Development of a javascript web software for centrifuges sizing

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***Abstract*— As the technology advances the way of performing daily tasks have been up to dated, once basic activities earlier made by the human hands have been replaced by modern technologies. In this sense, Optas (Unit Operation Software) was developed using technology in favor of chemical engineering teaching. This software was programmed in a way to permit the users to size on-line different industrial operations, besides providing explanations on the involved key variables and obtained results, based on specialized literature.**

Keywords—javascript web; unity operation; chemical engineering ; tubular centrifuge; basket centrifuge

I. Introduction

There are many softwares available that perform many operations. These operations are useful for solve chemical engineering problems and can be used for teaching in universities. This uses become common as the technology advances [1]. Based on that, Optas was design to offer an online option for students.

Optas is a program developed on the Javascript web platform, applying concepts of the class unit operations theory in an automated system, which has as premised being used of the unit operations teaching in graduation engineering courses. To exemplify the application of Optas, this paper will cover the design of a tubular centrifuge and a basket centrifuge.

Centrifugation is the unit operation that utilizes the application of rotation in a liquid-particle system to accelerate the settling process. This process applies centrifugal force to separate the particles from the liquid [3]. In this process, it can be measured the particles diameters in which there will be a collection effectiveness and the variables that exert influence on the equipment efficiency [4].

II. MATERIAL AND METHODS

In order to begin the sizing, the users must know the parameters values required by the system as: the particle sphericity (ϕ), the solid density (p_s), the liquid density (p_f), the liquid viscosity (μ), the centrifuge height (l) , the centrifuge radius (r), the distance between centrifuge wall and the outlet nozzle (H) and the system feed flow (q) [2].

Given the values for the parameters, it's possible to calculate the system variables, residence time (t_r), particle drop time (t_q), cutting diameter (d_c), particle terminal velocity (v_t), efficiency (n_f) [2].

Optas was structured in accordance with the literature to consider some particularities on the centrifuges involving the working operation regimes as: the ratio between the height of the centrifuge and its diameter, the comparison between the angular velocity and the system flow rate, the range of values in which the system can operate and achieve with better efficiency [2].

First the values are converted to SI to standardize the units and maintain the cohesion of the calculations [4].

The second step is to apply the working conditions in logical comparison system, as an example the equation demonstrates the flow comparison for a tubular system.

$$\text{if } (q1 <= qt1 \;\&\&\; q > 0) \tag{1}$$

In this system the flow is compared to the input value that must be less than or equal to that was established in the literature and greater than zero. If after comparison the system finds that the indicated flow rate is not within the set parameters, it informs the user that their data is not correct for a centrifuge system.

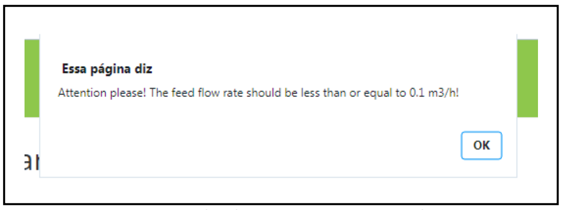

Fig. 1. Error massage for flow on tubular centrifuge.

If the data entered for the feed flow is in accordance with set parameter, the software step forward to perform the angular velocity comparison. If the velocity is unknown, the Optas establishes the average angular velocity as the basis of calculation and, if the velocity is outside the parameters, it informs the user.

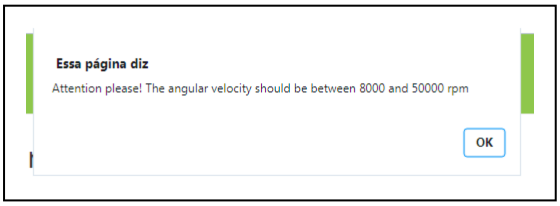

Fig. 2. Error massage for angular velocity.

If the data entered for the speed is in accordance with the literature, the system applies the comparative ratio of the height to the diameter of the centrifuge. If the ratio is outside the parameters established in the literature, the system informs the user.

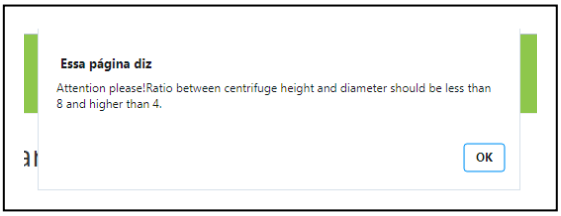

Fig. 3. Error massage for ratio between height and diameter.

If the data entered is in accordance with the literature then the system can perform the calculations for the system.

For the basket centrifuge the flow rate should be between 6 and 10 m³ / h, the angular velocity between 350 and 450 rpm and the height to diameter ratio should be 0.6. In order to size the centrifuges the formulas was transcript to the javascript web language.

III. Sizing a Tubular Centrifuge

For basket centrifuges the feed speed is determine with the equation

$$uz = q / (2 * r * h); \tag{7}$$

The terminal velocity of the particle is defined as

$$vt = q / (4 * \pi * r * l); \tag{8}$$

Particle residence and fall times are direct influences of particle feed velocity and terminal velocity.

$$tq = (h / 2) / vt; \tag{9}$$

$$tr = l / uz; \tag{10}$$

The smallest radius of the centrifuge refers to the space between the centrifuge center and the centrifuge inlet nozzle and is defined by the equation

$$rl = r - (h / 2); \tag{11}$$

It can be define the smallest diameter collected by the centrifuge with 100% efficiency which is called the minimum diameter and the cutting diameter for 50% efficiency.

$$dmin = ((9 * mi_1 * q_1) / (\pi * r^2 * l * (ps - p) * w_1^2))^{1/2}; \tag{12}$$

$$dc = ((9 * mi_1 * q_1) / (2 * \pi * r^2 * l * (ps - p) * w_1))^{1/2} \tag{13}$$

Where:
mi_1= viscosity ((kg/ (m.s)),
q_1= feed flow (m³/s),
w_1= angular velocity (m/s).

The variables presented with $_1$ in front indicate that their values were adequate for SI.

To calculate the efficiency, Optas performs a secondary calculation for the ratio of the particles minimum diameter and the particles cutting diameter, and then applied to the efficiency formula.

$$dd = dmin / dc; \tag{14}$$

$$nf = 0.5 * dd^2 \tag{15}$$

At the end of the calculations of equations (7) to (15), Optas will supply the centrifuge suitable dimensions for the user.

IV. Sizing a Basket Centrifuge

For a basket centrifuge the feed speed is determine through equation (16).

$$uz = q_1 / ((2 * \pi * r * h) - (\pi * h^2) \tag{16}$$

On the other hand, the particles terminal velocity is defined by equation (17).

$$vt = q_1 / (4 * \pi * r * l); \tag{17}$$

The smallest radius of the centrifuge refers to the space between the centrifuge center and the centrifuge inlet nozzle and is defined by the equation

$$rl = (r^2 - (r * h) - (h^2 / 2))^{1/2}; \tag{18}$$

Particle residence and fall times are direct influences of particle feed velocity and terminal velocity.

$$tq = (r - rl) / vt; \tag{19}$$

$$tr = ((r * \pi * r * h) - (\pi * h^2 * l)) / q_1; \tag{20}$$

It can be define the smallest diameter collected by the centrifuge with 100% efficiency which is called the minimum diameter and the cutting diameter for 50% efficiency.

$$rh = (r - h); \tag{21}$$

$$dmin = ((18 * mi_1 * q_1 * \ln(r / rh)) / (\pi*(2 * r * h - h^2 * l * (ps - p) * w_1^2))^{1/2}; \quad (22)$$

$$dc = ((18 * mi_1 * q_1 * \ln(r / rl)) / (\pi*(2 * r * h - h^2 * l * (ps - p) * w_1^2)^{1/2}; \quad (23)$$

To calculate the particles collection efficiency by the centrifuge, Optas performs an additional calculation to avoid errors with the javascript language (equation 24) and correctly applies the calculated value in the efficiency equation (25).

$$ctb = -(d^2 * (ps - p) * w1^2 * \pi * l * ((2 * r * h) - h^2) / (9 * mi_1 * q_1)); \quad (24)$$

$$nf = (r^2 / ((2 * r * h) - h^2) * (1 - exp^{ctb}); \quad (25)$$

V. TEMPLATE AND EXECUTION

Opening the program, two sizing options appear to user, as shown at the Figure 4: tubular centrifuges or basket centrifuges.

Fig. 4. Home page for centrifuges.

By selecting the option “tubular”, a new page will be opened, requiring the variables data entering needed for the sizing calculations, as ilustratted by Figure 5.

Fig. 5. Webpage for of tubular centrifuge dimensioning.

As a next step, Optas will open a pop-up page presenting presenting the calculated variables (Figure 6). If the variables do not attend the criteria on the item I, Optas will present an error message for the user analysys.

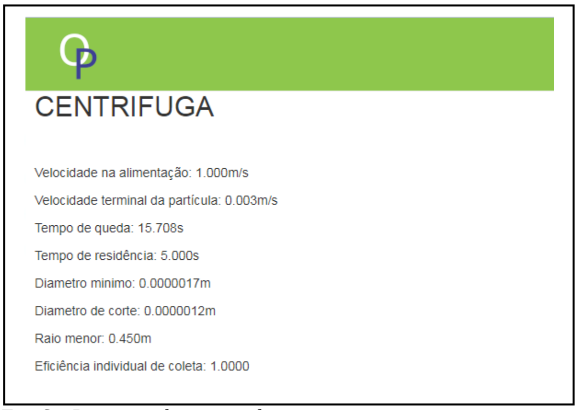

Fig. 6. Pop up with measured system parameters.

By selecting the second option “cesto”, a new page will be open as asimilar way as for the option ”tubular”, demanding the user the insertion of data, on the variables needed for the dimensioning calculations, as Figure 7 shows.

Fig. 7. Webpage for basket centrifuge dimensioning.

After iserting the necessary variables data, Optas will open a pop-up page to present the user, the dimensions reached for the basket centrifuge (Figure 8). If the variables do not attend the criteria described at the item I, Optas will present an error message for the identified problem, permiting the user analisys.

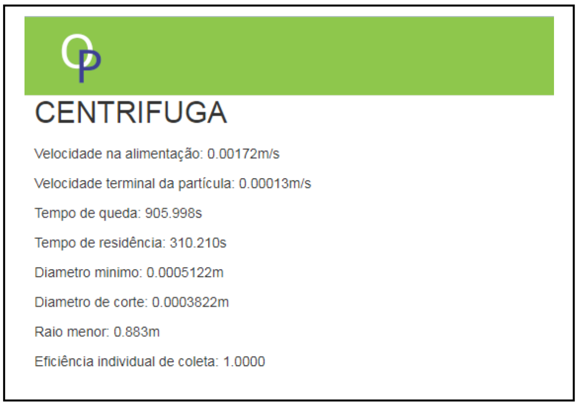

Fig. 8. Pop-up page showing the results for the basket centrifuge.

As a matter of fact, for any of the two sizing options, Optas operates in similar way, offering the users a friendly interface for obtaining reliable results for the tubular or basket centrifuges' dimensions.

VI. CONCLUSION

The Optas successfully scales the centrifuges according to the regimes established by the specialized literature.

The program was developed to fill a gap in online softwares for unit operations dimensioning within education. The future development will address the unit operations taught on engineering graduation.

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