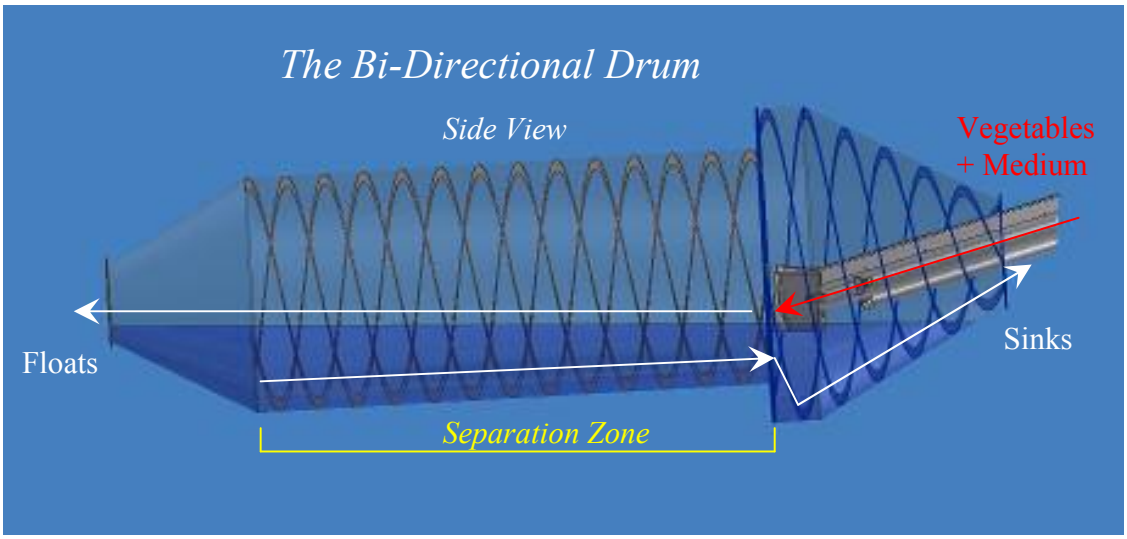
The Dense Medium Separation of Potatoes

Back in 1985 the largest cannery in Belgium, NV Talpe, had asked me to design a separator that would remove all extraneous material from freshly harvested carrots. Over the years this cannery had just about given up all hope of isolating carrots and other root vegetables from the endless variety of contaminates that so often surround them. Two dynamic effect separators, followed by a sophisticated color-sorting apparatus, followed by a group of twenty women, all failed to deliver a clean carrot. It was clear to me that the root vegetable industry in Europe demanded a radically new technology that would not generate separation errors and would deliver a thoroughly consistent and predictable product.

My background in mineral separation put at my disposal a broad field of techniques and gadgets to separate mineral from mineral or maceral from mineral, and there was only one process that stood out from all the rest: *dense medium separation*. Here we find the dynamic of a quiescent bath where the density of water is changed by means of fine particles in suspension. At first glance, nothing could be simpler: one fraction floats, while the other fraction sinks. But root vegetables demand an accuracy of separation that exists nowhere in the world of mineral separation, and where should one go to find the suspension materials needed to change the density of water in a root vegetable application?

The first challenge was to redesign the conventional dense medium drum. Over the last 100 years, this short, fat, mono-directional drum had never evolved in its basic design. So I put forward the radically new concept of a bi-directional drum, that has floats moving in one direction and sinks being scrolled out in the opposite direction. This new design assured that at the critical moment of the introduction of solids into the bath floats would not be buried by sinks. Its shallow bath depth imparted extraordinary stability to the suspension medium. Its long separation zone made it impossible to find sinks in floats, and a special curtain, situated completely outside the separation zone, made it impossible to find floats in sinks (US Patent 5,373,946).



But even with this neat bi-directional design, I still faced the problem of where to find the fine particles needed to create a suspension medium. In mineral separation, the density of water is changed by means of fine metallic powders such as magnetite or ferrosilicon. Some of these powders cost over $1,000 per ton, and who could justify using them alongside food products? One way around this problem involves the use of salt. Salt in solution is cheap, but how does one dispose of the brine generated by this process? What maintenance engineer would want to deal with the corrosive effects of salt throughout a vegetable line?

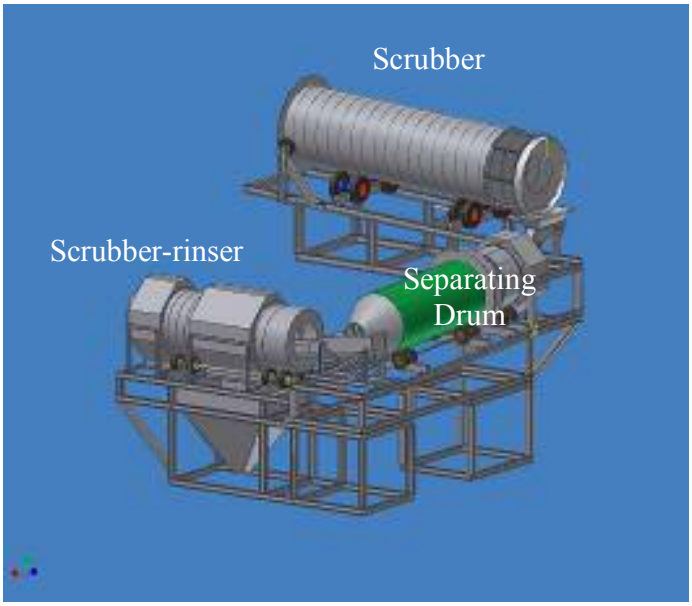
No metallic powders and no salt, so where then on earth can one find inexpensive and safe suspension fines to float carrots? Surprisingly we need look no further than to the vegetables themselves. Just about all soils in which potatoes are cultivated contain ultra-fine sand between 15 and 60 microns. By means of two stages of classifying cyclones, this fine sand can be easily isolated and reclaimed from the scrub and rinse water of a root vegetable line.

With the logic of a bi-directional dense medium drum and with an abundance of sand freely available from the vegetables themselves, I commissioned the first bi-directional dense medium separator during the summer of 1985. It was hard to believe the initial results. Not only were all the stones and metals removed from the carrots, but also this separator removed all near-gravity extraneous material such as corn stubble, fly ash and bits of plastic. Even young potatoes that had sprouted from a previous year's harvest separated out nicely and reported in their entirety with the stones (see picture above). But the biggest surprise of all was the precise separation of a good carrot from a partially dehydrated carrot.

Imagine a load of carrots temporarily dumped on a concrete slab waiting to be processed. Some of the carrots on the surface of the pile that see the sun may become soft and partially dehydrated. With a loss of moisture, there is a slight increase in density, and with an increase in density by only a few points to the third decimal place, this bi-directional dense medium drum has all that it needs to make a precise

separation. No color sorting apparatus can remove partially dehydrated carrots, since an hour or two of sunshine does not change the color of a carrot.

Eventually sixteen bi-directional dense medium separators were sold in Belgium and France. The leading vegetable processor in Europe, Bonduelle, with a 30% market share, bought five separators. Their fifth separator, recently installed in August 2004 in Renescure, France, is the first vegetable separator designed by ESR LLC that does not employ vibratory screens (see picture on previous page). The food giant, Nestle, bought two 60 TPH potato separators which were installed at its dehydrating facility in Rosiere, France.



Oftentimes potatoes and other root vegetables in Europe are harvested during rainy weather, and as much as 60% of what is brought out of the field under such conditions consists of mud and clay balls. ESR LLC designed a scrubber barrel to liberate freshly harvested vegetables from this muddy mess, while effecting minimal damage and breakage.

After separation, the dewatering and rinsing of the potato poses a special problem. To dewater by means of vibratory dewatering screens is far from ideal. All vibrating screens are difficult to maintain, they have limited material transfer capacity, their panels easily blind up with trash, and they presuppose large volumes of rinse water emanating from spray nozzles that only impact the surface of a bed of potatoes. Based on its experience in the processing of nonferrous metals, ESR LLC developed a unique dewatering, scrubbing and rinsing device called a scrubber-rinser.

A scrubber-rinser is a counter-flow vessel consisting of one or more stages of scrubbing and draining. In a scrubber-rinser solids are scrolled in one direction and rinse water is pumped from scrub section to scrub section in the opposite direction. Since in the scrub stage the potatoes are totally immersed in water, the rinsing efficiency is far higher than what we typically see in the case of a vibratory screen equipped with multiple banks

of spray nozzles. The final rinse water from the scrubber-rinser is routed to classifying cyclones to recover the fine medium sand. The above picture shows a one-stage scrubber-rinser installed at Bonduelle in France.

With this technology not only is it easy to remove extraneous material from potatoes, but it also becomes possible to do things that were never available to the industry at a reasonable price: to separate low solids content potatoes (1.04 to 1.08 RD) from high solids content potatoes (1.08 to 1.12 RD); to separate hollow-heart, brown center, "jelly-end" and other low-density defects (<1.04 RD) from good potatoes; or to isolate and remove potatoes with embedded stones or adhering clay (<1.12 RD). Exciting possibilities open up of eliminating a whole range of diseased, bruised, damaged, stressed or improperly stored potatoes.

Fry color is due primarily to the reaction of reducing sugars with amino acids in the presence of heat. If, by means of this technology, the processor can control tuber density, he can control the presence of reducing sugars and ultimately fry color. At the same time, a potato is considered good for canning if it does not slough or disintegrate during processing, and non-defective potatoes of low solids content or low specific gravity are ideal for canning. Frying and canning have quality requirements that situate at different ends of the density spectrum, and with this technology it is possible to give to each exactly what it needs.

With sixteen bi-directional dense medium separators in continuous operation in Europe, some for almost 20 years, it is truly remarkable that no one to this day has ever been able to establish a single separation error in the finished product. If the potato industry wants to reduce maintenance costs and take pride in producing a thoroughly consistent and predictable product, the simple and inexpensive technology outlined in this paper is surely the way to proceed.

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