VisiMix TURBULENT.
Tackling Safety Problems in Stirred Reactors:
Incident / Accident Investigation

Incident / Accident Description.

An incident took place in the crystallizer for the phosphoric acid production (with volume >2000 m^3) equipped with a massive cast impeller with a tip diameter 5.33 m and mass about 2000kg and a draft tube. The crystallizer design is similar to the depicted below in the Figure 1. The incident starts shortly after the drive motor startup. It was noticed that the startup was followed by the shaft vibration. This fact was placed in the center of the accident investigation.

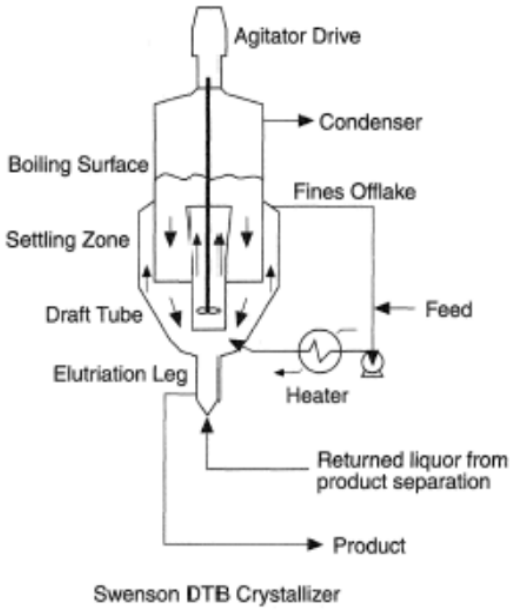

Figure 1. Crystallizer with a Draft Tube

Problem Solution.

The equipment menu of the existing VisiMix® version does not consider agitators inserted into a draft tube. Because of this, VisiMix® application is based on the simplified model that differs from the original design by the lack of the draft tube (see Figure 2).

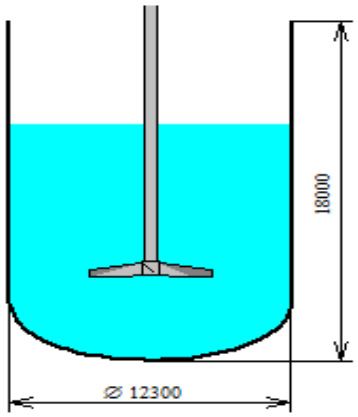

Figure 2. VisiMix® Simplified Model

The VisiMix® model of the shaft is presented in the Figure 3.

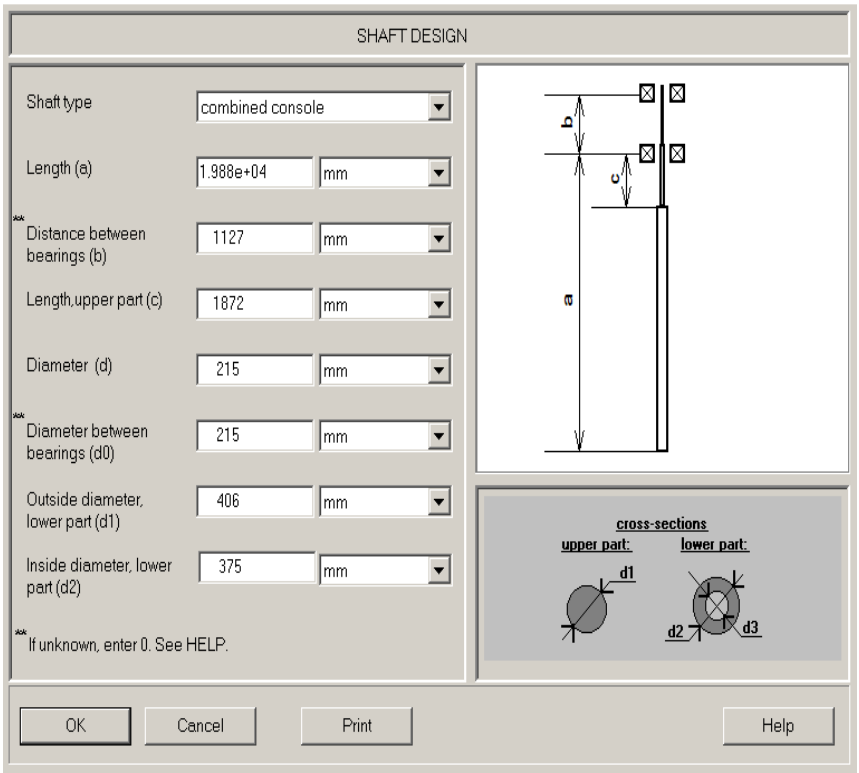

Figure 3. The VisiMix® Model of the Shaft

Analysis Results.

As far as the problem under investigation is connected with the shaft breakage the VisiMix® submenu **Mechanical calculation of the shaft** was selected for the following study. This submenu enables to define **Torsion shear** and **Shaft vibration characteristics**. Any of them results in the following warning message (Fig.4).

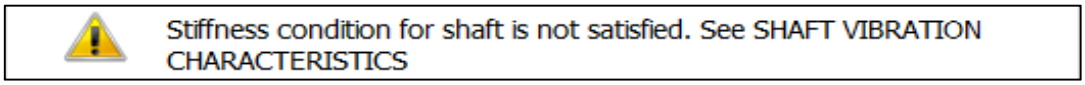

Figure 4. The VisiMix® Warning Message

Checking shaft vibration characteristics results is presented in the following table (Fig.5).

Parameter name	Units	Value
Critical frequency	1/s	0.309
Rotational frequency	Rps	0.412
Rotational to critical frequency ratio		1.33

Figure 5. Shaft vibration characteristics

The fact, that the shaft rotational frequency exceeds it critical value, means that after the massive impeller motor was switched on, the rotation speed increases gradually from the zero value up to the operation one. This start regime because of the impeller considerable mechanic inertia goes slowly and there is always a time interval when the shaft rotational frequency is close or equal to critical frequency that causes resonance oscillation with possible subsequent shaft breakage.

A possible solution of the above problem is to increase the shaft stiffness. It can be achieved by replacement of the existing shaft with a mechanical scheme (combined console) with a new shaft with another mechanical scheme (combined beam) presented below in the Fig.6. Modified Shaft vibration characteristics are presented in the following table (Fig.7).

Conclusion.

The table with Modified Shaft vibration characteristics conclusively demonstrates that the rotational frequency of the modified shaft is much below its critical frequency and thus the modified shaft design does not jeopardize appearance of the resonance oscillations.

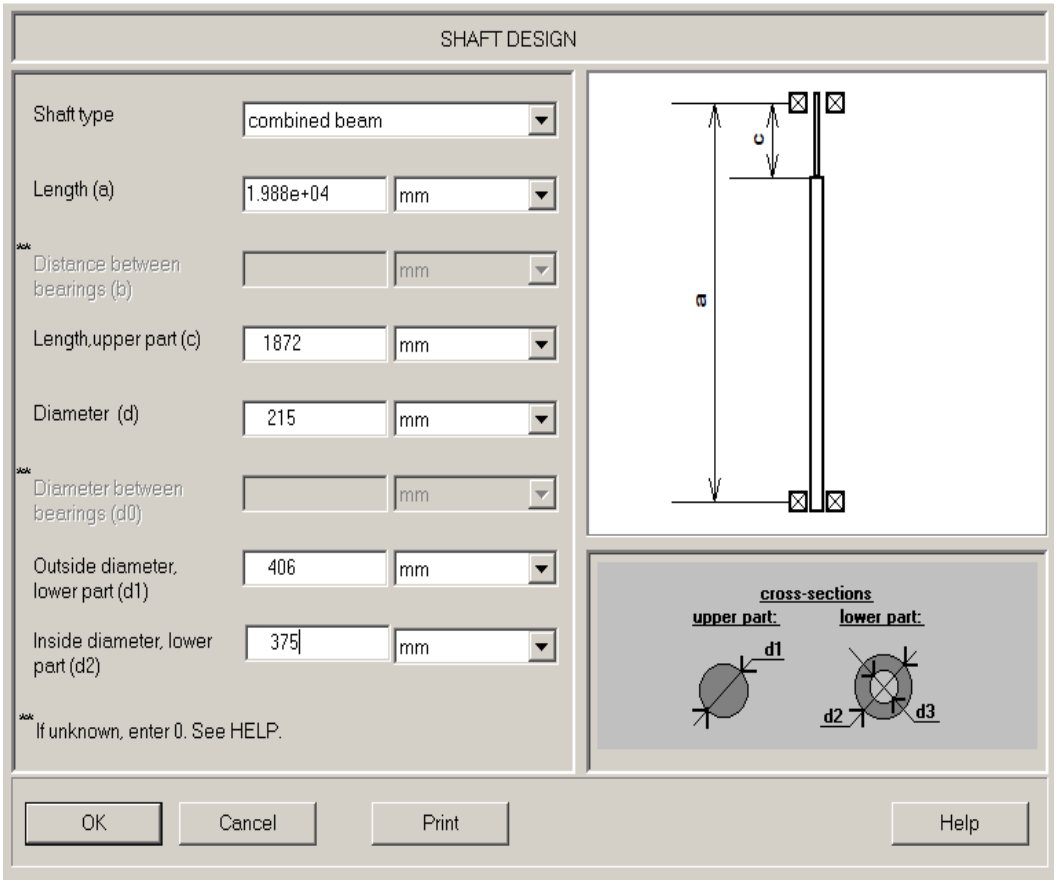

Figure 6. The VisiMix® Model of the Modified Shaft

SHAFT VIBRATION CHARACTERISTICS

Parameter name	Units	Value
Critical frequency	1/s	1.55
Rotational frequency	Rps	0.412
Rotational to critical frequency ratio		0.266

Figure 7. Modified Shaft Vibration Characteristics