Blentech CORPORATION

WHITE PAPER

CHOOSING BETWEEN HEMISPHERICAL, HORIZONTAL, AND CONICAL KETTLES

Two kettles with the same stated capacity can perform very differently once product is added. Vessel geometry affects how the product circulates, how much heated surface is available, how effectively that surface is renewed, how readily moisture can escape, and how the finished product leaves the vessel.

For thin, free-flowing products, several geometries may work well. The differences become more important as products become thicker, more particulate, more shear-sensitive, or more difficult to discharge.

The practical question of "What size kettle do I need?" isn't enough. The question to answer is:

What combination of vessel geometry and agitation will continue to move, heat, and discharge the product when it reaches its most difficult condition?

For most applications, four factors drive that answer:

01 PRODUCT RHEOLOGY AND SOLIDS LOADING

02 MIXING AND PRODUCT MOVEMENT

03 HEAT-TRANSFER AND EVAPORATION REQUIREMENTS

04 DISCHARGE AND FINISHED-PRODUCT RECOVERY

PRODUCT BEHAVIOR DRIVES THE MIXING STRATEGY

Viscosity is useful, but it is only part of the picture.

Many food products change significantly during processing. Starches hydrate, proteins set, fats render, water evaporates, and solids absorb liquid. A product that pours easily when loaded may become thick, sticky, or difficult to move twenty minutes later.

Many sauces, cheese products, fillings, and prepared foods are also shear-thinning. Product close to an agitator may move easily while product farther away remains comparatively stagnant, creating an important distinction.

Agitator motion is not the same as full-batch turnover.

HEMISPHERICAL KETTLES

Hemispherical kettles work particularly well when the product remains capable of circulating. Their curved geometry supports predictable scraper contact, and different agitator configurations can extend their operating range. Anchors provide gentle wall movement, propellers increase circulation, and concentric systems or angled agitators can provide stronger vertical turnover for thicker or particulate products.

This makes hemispherical kettles a strong general-purpose choice for sauces, soups, gravies, dairy products, and many conventional batch-cooking applications.

HORIZONTAL KETTLES

Horizontal kettles become increasingly attractive when the product is less willing to circulate on its own.

Paddles or ribbons physically lift, fold, and displace product through the vessel rather than depending primarily on fluid circulation. This is particularly useful for thick sauces, meat fillings, beans, pet food, fruit fillings, prepared meals, and high-solids products without sacrificing the ability to produce the thinner products processed in hemispherical kettles.

The agitator can also move substantial product volume at relatively low rotational speed, which can help protect large or fragile particulates.

CONICAL KETTLES

Conical kettles offer a different advantage.

Their shape naturally directs free-flowing product toward a bottom outlet, which can improve drainage and product recovery. They often also allow a large surface area for heating applications.

That advantage decreases as yield stress increases or particulates are added. Once a product no longer readily flows under gravity, a steeper bottom does not necessarily solve the problem.

SELECTION GUIDELINE

Favor hemispherical when the product still circulates readily and flexibility, compact footprint, and broad process capability are important.

Favor horizontal as viscosity, yield stress, solids loading, or particulate size make positive mechanical movement increasingly valuable or the widest range of applications is required.

Favor conical when the product remains free-flowing and drainage or product recovery is a primary requirement.

MIXING EFFECTIVENESS IS MORE THAN RPM

Agitator speed is easy to compare but can be misleading.

Tip speed is:

$$v = \pi DN$$

where D is agitator diameter and N is rotational speed. A small agitator operating quickly may create high local velocity while moving relatively little of the overall batch. A large paddle operating slowly may create lower local shear while displacing much more product.

For many food applications, the second behavior is more useful. The more important question is: How effectively is the entire batch being turned over? This matters especially when the product contains:

- high solids
- large particulates
- fragile inclusions
- significant yield stress
- ingredients that float or settle

Horizontal paddle and ribbon systems are naturally suited to large-volume displacement and folding. Hemispherical systems can also provide strong circulation, particularly with properly designed propeller or concentric agitation. Conical vessels require particular attention to circulation in the lower cone, where solids or thick product can accumulate.

SELECTION GUIDELINE

Favor hemispherical when circulation can be achieved without aggressive mechanical displacement.

Favor horizontal when the process requires repeated lifting, folding, or movement of a large portion of the batch at relatively low speed.

Favor conical when mixing requirements are moderate and drainage carries more value than aggressive bulk movement.

Blentech CORPORATION

2899 Dowd Drive, Santa Rosa, CA 95407 · 707-523-5949 · Blentech.com

©2026 Blentech Corporation. All Rights Reserved · BLT-KET-WP · Rev 01

HEAT TRANSFER DEPENDS ON BOTH SURFACE AREA AND PRODUCT MOVEMENT

The basic heat-transfer relationship is:

$$Q = U \cdot A \cdot \Delta T$$

where A is effective heating area and U reflects how readily heat passes from the heating medium through the vessel wall and into the product.

For kettle comparison, one useful measure is:

Heated Surface Ratio = Heated Surface Area / Working Volume

Two vessels with the same working volume can therefore have different thermal performance. But surface area alone is not enough. Heat enters the product at the vessel wall. If thick product remains against that wall, resistance to heat transfer increases and scorching or fouling may occur.

Scrapers therefore serve two purposes:

- remove product from the heating surface
- replace it with material from the rest of the batch

The more useful question is not simply: "How much jacket area is available?" It is: "How much useful heated area is available, and how effectively is fresh product brought back to it?"

HEMISPHERICAL

The continuous curved surface of a hemispherical kettle is well suited to scraper contact. When the product still circulates effectively, this provides a strong combination of heat transfer, surface renewal, and relatively compact geometry.

HORIZONTAL

Horizontal geometry spreads the batch through a relatively shallow vessel and can provide substantial heated surface relative to working volume. Paddle or ribbon agitation also continually moves product across that surface. This combination becomes increasingly useful as viscosity rises.

CONICAL

Conical vessels can be jacketed effectively, but circulation and scraper geometry become more challenging as vessel diameter narrows toward the bottom. In these cases, pump over solutions may be added where feasible.

SELECTION GUIDELINE

Favor hemispherical when the product remains mobile enough for strong circulation and scraper renewal.

Favor horizontal when high viscosity and high heat-transfer demand occur together.

Favor conical when thermal duty is moderate and drainage or recovery is the more important process requirement.

SCALE AND EVAPORATION CAN CHANGE THE ANSWER

Surface area does not increase as quickly as volume when equipment becomes larger.

That means:

Surface Area / Volume ratio generally decreases as vessel size increases.

A process that performs well in a small kettle may therefore not behave identically when scaled to a much larger vessel.

Larger batches can create:

- deeper product beds
- less heated area per unit of product
- longer circulation paths
- longer heating cycles
- greater dependence on agitator performance

Horizontal geometry can become increasingly attractive at larger capacities because the product can be spread through a longer, shallower vessel.

Evaporation introduces a second surface-area consideration. The jacketed surface used for heating is different from the free product surface available for vapor release.

Processes involving significant:

- reduction
- concentration
- moisture removal
- browning
- sautéing

can benefit from a higher exposed-surface-area-to-volume ratio. Horizontal vessels naturally provide a relatively broad product surface.

SELECTION GUIDELINE

Favor hemispherical when evaporation is secondary and the product continues to circulate well.

Favor horizontal when large batch size, high viscosity, or meaningful evaporation make surface area increasingly important.

Favor conical when drainage remains the primary geometric advantage.

DISCHARGE CAN DETERMINE ACTUAL CAPACITY

A kettle can mix and heat properly and still underperform if the finished product is difficult to remove.

A complete batch includes:

Load + Heat + Process + Discharge + Reset

Any one of these steps can control throughput. For a free-flowing product, gravity is highly effective. That naturally favors conical or bottom-discharge hemispherical designs. Thick products behave differently. When the finished product develops meaningful yield stress, mechanical movement toward the discharge can become more important than vessel slope.

Horizontal agitation can continue moving product during discharge, reducing dependence on gravity.

SELECTION GUIDELINE

Favor conical when complete drainage and recovery of a free-flowing product are important.

Favor hemispherical when the product remains pourable and a bottom outlet provides efficient discharge.

Favor horizontal when the finished product becomes difficult to move and mechanical assistance can materially reduce discharge time or product heel.

COMPARE THROUGHPUT, NOT VESSEL CAPACITY

Nominal vessel size is only part of the production equation.

The more useful comparison is:

Throughput = Finished Batch Mass / Total Cycle Time

A larger vessel with slow heating or poor discharge can produce less finished product per shift than a smaller kettle with better thermal and mixing performance.

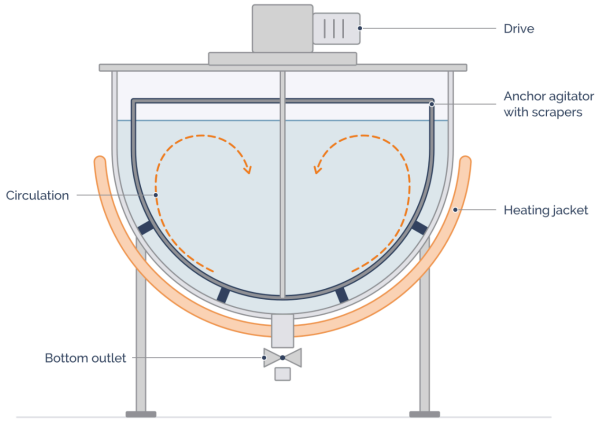
The correct equipment choice therefore depends on the real process bottleneck.

- If heating controls the cycle, evaluate heated surface and product renewal.
- If mixing controls the cycle, evaluate bulk movement and turnover.
- If evaporation controls the cycle, evaluate free surface and vapor removal.
- If discharge controls the cycle, evaluate gravity drainage versus positive mechanical movement.

©2026 Blentech Corporation. All Rights Reserved · BLT-KET-WP · Rev 01

THREE GEOMETRIES, THREE WAYS OF MOVING PRODUCT

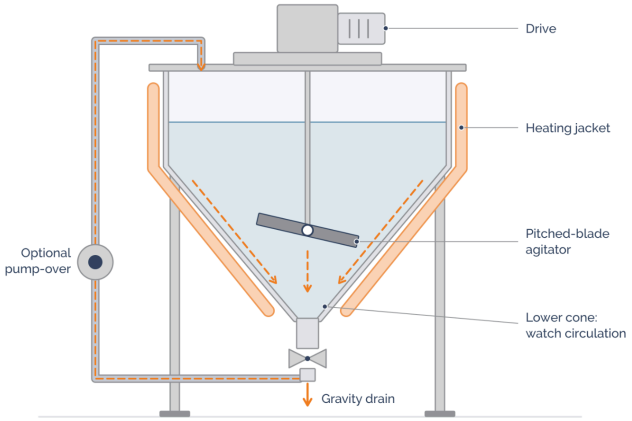
Each vessel relies on a different mechanism to turn the batch over. The kettle system at lower right shows how these vessels are delivered with an operator platform.



HEMISPHERICAL

CIRCULATION-DRIVEN

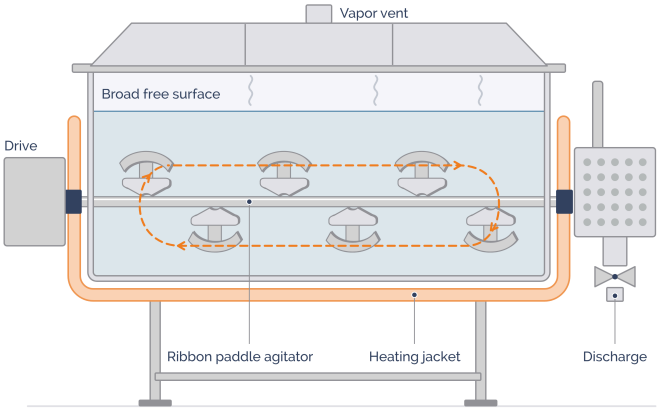
Curved walls keep scrapers in steady contact while the batch turns over by circulation — a compact, versatile starting point.



CONICAL

GRAVITY-ASSISTED

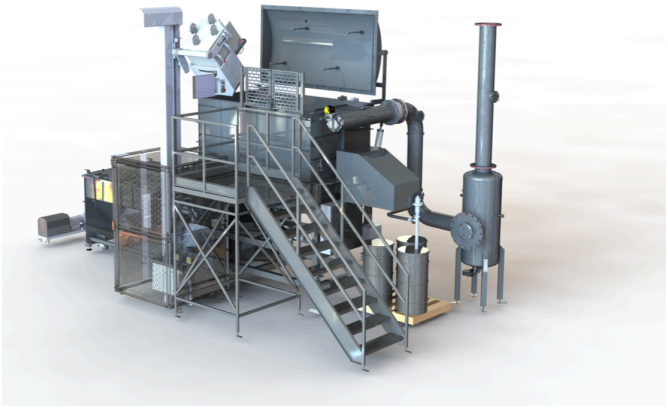
A sloped bottom directs free-flowing product to the outlet for fast drainage and recovery; the lower cone needs attention as product thickens.



HORIZONTAL

MECHANICALLY MOVED

Paddles lift, fold, and displace thick or particulate product through a long, shallow vessel with a broad surface for heating and evaporation.



SYSTEM VIEW

KETTLE SYSTEM WITH PLATFORM

A complete kettle system with operator platform and access, shown with its supporting process equipment.

©2026 Blentech Corporation. All Rights Reserved · BLT-KET-WP · Rev 01

PRACTICAL SELECTION GUIDE

PROCESS CHARACTERISTIC	HEMISPHERICAL	HORIZONTAL	CONICAL
Thin, free-flowing products	Excellent	Excellent, often unnecessary	Excellent where drainage matters
Moderate viscosity	Excellent with proper agitation	Excellent	Good
High viscosity / yield stress	Application dependent	Strong advantage	Increasingly difficult
Low solids loading	Excellent	Excellent	Good
High solids loading	Good with advanced agitation	Strong advantage	Application dependent
Large or fragile particulates	Good	Strong at low speed	Application dependent
High heat-transfer demand	Good	Strong	Configuration dependent
Significant evaporation / reduction	Moderate	Strong advantage	Limited inherent advantage
Scorch-sensitive products	Strong with good scraping	Strong at high viscosity	Requires careful design
Free-flowing product recovery	Good	Good	Strong advantage
Thick-product discharge	Moderate	Strong advantage	Gravity benefit declines
Compact footprint	Strong advantage	Requires more floor space	Strong
General-purpose versatility	Strong	Strong	More specialized

©2026 Blentech Corporation. All Rights Reserved · BLT-KET-WP · Rev 01

WHICH PRODUCTS FIT WHICH KETTLE

HEMISPHERICAL	HORIZONTAL	CONICAL
GENERAL-PURPOSE COOKING	**DIFFICULT-TO-MOVE PRODUCTS**	**FREE-FLOWING PRODUCTS**
Sauces & gravies	Thick sauces & fillings	Broths & stocks
Soups	Meat & poultry	Brines
Dairy & cheese sauces	Beans & legumes	Syrups
Dressings & emulsions	Prepared meals	Thin sauces
Starch-based products	Pet food	High-recovery applications
Moderate-viscosity foods	Rice, grains & pasta	Drain-sensitive products

THERE IS NO UNIVERSALLY SUPERIOR KETTLE GEOMETRY.

A SIMPLE WAY TO THINK ABOUT THE CHOICE

CHOOSING THE GEOMETRY

Hemispherical kettles are generally the strongest starting point when the product still circulates well and flexibility, footprint, and broad batch-processing capability matter.

Horizontal kettles become increasingly attractive as products become thicker, more particulate, harder to circulate, more dependent on heat-transfer surface, or more difficult to discharge.

Conical kettles are strongest when the product remains free-flowing and drainage, bottom discharge, or recovery is a primary process requirement.

The dividing line is rarely vessel capacity. It is usually the point at which the product stops behaving primarily like a fluid that can be circulated and starts behaving like a mass that must be mechanically moved. Alternatively, decisions to select one vessel over the other options is driven by how much flexibility is required in the future.

TECHNICAL REFERENCES

The engineering principles discussed here are covered in established food-processing, heat-transfer, and industrial-mixing references, including:

- Singh and Heldman, *Introduction to Food Engineering*
- Fellows, *Food Processing Technology*
- *Perry's Chemical Engineers' Handbook*
- Paul, Atiemo-Obeng, and Kresta, *Handbook of Industrial Mixing*
- Incropera et al., *Fundamentals of Heat and Mass Transfer*

For difficult products or applications near the practical boundary between geometries, testing under representative process conditions remains the most reliable way to confirm mixing, thermal performance, product quality, and achievable throughput.

2899 Dowd Drive, Santa Rosa, CA 95407 · 707-523-5949 · Blentech.com

©2026 Blentech Corporation. All Rights Reserved · BLT-KET-WP · Rev 01