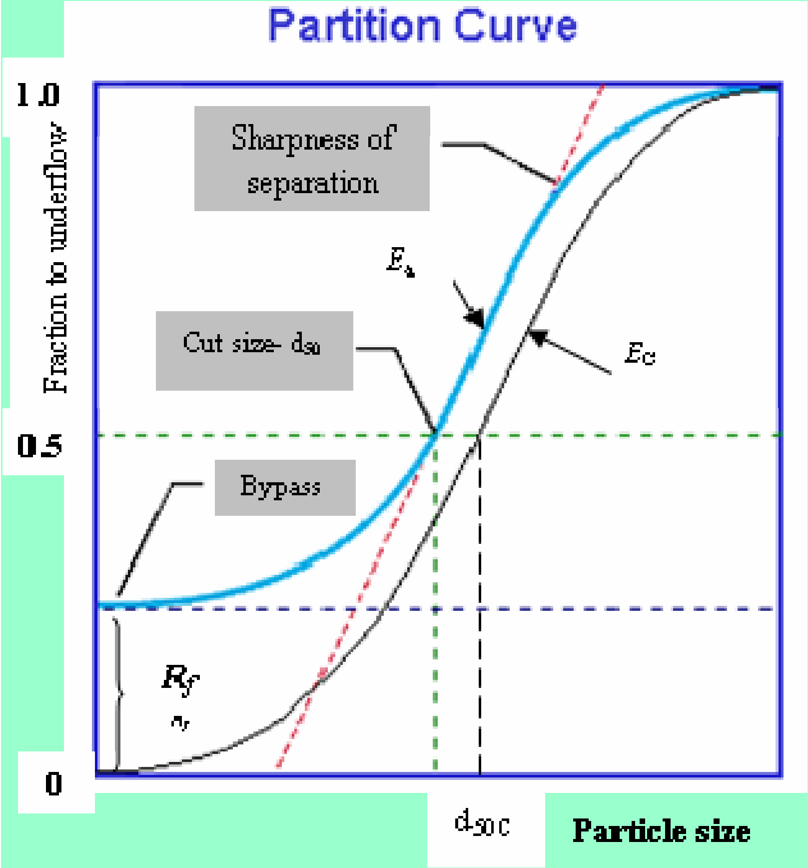


Illustration of Inlet Velocity Components



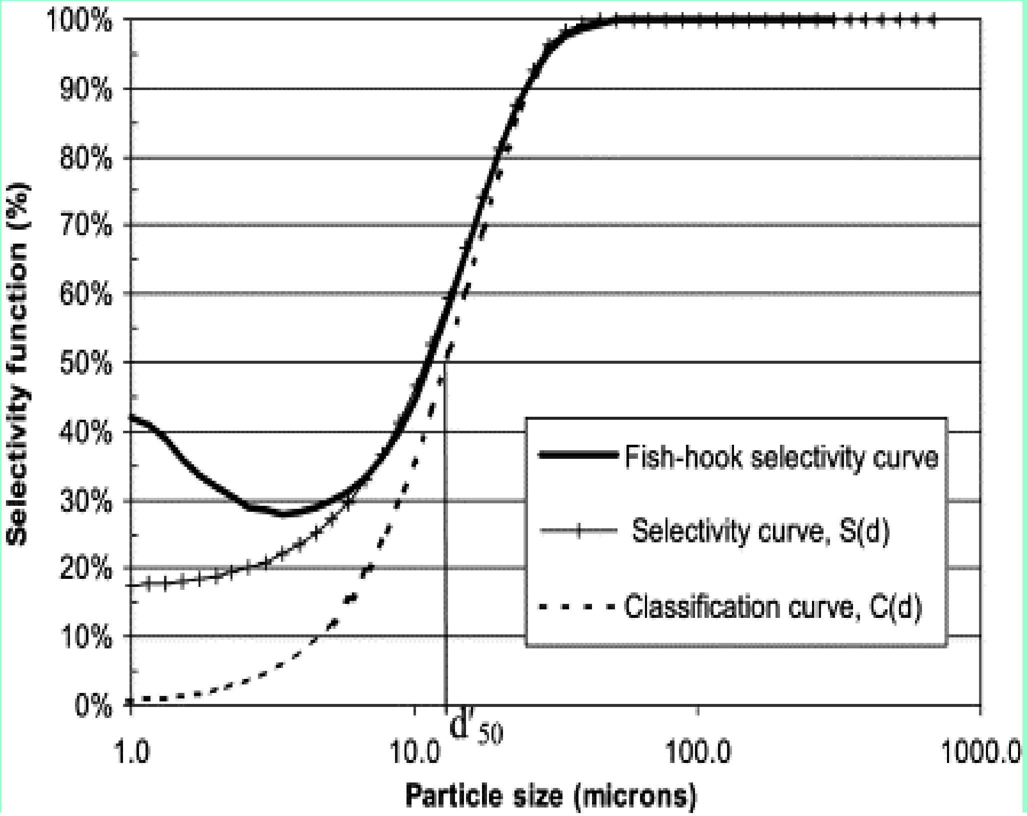
CYCLONE EFFICIENCY

- The ***partition*** or ***performance*** curve is the method of representing the cyclone ***efficiency***.
- The curve relates the ***weight fraction*** or ***percentage*** of **each size fraction** found in the feed, which reports to the **underflow** (coarse material).
- The **cut size** (separation size) or d_{50} is the mean size fraction for which, 50% of its particles in the feed reports to the underflow (equal chance of going either with the underflow or with the overflow).
- The ***sharpness*** of the separation depends on the slope of the ***central section*** of the partition curve.
- The closer to vertical is the slope, the higher is the efficiency.



Typical hydrocyclone partition curves (actual E_a and corrected E_c efficiency curves)

Comparison between typical partition curves and the fish-hook effect



CYCLONE EFFICIENCY (continued)

- The slope of the partition curve can be approximated from the below given equation (d_{75} and d_{50} are the particle sizes on the curve with 75% and 25% of the feed in the underflow).
- The efficiency of the separation is called also **imperfection *I*** and is given from the same equation.

$$I = \frac{d_{75} - d_{25}}{2d_{50}}$$

RELATIONSHIP BETWEEN actual efficiency E_a and corrected efficiency E_c

- In many mathematical models of hydrocyclones the term (mean size fraction) d_{50c} is used, since it is assumed that solids from all size fractions are entrained in the coarse product due to **short –circuiting,** in direct proportion to the fraction of feed water reporting to the underflow.
- The relationship between E_a (separation size d_{50}) and E_c (d_{50c}) is given from

$$E_c = \frac{E_a - R_f}{1 - R_f}$$

Models used for the corrected efficiency E_c curves

$$E_c = \frac{e^{[a(d/d_{50c})]} - 1}{e^{[a(d/d_{50c})]} + e^{a} - 2}$$

(Lynch model, 1965)

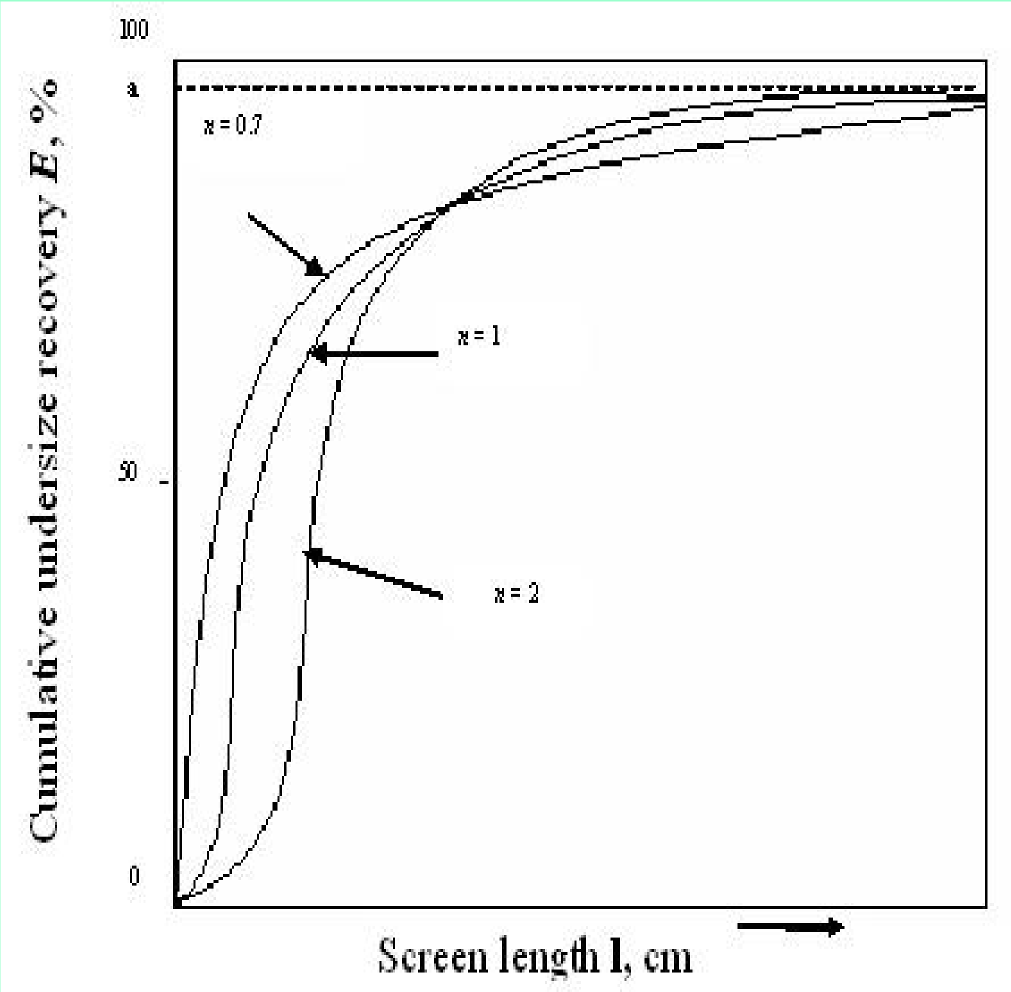
$$E_c = 1 - e^{\left[-0.6931\left(d/d_{50c}\right)^{m}\right]}$$

(Plitt-Reid model, 1971)

$$E_c = 1 - \left[1 - (d/d_{max})^{m}\right]^{r}$$

(Harris model, 1972)

DERIVATION OF THE NEW MODEL



Model used

$$E = ae^{-\left(\frac{b}{l^n}\right)}$$

NEW MODEL

- Equation can be suitably modified to give:

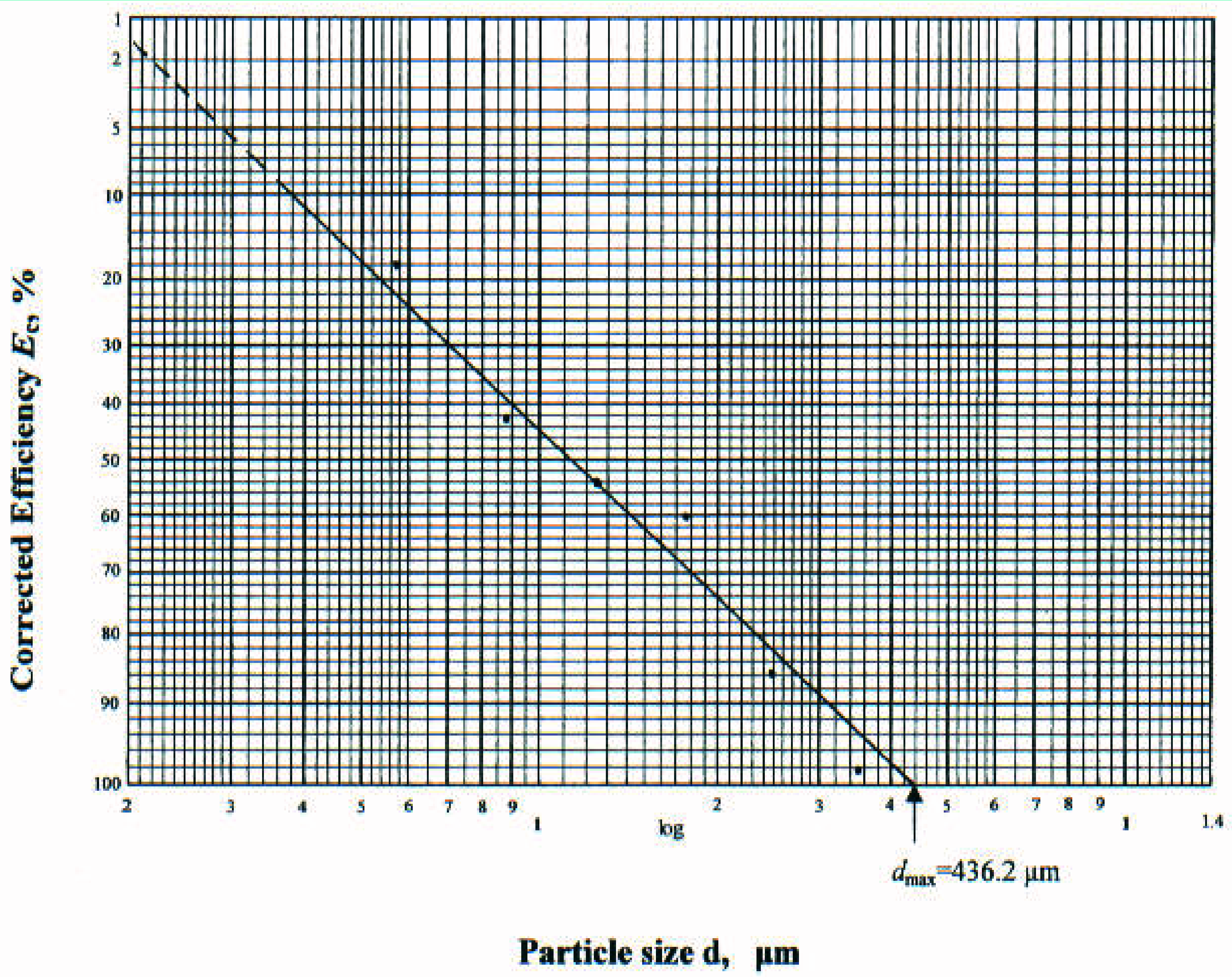
$$E_c / 1.359 = e^{-\left(d_{50c}/d\right)^n}$$

$$A = e^{-\left(d_{50c}/d\right)^n}$$

OBSERVATIONS ON THE MODEL

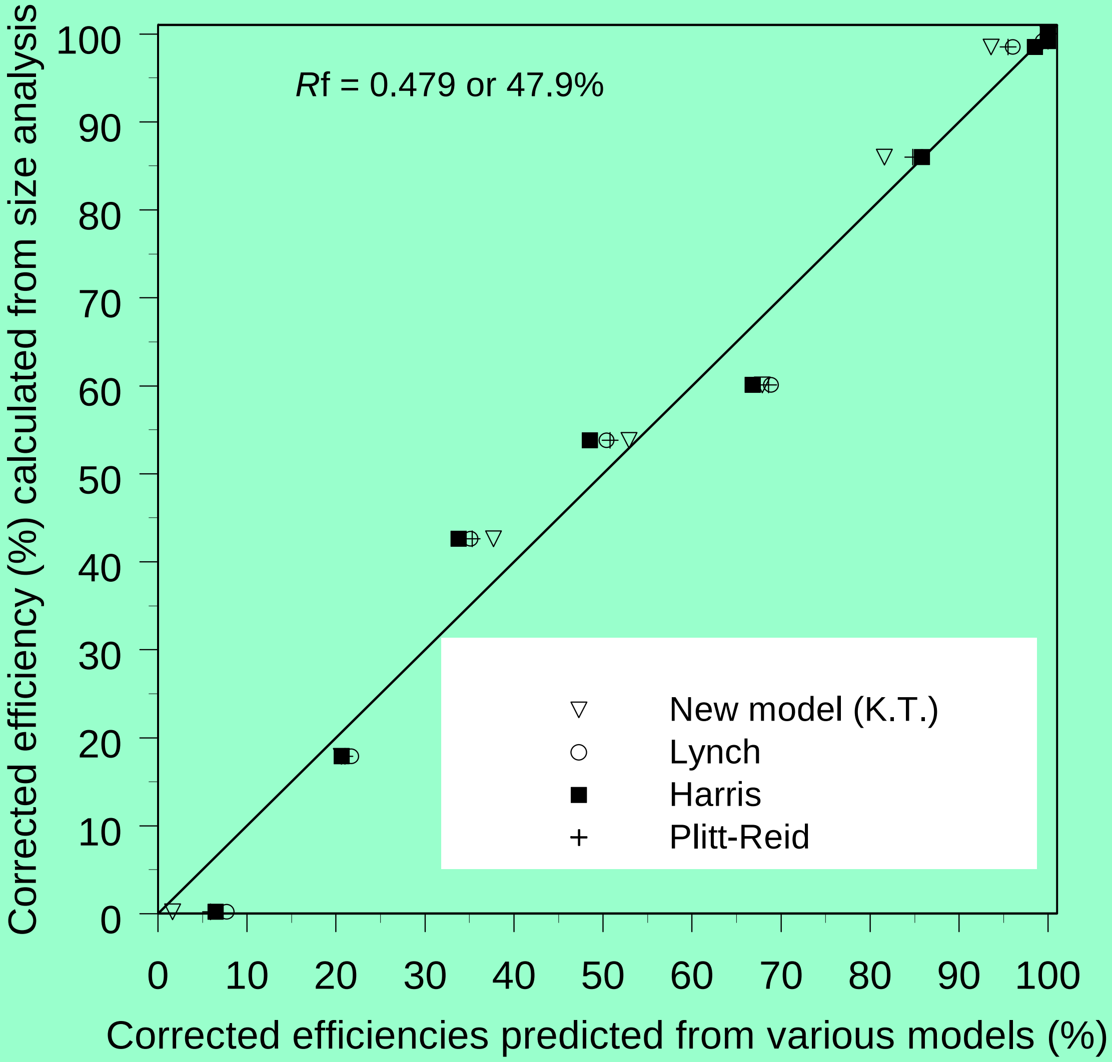
- The model is a ***modified*** Rosin-Rammler equation. It is clear that, when $d=d_{50c}$ then A=0.3679 or 36.79%, which corresponds to E_c=0.5 or 50%. Similarly, when E_c=1 or 100%, then A=0.7358 or 73.58 %. Taking into account the above observations, the ordinate (y-axis) of a Rosin-Rammler graph was modified, putting in the points of 36.79% and 73.58% retained, the values 50% and 100% for E_c, respectively.

$$A = e^{-(d_{50c}/d)^n}$$



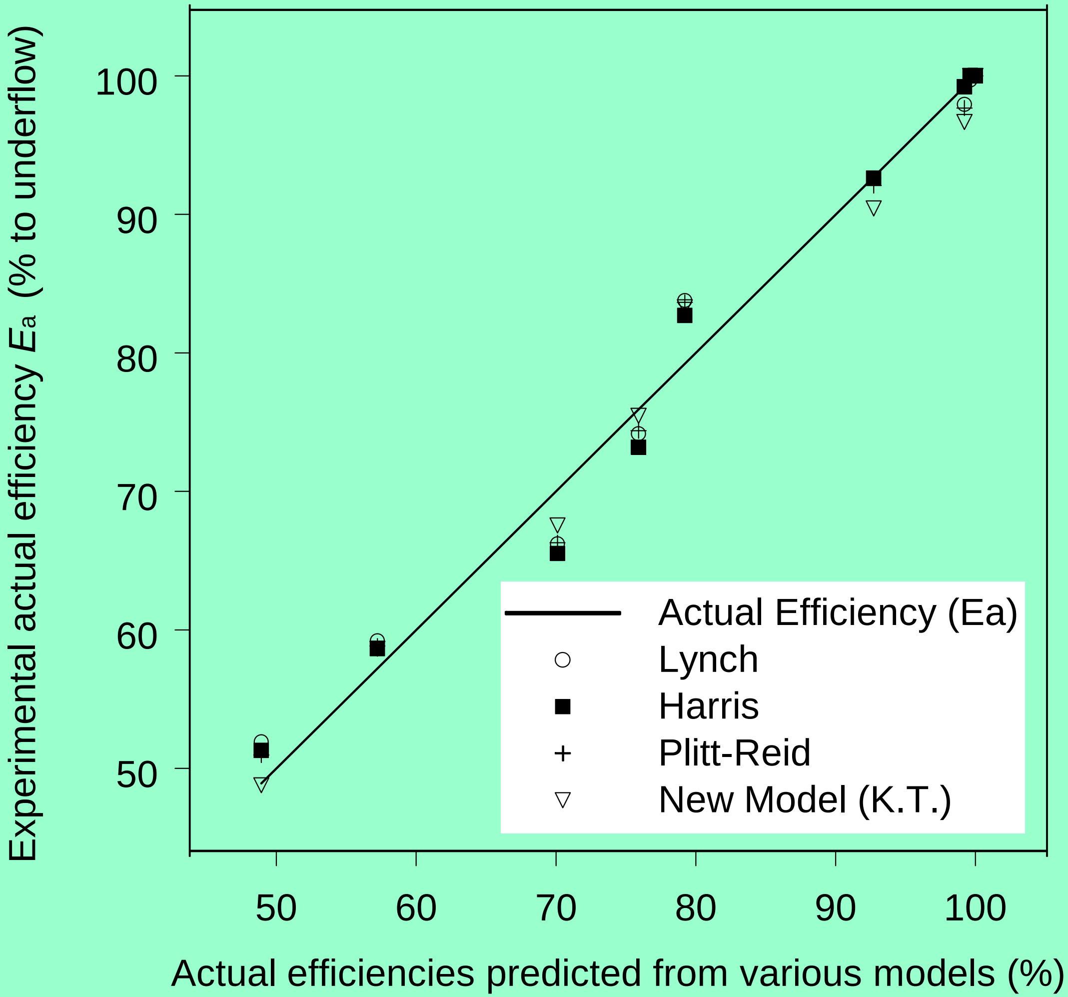
Corrected Efficiency E_{cs} %
1
2
5
10
20
30
40
50
60
70
80
90
100
2
3
4
5
6
7
8
9
1
log
2
3
4
5
6
7
8
9
1
1.4
d_{max}=436.2 µm
Particle size d, µm

RESULTS



Comparison of the corrected efficiency $\boldsymbol{E_c}$, calculated from the experimental actual efficiency $\boldsymbol{E_a}$, with the corrected efficiencies predicted from the various models. Solid line corresponds to **y=x**.

RESULTS (continued)



Comparison of the actual efficiencies predicted from various models to the actual efficiency (***E_a***) from size analysis. Solid line corresponds to **y=x.**

COMPARISON between the various models

Model	**Lynch**	**Plitt-Reid**	**Harris**	**New model**
Values of the parameters	d_{50c} = 123 µm	d_{50c} = 122 µm	d_{max} = 433.1 µm	**d_{50c} = 116 µm**
	a = 1.602	**m = 1.42**	**m = 1.263**	**n = 0.892**
			r = 2.878	
Method of prediction	Non-linear regression	Simple linear regression & graphically	Non-linear regression & graphically (very complicated)	**Simple linear regression & graphi-cally**

CONCLUSIONS

- The model is a powerful ***two-parameter*** model.
- Its parameters describing the performance of a classifier can be **mathematically** and **graphically** obtained with **accuracy comparable** to that presented by the already known models.
- It can be used as an alternative tool or in parallel with the already applied models for the prediction of d_{50c}, d_{max} and d_{50} (actual separation size).
- d_{50} (**28.3 μm**) predicted (from the new model) is closer to the experimental one **(>22 μm)**, than those predicted from the other models (from 11.83 to 16.7 μm). Probably this is due to the superior fitting capability of the proposed model for the fine size fractions.

CONCLUSIONS (continued)

- It can also be thought as an advantage of the proposed model that E_c is predicted to be ***1.359*** or ***135.9%*** at infinite particle size, whereas E_c = ***1*** or ***100%*** at a finite particle size d_{max}, as it actually happens in wet classification.
- The proposed model is in most cases **reliable** and **adequate** for the representation of the classifier efficiency (corrected and afterwards actual).
- It needs further testing for its applicability to other classification tests.
- It proved to be valid for the cases examined here.

THANK YOU