



TECHNICAL ARTICLE

Choosing Between Batch, Semi-Continuous and Continuous Used-Oil Processing

A technical evaluation based on feed variability, process configuration, product objectives, plant capacity and operating philosophy.

BALAJI CONSULTANTS | KNOWLEDGE CENTRE

CORE SPECIALISATION: USED-OIL RE-REFINING

There is no single 'best' processing configuration

Batch, semi-continuous and continuous plants solve different operating problems. Capacity alone should not determine the process route.

Used lubricating oil is inherently variable. Water, fuel dilution, sludge, degraded additives, metals, carbonaceous material and the distribution of recoverable lube-range hydrocarbons can change between suppliers and even between individual tanker loads.

The correct process philosophy therefore has to balance feed flexibility, product objectives, recovery, energy use, operator capability, automation, utilities and capital investment. A configuration that is appropriate for one re-refinery may be unnecessarily complex—or operationally restrictive—for another.

Key principle

Plant configuration should be selected around the feedstock, required base-oil products and business model—not around a preference for batch or continuous equipment.

Three operating philosophies

- Batch: feed preparation and main high-vacuum distillation are performed in defined processing cycles.
- Semi-continuous: dehydration and degassing remain batchwise, while conditioned feed is buffered and processed continuously through one or more WFEs.
- Continuous: feed and products move continuously through an integrated process train under steady operating conditions.

Dedicated batch conditioning followed by separate high-vacuum distillation

Batch technology can be applied at significant commercial capacity where flexibility and campaign operation are important.

In the Balaji standard batch configuration, used oil is first processed in a dedicated dehydration and degassing vessel. Water, entrained gases and volatile contaminants are removed under controlled vacuum before the conditioned oil is transferred to a separate high-vacuum distillation vessel.

The high-vacuum vessel then recovers the light hydrocarbon fraction followed by one combined base-oil fraction or multiple viscosity-grade cuts, depending on the required product slate. The remaining non-distillable material is discharged as residue.

Commercial scale

Balaji Consultants has successfully designed and supplied batch re-refining plants with capacities up to 120 TPD and beyond. Batch processing should therefore not be described as a technology limited only to small plants.

Advantages

- Exceptional flexibility for variable feedstocks and campaign operation.
- Multiple base-oil grades can be recovered from the same plant.
- Lower instrumentation complexity than a fully continuous refinery.
- Operating conditions and cut points can be adjusted batch by batch.
- Dedicated dehydration protects the high-vacuum section from water and volatile loading.
- Straightforward isolation, reprocessing or diversion of off-specification batches.

Limitations

- Charging, heating, distillation and residue discharge are cyclical rather than steady-state.
- Repeated thermal cycles can reduce overall energy efficiency.
- Higher operator involvement per unit of production.
- Throughput expansion can require larger vessels or additional staggered batch trains.

Batch flexibility. Continuous WFE performance.

The defining Balaji configuration is batch dehydration and degassing followed by continuous Wiped Film Evaporation.

A measured batch of used oil is dehydrated and degassed under controlled vacuum. Once conditioned, the oil is transferred to a buffer tank. The buffer tank decouples the batch front end from the continuously operating separation section.

From the buffer tank, the oil is pumped through a feed preheater and continuously fed to one or more Wiped Film Evaporators. The WFE section operates under deep vacuum with short residence time, continuously recovering valuable base-oil distillate while heavy non-volatile residue is discharged from the final evaporator.

Typical process sequence

Batch dehydration & degassing → Buffer tank → Preheater → WFE / WFEs → Condensation & product collection → Finishing

The number and arrangement of WFEs are selected around the required product slate. A single WFE can recover one combined base-oil cut; multiple WFEs can recover progressively heavier fractions.

Advantages

- Retains batch flexibility at the feed-conditioning stage.
- Provides stable and continuous feed to high-value WFE equipment.
- Higher average throughput than conventional batch distillation.
- Short thermal residence time and reduced risk of product degradation.
- Continuous residue discharge.
- Excellent route for upgrading existing batch plants while retaining useful dehydration equipment.

Steady-state operation for sustained, well-controlled production

Continuous processing provides its greatest benefit when feed availability, utilities and operating conditions can be maintained within a defined design envelope.

In a fully continuous re-refining plant, feed preparation, separation, product recovery and selected finishing stages operate as an integrated steady-state process. Feed flow, temperatures, vacuum levels, product cut points and recycle streams are controlled continuously.

Advantages

- High sustained throughput for a given equipment train.
- Stable temperatures, flow rates and vacuum conditions.
- Strong opportunity for heat integration and energy recovery.
- Lower routine operator intervention per tonne or kilolitre processed.
- Well suited to PLC/SCADA control, trending, alarms and interlocks.
- Consistent product quality when feed remains within the design envelope.

Limitations

- Higher capital investment and greater control-system complexity.
- More dependent on consistent feed conditioning and equalisation.
- Process disturbances can propagate rapidly through an integrated train.
- Requires reliable utilities, trained operators and disciplined maintenance.

Continuous does not mean automatically better.

A poorly controlled continuous plant processing highly variable used oil can perform worse than a well-engineered batch or semi-continuous facility. The process route must match the actual feed and operating environment.

How the three configurations differ

Factor	Batch	Semi-Continuous	Continuous
Feed variability	Highest tolerance; each batch can be adjusted.	High tolerance at batch conditioning stage; buffer stabilises WFE feed.	Requires effective equalisation and tighter feed control.
Main separation	Separate batch high-vacuum distillation vessel.	Continuous WFE/WFEs after batch conditioning.	Continuous separation train.
Capacity potential	Commercial plants up to 120 TPD and beyond are proven by Balaji.	Scalable through WFE configuration and parallel/series arrangements.	Strongest at sustained high throughput where steady operation is justified.
Product flexibility	Very high; cut points and campaigns can change batchwise.	High; one or multiple WFE cuts can be configured.	Best where product slate is relatively stable.
Thermal residence	Longer than WFE-based separation.	Short residence time in WFE section.	Depends on selected continuous separation technology.
Automation	Manual to PLC; relatively simple.	Moderate to high; continuous WFE section benefits from automation.	Typically highest instrumentation and automation requirement.
Revamp suitability	Existing batch plants remain viable and expandable.	Excellent pathway for converting batch plants to WFE-based recovery.	Usually requires broader plant redesign for a full conversion.

Capacity should not be used as a rigid dividing line.

Plant capacity is important, but it is only one selection factor. Balaji's experience with batch facilities at 120 TPD and beyond demonstrates that feed variability, product flexibility, investment philosophy and operating preference can justify batch technology even at substantial commercial scale.

Seven practical questions before choosing the process route

1. Feed Variability

Where water, viscosity, fuel content, sludge or contaminant loading varies widely, batch conditioning or effective equalisation provides valuable protection for downstream separation equipment.

2. Product Slate

Frequent changes in viscosity grade or campaign products favour batch flexibility. Stable high-volume production can favour WFE-based semi-continuous or fully continuous operation.

3. Required Recovery & Thermal Severity

Where high-boiling fractions must be recovered with minimum thermal exposure, continuous WFE separation can offer a major advantage.

4. Existing Plant Infrastructure

An existing dehydration and degassing section can often be retained and integrated with buffer storage, preheating and WFEs, making semi-continuous modernisation commercially attractive.

5. Utilities

Continuous systems depend more strongly on reliable power, heating, cooling, vacuum and instrument air. Utility reliability must be treated as part of process selection.

6. Operator & Automation Capability

The control philosophy must match the operating team's actual technical capability. More automation is beneficial only when it can be properly operated and maintained.

7. Future Expansion

Batch plants may add vessels or staggered trains; semi-continuous plants may add WFE capacity; fully continuous plants can be designed with future parallel trains or debottlenecking provisions.

Choose the route that fits the plant—not the label

Choose Batch when...

- Feed quality varies substantially between batches.
- Campaign operation and multiple product grades are important.
- The owner values operating flexibility and straightforward process intervention.
- A robust commercial batch plant is preferred—even at substantial capacity.
- Phased expansion through additional vessels or staggered operation is practical.

Choose Semi-Continuous when...

- Batch dehydration and degassing are valuable for variable feed.
- The main base-oil recovery section would benefit from continuous WFE operation.
- Shorter thermal residence time and continuous residue discharge are required.
- An existing batch facility is being modernised without replacing the complete front end.
- One or multiple base-oil cuts are to be recovered through WFE/WFEs.

Choose Continuous when...

- Feed supply and composition are sufficiently consistent for sustained operation.
- High utilisation and steady-state production are central project objectives.
- Reliable utilities, automation and trained operating personnel are available.
- Product campaigns are long and process conditions remain within a controlled design envelope.
- The additional integration and automation are justified by lifecycle economics.

Selection is a process-engineering decision.

The correct configuration emerges only after feedstock characterisation, product definition, capacity review, utility assessment and evaluation of the owner's operating philosophy.

Flexibility, WFE performance and steady-state efficiency each have a place

Batch, semi-continuous and continuous re-refining should not be viewed as a simple progression from basic to advanced technology. Each is a valid process architecture suited to different feedstocks, products and operating strategies.

Balaji batch technology uses dedicated dehydration and degassing followed by separate high-vacuum distillation and has been successfully applied at capacities up to 120 TPD and beyond. Semi-continuous technology retains batch feed conditioning but transfers the treated oil through a buffer and preheater to continuously operating WFE/WFEs. Fully continuous operation is most effective where feed, utilities and production campaigns support sustained steady-state processing.

The best plant is the one designed around the actual project.

Feed variability, desired base-oil cuts, thermal sensitivity, recovery target, existing infrastructure, capital philosophy, automation and future expansion should be evaluated together before the process route is frozen.

Balaji Consultants specialises in used-oil re-refining process technology and complete plant supply. We develop batch, semi-continuous and continuous process configurations, as well as plant revamps, WFE upgrades and performance optimisation, around the client's feedstock and required base-oil products.

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