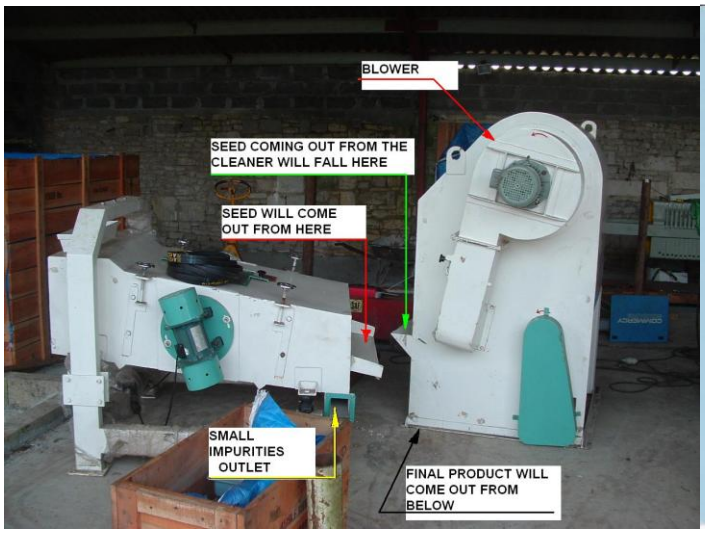
Expeller Technology and Plant Design Critical to Sustainability of Vegetable Oil Production Facilities

Nebraska Screw Press has been a strong believer in the opportunity to successfully develop community scale oilseed processing facilities to supply cost effective feedstocks to the biofuel industry. Key areas include expeller design and material preparation systems that can adjust to changing feedstock inputs. To be sustainable in a challenging and volatile marketplace, vegetable oil facilities should be prepared to process a number of locally produced materials and create a diverse product set. Vegetable oil production plants that want to stay in this industry long term will need to utilize a diverse set of biomass and energy inputs that can supply vegetable oil based products to numerous markets including human food, animal feed and renewable diesel markets. This paper will address three different areas that should be considered when in design phase of a vegetable oil processing plant. Seed input designs, expeller technology and output products.

Flexibility of seed inputs is a critical factor in ensuring long term viability for a vegetable oil production facility. Crop prices vary from market conditions and harvest cycles every day and having the ability to change the seed processing facility inputs provides the Plant Manager a powerful tool to ensure plant viability despite market fluctuations. Seeds are often handled differently like canola which nearly flows like water to cotton seed that requires live bottom and feed augers for all transfers. Choosing flexible feed systems for all the present and future oilseeds in your area is a wise investment. Selecting material handling equipment with high quality bearings and materials will keep maintenance low in these areas.

Besides the need to consider the means to handle a variety of different seeds, the seed preparation steps themselves are often different for each type. Areas where equipment can be used for various seeds pays big dividends over having separate lines. Working with a knowledgeable supplier will help you tremendously in this area. An example of this potential synergy can be noted with soybean and sunflower. While very different seeds in almost all ways, they can both be prepared by vibratory cleaning followed by cracking through a rotary impactor. These broken materials can then be sent over a cleaner with hulls and shells removed before feeding to oil recovery systems. Seasonal availability of local seed may also be considered to help the plant operate at full rate throughout the year while serving a more diverse market. Designing feedstock flexibility into the seed preparation section is becoming much more accepted at all levels of production and just makes sense.



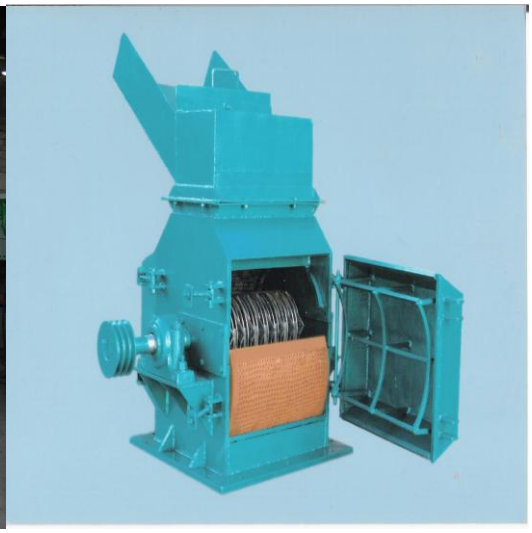


Fig 1: Preparation System: Vibratory Seed Cleaner with blower Hammer Mill

After feedstock preparation design, the oil extraction technology selected for the facility play it's role. Generally speaking mechanical crushing of oil bearing seed is the only cost effective method of operating in the capacity range we are considering, from 1-500 tons/day of seed input. . Chemical extraction on a distributed scale is generally not cost effective and gas extraction methods are only showing viability for high value materials at very small scales. Many variables must be considered when considering equipment to perform the critical steps of the process including cost, manpower, input flexibility, efficiency, expandability, cost and maintenance. In some regions labor is not a big issue, in others it is. These variables must be considered in the context of the specific example being studied and knowledgeable consultants can help guide you through this selection process.

Within mechanical expelling technologies available, there are a myriad of choices but the three most common types are the machines with larger sectional, horizontal screws of varying pitch surrounded by cage bars separated by spacers of a selected thickness to allow oil release when the oil bearing biomass is put under pressure in the cage. These types generally exhibit 65-85% efficiency per pass and cost $2-4,000 per daily ton of capacity. The longer the cage the better this efficiency generally is, as extended dwell times under pressure results in better oil recovery.

The solid screw type machines are typically chrome and stainless steel construction and boast 90-95% efficiency in oil recovery. These machines are much simpler to use, but have a much higher cost than standard machines and are generally best suited for food grade and high value oil bearing materials. These machines can be multiplexed and can also achieve high volumes, but rarely above 10-20 Ton/day.

The third type of expellers are the Chinese types which are unique and not considered here as they are best suited for individual producers. These machines use a series of concentric rings that allow oil to escape when pressure is created in the chamber, instead of horizontal cage bars and spacers. Chinese machines are typically the lowest cost option and are not built for long life in a commercial environment. Individuals producing their own fuel will typically select this option as

because of low entry cost and since the meal is generally self-consumed, efficiencies are not as critical and run from 55-75%.

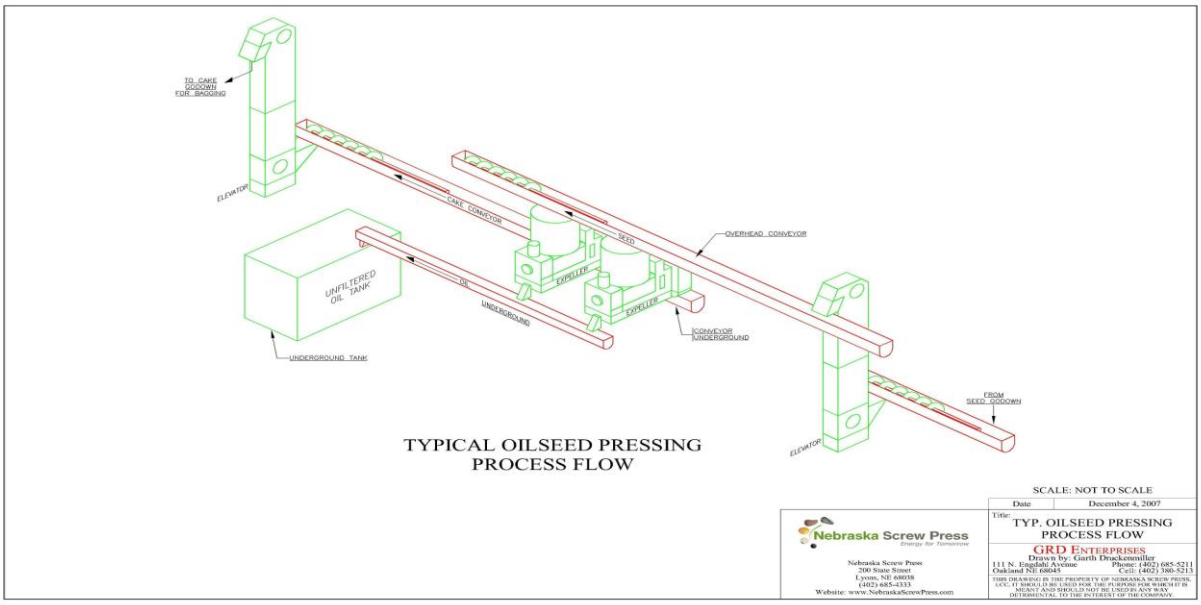


Fig 2: Typical oilseed crushing arrangement using sectional screws and horizontal cage bars

Figure 2: Typical Horizontal bar and sectional screw machines with components by Goyum

Although the horizontal bar machines as invented and patented by Valerius Anderson in 1901 still dominate this industry, smaller, solid shaft machines can offer distinct advantages over these units. These solid shaft machines do not require the expertise and experienced operators to operate efficiently like the horizontal bar machines do. In fact, these solid shaft machines are meant to operate without any supervision and boast much greater efficiencies.

Figure 3: Solid Shaft machines can be engineered into groups like these

Like most commercial processes, vegetable oil plants benefit from economies of scale and with commodity seeds to produce oil for biofuel markets, a plant capacity of at least 20-40 Ton/day is needed to hire the first operator. Before an investment like this is made, supply and take off contracts should be negotiated and the right plant design adopted for the facility. It often makes sense to build the plant at half capacity to limit initial capital required and then expand into the design as inputs and ouputs allow. This leads to our final area of discussion.

Figure 4: Goyum 1500 Long Cage 50 Ton/day Expeller with three cage sections

Vegetable oil plants supplying the biodiesel industry must consider all options for their co-products. Low oil content seed creates far more meal cake than oil after expelling and profitable markets must be found for these materials to ensure positive cash flow. Many oilseeds create meals that can be sold into human food markets, providing the best possible return. Most meal will end up in livestock markets as feed where they will not be the lowest cost out there because of the 5 - 10% oil residual remaining in the meal. For example, soybean meal is a 60lb bushel. At 75% efficiency, 9lbs of oil are separated and 51lbs of meal are generated.

Low value markets for the meal portion of the seed output can bring a lot of economic pressure on the plant. Non-food oils such as camelina, jatropha and others are great oil sources for Biofuels,

but the meal portion is a challenge to obtain animal feed value and must be composted. Seeds with higher oil content can greatly shift the economic burden onto oil, which can generally find higher value markets than the meal, pound for pound. Tree nut oils are a great example of this where pecans with 70% oil dominates the output of the plant, taking a lot of pressure off meal marketing.

Deciding where further value can be added to outputs is also a consideration in any product off take discussion. While any oil leaving the plant must be filtered, biofuel conversion facilities may provide better pricing for partially or completely refined oil. Since biofuel does not benefit from bleaching and deodorization steps with vegetable oil feedstocks, basic refining may well be within the ability of the vegetable oil Plant Manager. Of course, your customers should be prepared to pay more and you should be sure to do your due diligence by clearly defining your costs involved and making sure you find a market for you soap stock.

In Summary, Vegetable oil plant design and operations should exhibit flexibility throughout so that they are best able to adjust to changes in cost and availability of inputs available by designing their facility to be able to adjust to various input seeds reasonably expected to grow in the area. Flexibility of seed preparation and milling sections are critical to accommodate various seeds and materials for oil recovery. Using quality materials from experienced designers will pay big dividends in the long run. Integrate expansion planning into your plant design if you desire a 'softer start' into the market. A diverse product market for all outputs will help to maximize value of the process and help ensure long term economic viability of the facility.

Robert Byrnes is an Organic Chemist and Manager of Nebraska Screw Press in Lyons, Nebraska and has been involved with vegetable oil processing and biodiesel production for about 10 years. His efforts resulted in an integrated seed to fuel facility in Scribner, Nebraska capable of producing 5 million gallons per year of renewable diesel which opened in 2008.