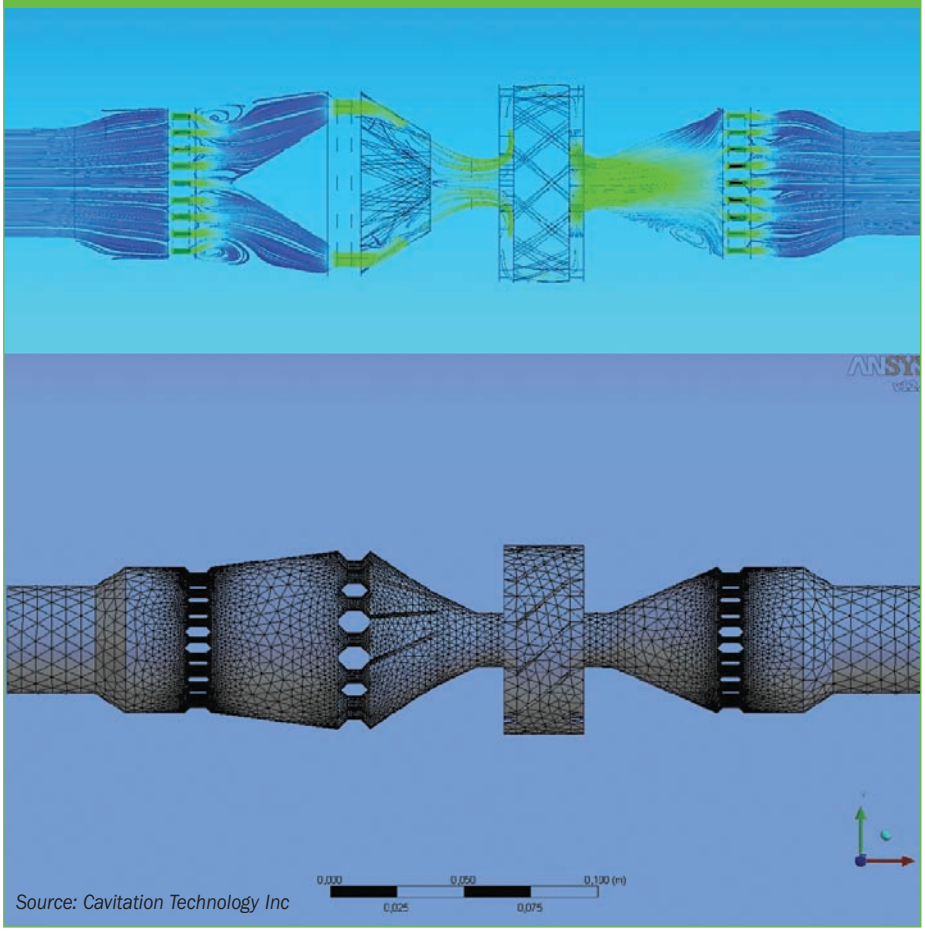
Nano cavitation: a proven new concept

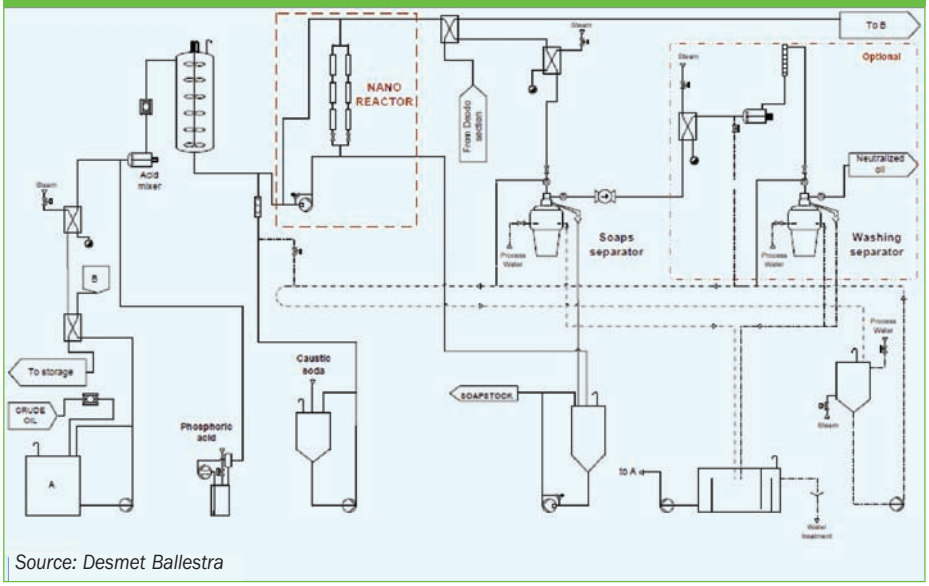
Nano neutralisation is a novel technology which increases oil yield while substantially reducing the chemicals required to produce refined vegetable oils. Dr Marc Kellens explains the process behind the technology

FIGURE 1: COMPUTER IMAGE OF A NANO REACTOR (INTERNAL)



Source: Cavitation Technology Inc

FIGURE 2: TYPICAL NANO NEUTRALISATION PROCESS FLOW DIAGRAM



Source: Desmet Ballestra

Most vegetable oils need to be refined to render them more suitable for their final use, be it human consumption or industrial use. The main components to be removed are the free fatty acids (FFAs) and phospholipids. They are usually removed by applying a caustic soda and acid treatment in neutralisation and degumming, respectively.

Apart from these main unwanted oily substances, other minor components are also removed in refining.

Over the last decades, some important improvements have been introduced in oil treatment processes. Improved mixing of chemicals in caustic soda and acid treatment using ultra high shear mixers, and the introduction of enzymes (phospholipases) to specifically attack the gums, have substantially improved the efficiency of these wet oil treatment processes.

Today, a modern neutralising plant can produce oil with less than 0.05% FFAs and less than 5ppm in phospholipids in the oil exiting the plant.

The use of computer-controlled instruments and the development of better performing centrifugal separators have further helped vegetable oil refiners to better control their operation, decreasing their operating costs and improving oil yields. However, the basic process has remained unchanged for several decades.

Nano cavitation has now found its way into these processes and the first industrial application, nano neutralisation, is being commercialised successfully.

Nano neutralisation is a real novel, patented technology developed by Cavitation Technology Inc (CTI), USA, and introduced to the oils and fats processing industry by Belgium's Desmet Ballestra. It has been proven to increase oil yield and substantially reduce the chemicals required to produce refined vegetable oil while maintaining, and even improving, oil quality.

The heart of the technology is the Nanocavitation reactor. A nano reactor is a static device with no moving parts (*see Figure 1, above*). Its name is derived by the creation of nanometer-sized bubbles that are formed while the fluid is pumped through the nano reactor under high pressure, creating an intense hydrodynamic cavitation.

Which physical and chemical actions actually take place in the nano reactor is not yet fully understood, but its effect is amazing.

Crude vegetable oil is pumped through a series of scientifically designed geometries.

TABLE 1: EXAMPLE OF A REFINED SOYABEAN OIL BEFORE AND AFTER INSTALLING NANO REACTOR

Component	Before nano reactor	After nano reactor
Phosphorus	7 - 15 ppm	<3 ppm, 1 ppm typical
Calcium	1 - 3 ppm	<1 ppm
Magnesium	1 - 3 ppm	<1 ppm
Soap	300 ppm	<150 ppm, 50-100 typical

Source: Desmet Ballestra

TABLE 2: NANO NEUTRALISATION MONTHLY SAVINGS (20 TONNES/HOURS, 27 DAYS/MONTH)

Component	Change	Savings (kg/hour)	Price/kg	Monthly savings
Oil yield	0.3% increase	60	US$1.10	US$42,768
Phosphoric acid	90% reduction	12	US$1.65	US$12,830
Sodium hydroxide	30% reduction	17	US$0.40	US$4,406
Silica	100% reduction	22	US$1.50	US$21,384
Total				**US$81,406**

Source: Desmet Ballestra

At each stage, there is a dramatic pressure drop. The water molecules in the oil vaporise and recompress to a liquid at each stage, creating shockwaves that break the phospholipid micelles to their molecular level and, hence, make the non-hydratable phospholipids more hydratable.

In addition to that, the nano reactor thoroughly mixes the acid and caustic soda solutions that have been added to the crude vegetable oil to a level that even the best high shear mixer cannot achieve.

A nano reactor can be installed in any existing neutralisation process with relative ease and at minimal cost. A typical nano neutralisation process flow diagram is shown in Figure 2 (*previous page*).

The temperature of the crude vegetable oil only needs to be heated to 40-60°C instead of 80-90°C typically needed for acid treatment. The fluid pressure before the nano reactor can reach up to 100 barg, but typically it operates between 60-70 barg.

Results and benefits

Nano neutralisation has been found to substantially reduce chemical consumption. The acid that is normally used to chemically cleave the calcium (Ca)/Magnesium (Mg) metals from the non-hydratable phospholipids is nearly eliminated. With no need to neutralise excess phosphoric or citric acid, and with the outstanding mixing in the nano reactor, the quantity of caustic soda required to neutralise the FFAs falls even below stoichiometric.

By reducing excess caustic soda, there is less saponification of oil into soap and a much cleaner separation in the centrifugal separator. This results in a valuable increase in oil yield as less neutral oil passes with the soapstock.

The cleaner separation also results in less soap remaining in the oil exiting the soap separator. Less soap in the oil reduces the amount of silica or water wash needed to remove the soaps prior to bleaching.

Trials at several separate commercial installations in the USA have shown it is possible to completely eliminate the need for acid treatment when processing either crude non-degummed or crude degummed soyabean oil. In all cases, a phosphorous level below 10 ppm, even less than 5ppm, was achieved.

The nano reactor allowed the caustic soda addition to be reduced by 30-50%. The soaps off the neutralising centrifuge were below 150 ppm (*see Table 1, above*).

In addition to the acid and caustic soda savings, both industrial trials gave significant improvements in oil yield. The oil yield improvement has been found to be above 0.3% and, in some cases, greater than 1%.

A commercial installation that is processing approximately 20 tonnes/hour of crude water degummed soyabean oil has been operating a nano reactor since early 2011. There have been savings in phosphoric acid, caustic soda and silica. The plant is currently using approximately 90% less phosphoric acid and 50% less caustic soda than before the nano reactor was installed. In addition, the silica addition has been reduced to nil. But most significant in terms of savings was the gain in refined oil yield of around 0.3 %.

The choice to go for a nano reactor in oil neutralising is driven by its economic benefits. But on top of that, it has also been shown to be more forgiving on incoming oil quality. This allows a smoother operation and more consistent oil quality output. The monthly savings of a refinery with a nano reactor are shown in Table 2 (*left*).

Using a nano reactor in a vegetable oil refinery provides several other benefits. The substantial chemical savings are better for the environment, adding another significant economic benefit. Crude vegetable oil processed through a nano reactor allows the neutralisation centrifuge to operate more smoothly since the separation line between the light and heavy phase is more defined.

Other nano cavitation applications

With the results obtained in nano neutralisation far exceeding expectations, the focus today is on the degumming process. Comparable benefits are to be expected here as well.

And the list of nano cavitation applications in oil processing will become even longer the more the working principle of this unique and truly revolutionary technology is revealed. More research and science behind this technology will help us to better understand the process and hence its potentials: a real challenge for every scientist and plant operator. ●

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PHOTO: DESMET BALLESTRA

A NANO REACTOR FOR A LOW CAPACITY NANO NEUTRALISING PLANT OF <200 TONNES/DAY