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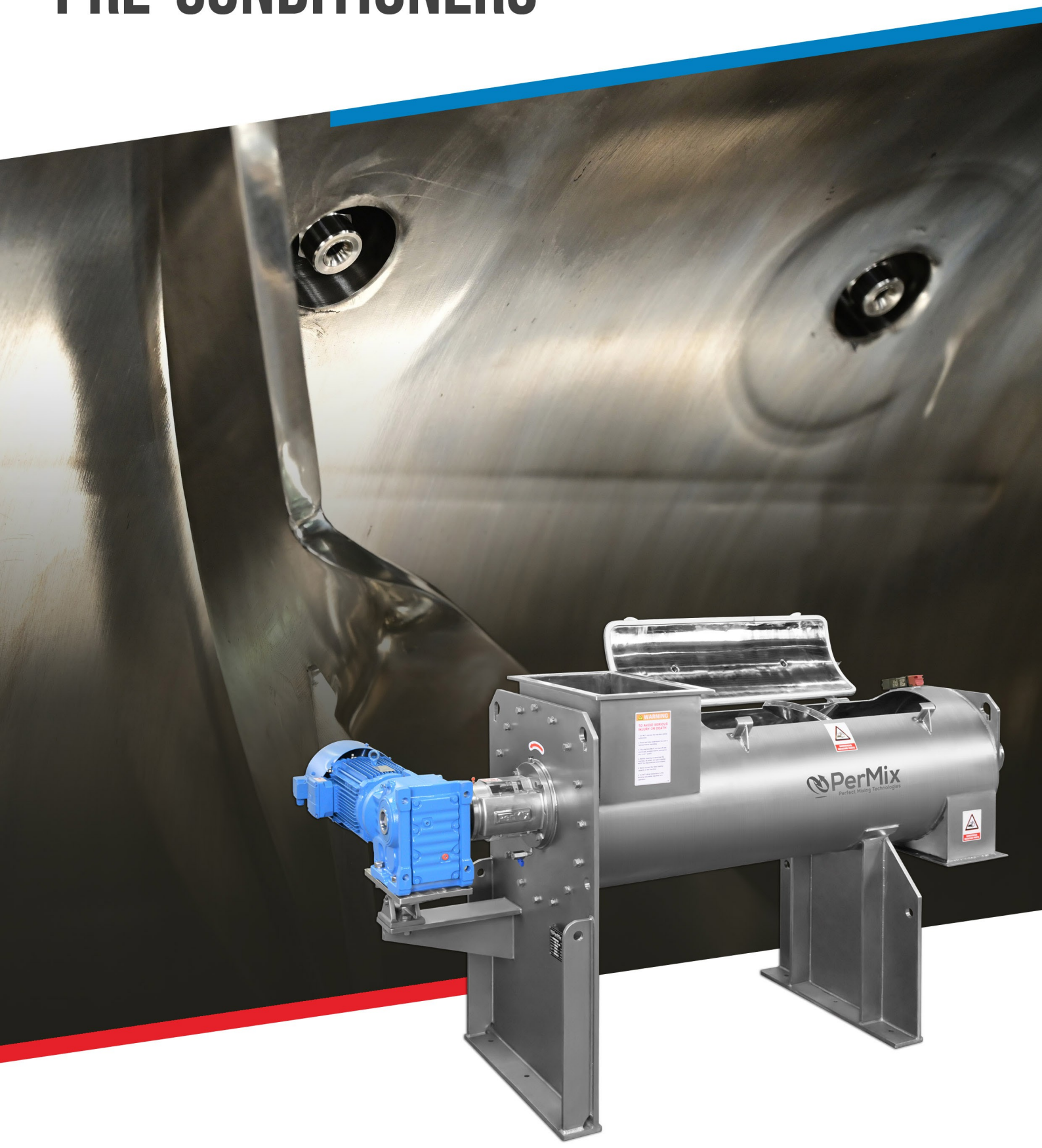
PRE-CONDITIONERS



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WHAT IS PRECONDITIONING?

Preconditioning means to condition or prepare a material before it is processed further. In the context of extrusion processes, preconditioning occurs just prior to extrusion inside a piece of equipment called a preconditioner.
The preconditioned raw material exits the preconditioner and moves into the extruder for further processing down the line.

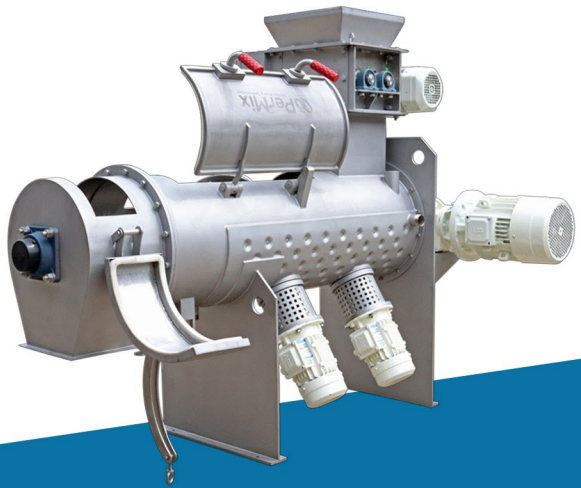
The dry raw material is conditioned or prepared by addition of water and steam in a continuous mixing environment. This softens the material due to partial hydration and cooking achieved during the process.

WHEN IS PRECONDITIONING NEEDED?

Preconditioning is generally preferred as a part of the extrusion process. However, not all processes require preconditioning. For product formulations needing less than 18% process moisture, preconditioning process may be avoided. These types of products are low-moisture and highly expanded products such as corn puffs. Due to the low process moisture requirement for such products, the mechanical energy generated by the screw inside the extruder barrel is sufficient to gelatinize/dextrinize the starch.

For formulations needing greater than 18-20% moisture and longer residence times, preconditioning helps in process and product quality. At higher moistures, if preconditioning is excluded then the product may not be completely cooked due to low residence time, and low shear (due to high moisture content) inside the extruder. Alternately, in order to achieve the same degree of cooking as with a preconditioner, the mechanical shear and barrel temperatures may have to be raised and/or the L/D ratio (length of extruder barrel as compared to its diameter) has to be increased. These changes would expose the product to high shear conditions and would lead to quality issues such as an increase in dextrinization and burning of the material. Therefore, higher moisture recipes benefit from being preconditioned prior to entering the extruder for final cooking. The cooking process initiated inside the preconditioner helps fully cook the product inside the extruder.

Therefore, preconditioning would benefit any process that requires higher moisture and higher retention time. Some of the products that would benefit from preconditioning include precooked pasta, textured vegetable proteins, breakfast cereals, pet foods and 3G snacks (also called semi- or half-products and snack pellets, because of the pelleted form that's expanded later when the product is consumed).



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BENEFITS OF PRECONDITIONING

Preconditioning offers many benefits, including

- initiating the cooking process,
- contributing to better ingredient mixing,
- reducing wear on the extruder due to reduction in abrasiveness of the raw material (the raw material softens due to hydration and cooking),
- allowing for the addition of extra ingredients like meat slurry and oil in the recipe,
- adding thermal energy to the process and thus lowering the need for higher mechanical energy (inside the extruder),
- increasing the throughput of the extruder due to low energy requirements,
- increasing the possibility of using slightly higher particle size ingredients for products like extruded cereals and thereby bringing its flavor and texture close to traditional cooked cereal,
- improving the product quality and
- extending the life of wear components inside the extruder barrel.

PHYSICOCHEMICAL CHANGES DURING PRECONDITIONING

The application of water and steam inside the preconditioner hydrates and partially cooks the raw material. Hydration (in this case) refers to the process of imbibition of water by starch and protein molecules inside a heated environment. The starch absorbs the water and starts the process of gelatinization. The increase in temperature due to added steam also helps reduce anti-nutritional factors present in the raw mix and aids in improving digestibility.

Due to the hydration and increase in temperature, the raw material transforms from a 'glassy' state to a 'rubbery' state. This transformation occurs due to a lowering of the glass transition temperature by adding water and the steam input then increases the temperature of the raw material above its glass transition temperature. Thus, the raw material turns from a dry and hard material to a soft and pliable material which is ready to be cooked in the extruder

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PRECONDITIONER **DESIGN**

The primary purpose of preconditioners is to prepare the raw material prior to the next step of extrusion. This is mainly achieved by adding steam and water into the raw material and mixing it for 2-4 minutes.

A general design of a preconditioner would have an inlet for water to be sprayed and steam into an enclosed chamber with mixing paddles. Typically, the water inlet would be at the top of the preconditioner and the steam inlet would be at the bottom of the preconditioner. The common design involves using two rotating shafts with radially positioned paddles. The paddles can rotate at same or different speeds (depending on the design) to enable better mixing and forward movement of the material.

Generally, the preconditioners are positioned above the extruder in such a way that the outlet of the preconditioner is feeding the inlet of the extruder. However, some extruder designs have preconditioners placed next to the extruder to address sanitation issues. While cleaning these preconditioners, there almost no chance of dirty rinsing water to get into the extruder. Most preconditioners are operated in normal atmospheric conditions. Pressurized preconditioner designs can help achieve higher product discharge temperatures but may cause loss of nutrients and may be expensive to operate.

Preconditioners are also equipped with inlet ports for adding other ingredients to the dry recipe like fresh meat slurries, oil, flavors and coloring agents. Mixing these additional ingredients at this point allows for uniform mixing. If fat/oil has to be added, then it is added just before the discharge end of the preconditioner to enable maximum gelatinization of starch. Adding oil at the beginning or in the middle of the preconditioner would coat the dry recipe with oil. This hinders water imbibition by the raw material particles, and thus negatively affects the gelatinization process.

Adding meat slurries to the dry mix must be perfectly metered; otherwise non-uniform mixing may lead to formation of clumps. These clumps, or the non-uniformly mixed and preconditioned material, may cause problems like surging (change in output due to fluctuations in melt pressure and flow rate even at constant operating conditions), and out-of-spec products (like differences in size, shape and bulk density than what has been set for any particular product).

SPECIFICATION

Model	Total L	Capacity, L/Hr (residence 1 Min.)	Capacity, L/Hr (residence 3 Mins.)	kW	RPM	L	W	H	KG
PTS-200C	200	6,000	2,000	5.5	155	1960	1065	830	600
PTS-400C	400	12,000	4,000	11	140	2510	1350	920	700
PTS-600C	600	18,000	6,000	15	129	2845	1190	1010	900
PTS-1000C	1000	30,000	10,000	22	121	3320	1430	1120	1400
PTS-1500C	1500	45,000	15,000	30	115	3750	1470	1230	1900
PTS-2000C	2000	60,000	20,000	45	110	4030	1650	1360	2400
PTS-3000C	3000	90,000	30,000	55	102	4710	1700	1410	2700
PTS-4000C	4000	120,000	40,000	90	96	5155	1910	1550	3400
PTS-6000C	6000	180,000	60,000	110	80	5745	1960	1780	4400
PTS-8000C	8000	240,000	80,000	132	75	6315	3160	1900	5600
PTS-10000C	10000	300,000	100,000	160	70	6905	2230	2000	6700

Note: The best residence time to be decided by test or by experience

CONCLUSION

Overall, the preconditioners serve to partially cook and uniformly mix the raw material. A good preconditioner will have the minimum coefficient of variation (CV) for mixing. Due to the partial cooking occurring in the preconditioner, less mechanical energy is needed to cook the material in the extruder. This lowers the dextrinization of starch and improves the quality of the product.

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