High pressure processing technology

The food industry is increasingly moving towards new product development and innovative propositions, through new processing methods that allow you to do things you could not do before.

One of the most successful developments at this point in time is High Pressure Processing (HPP). It is basically a cold pasteurisation technique which consists of subjecting food, previously packaged in a flexible, water-resistant and sealed packaging, to a high level of hydrostatic pressure up to 600MPa/5922atm for a few seconds to a few minutes. It has the same effect that placing the food product 60km deep into the ocean would have (if an ocean this deep existed and placing the product at this depth was possible).

Pressure above 4000 bar/3948atm at cold (+5ºC to 10ºC) or ambient temperature inactivates the vegetative microorganisms (bacteria, yeasts, moulds) present in food products, respecting all of the organoleptic properties of food and giving HPP products a high sensory and nutritional quality, while maintaining their original freshness throughout their complete shelf-life.

The reason for the death of the pathogenous and altering microorganisms present in food is that high pressure modifies certain proteins and enzymes present, especially in their cellular membranes. This causes alterations in the transport and permeability functions of these molecules, leading to their inactivation. However, vitamins and other bioactive components of foods, and the components responsible for the aroma or flavour of the product are not affected by high pressure. This is because pressure is a very selective process that only acts on non-covalent bonds (those that maintain the three-dimensional structure of the membrane proteins and enzymes), and leaves the covalent bonds unchanged (those present in food components and molecules that are responsible for its sensory properties).

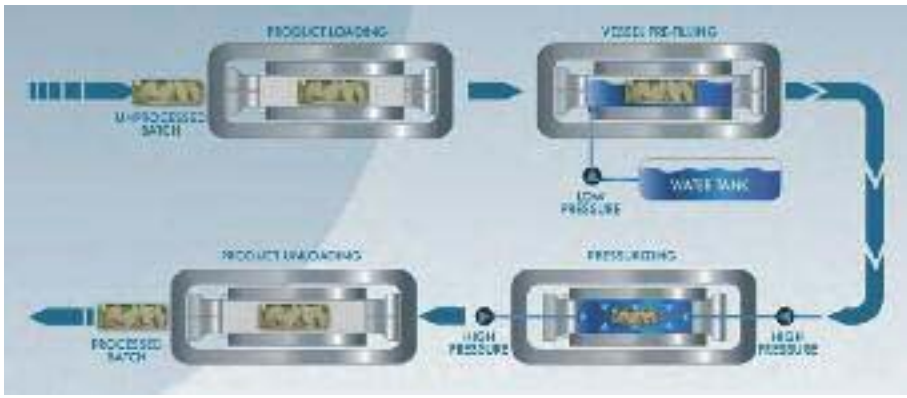

Diagram of operation of a HPP horizontal machine

Another big advantage of this process is that the uniform distribution of pressure in the whole volume of the product, whatever its shape or weight, makes it possible to uniformly pasteurise the entire product without the appearance of gradients of inactivation found in, for example, heat processes.

> **High Pressure Processing is most usually performed after the product has been introduced into its final packaging**

High Pressure Processing is most usually performed after the product has been introduced into its final packaging. This makes HPP one of the safest processing possibilities available to the industry, as we avoid the risk of any possible posterior cross contamination. Also, because it is a post-packaging intervention, it enables us to subtract from the product added preservatives or artificial ingredients. This is the secret behind many 'minimally processed, all natural, no preservatives' food products that can be found in the market nowadays and one of the main drivers that is making high pressure the fastest growing non-thermal processing technology.

The range of food products suitable for HPP is very wide: in general, any product containing a good percentage of water can be satisfactory processed by HPP, including a broad variety of meat products, fish and seafood, dairy, juices, and fruit and vegetable-based products. By contrast, products with lower water content (low Aw to be precise) such as flour, dry spices, or cakes cannot be processed successfully under pressure. Water is the indispensable tool through which to transmit the biophysical effects of high pressure to bio-components.

Line W420
LQ

The biggest limitation faced by HPP so far is the need for refrigerated conditions for cold pasteurised product storage. With the exception of a few which have a low pH or are dried (rice) or frozen (seafood) after processing, HPP shelf stable (sterilised) products are not yet available on world markets, though this process is under development.

To the advantages provided by a horizontal design we add wire-winding technology used for vessel manufacturing

The history of HPP

The effects of pressure on food flora have been well known for over a century, but because of the technology requirements needed to apply this process in the food industry, the first high pressure processed foods in the world had to wait until 1990 for commercialisation. These were strawberry, apple and kiwi jams launched on the Japanese market by Meidi-Ya that year. It was the result of an ambitious research and development project initiated by Prof. Rikimaru Hayashi from Kyoto University in the 1980s and the then newly created 'Association of High Pressure Application' composed of food manufacturers and HPP equipment suppliers.

Western countries waited several more years before offering their consumers a HPP product. The first industrial applications in Europe and America were citrus juices first processed in 1995 by the company Ulti in France, and avocado products commercialised by Fresherized Foods (formerly Avomex) from 1997 in USA. Nowadays, Fresherized Foods is without doubt the world's most important company in the HPP food business, regarding production capacity, variety of product range and HPP product sales.

By the end 2008, more than 125 industrial HPP machines were in production for food processing all over the world. Over 80% of them were installed after 2000. This slow start can be explained mainly by the novelty of the process whose benefits were not known by potential users before the turn of the millennium, but also by the inadequacy of the HPP machines offered by the providers of equipment up until then. HPP equipment is located mainly in North America (Canada, Mexico and USA), but also in Europe (Spain, Italy, Netherlands, Belgium, Greece, Portugal, France, UK, Czech Republic and Germany), Asia (mainly Japan but also China and Korea), South America (Peru) and Oceania (Australia and New Zealand).

The total production of HPP products is estimated at over 150,000 metric tons/year and is steadily growing. Some 60 different companies in the world are marketing more than 200 different HPP products.

HPP: technological advances

The main reason for the HPP peak in use by the food industry over the last decade is the great improvement in the equipment available. Technological advances have made it a much more reliable, durable and safe process and enabled much higher production capacities at lower costs.

Wave 420
loading

Wave 6000 55 with robots

The main technological advances are:

1. The development of a newly designed horizontal high pressure vessel

The high pressure vessel is one of two elements (along with the high pressure intensifier) that have a greater technical complexity, and it is the most costly part of the machine. Two improvements in this essential part of the machine are the main reasons for its advancement: horizontal design and wire-winding pre-compression.

In the year 2000, NC Hyperbaric, world leading provider of technology in the food sector, developed the first horizontal vessel especially designed for this industry. This meant a whole new range of advantages in aspects such as:

- Improved traceability of the process. Products enter the vessel from one side and exit on the opposite. By contrast, in vertical equipment, loading and unloading takes place from the same end, which increases the risk of confusion between processed product and product to be processed.
- Installation: The Installation of a horizontal machine is easier, more practical and much less costly than that of a vertical one. The small height (2.5m) of the horizontal equipment allows transport through the standard doors of any factory. No crane is required to stand the vessel up inside the factory. Also, the weight of the horizontal industrial equipment – between 20 tons for a 55L equipment and 60 tons for a 300L machine – is distributed on an area (7m^2 or 15m^2) such that in most cases there is no need for a reinforced floor as is necessary for vertical equipment.
- Ergonomics. Loading and unloading motions in the horizontal machines are made at waist level, and can be more easily done either manually or automatically than in a several-metre-high vertical machine. The machine can now work in a continuous way, as an unprocessed batch automatically enters the vessel while the processed products are automatically exiting through the opposite side. The operator can put the next batch onto the loading line and, when a cycle is finished, the next cycle starts automatically. This is very important for operational efficiency, as the operator does not need to waste time unloading one batch with a crane before being able to enter the next one. Another recent, successful development has been the installation of integrated conveyors for returning empty carriers back to the loading point.

Two improvements in this essential part of the machine are the main reasons for its advancement: horizontal design and wire-winding pre-compression

To the advantages provided by a horizontal design we add wire-winding technology used for vessel manufacturing. This process is much more complicated to develop than the previously used shrink-fitting or autofrettage, but it gives the best results, especially for large diameters and high volume vessels. It has proved to be key in guaranteeing a long life for this component, a reduction in material fatigue, a lighter weight, and an outstanding safety improvement.

Wave 6000 55

Diagram of operation of a HPP horizontal machine

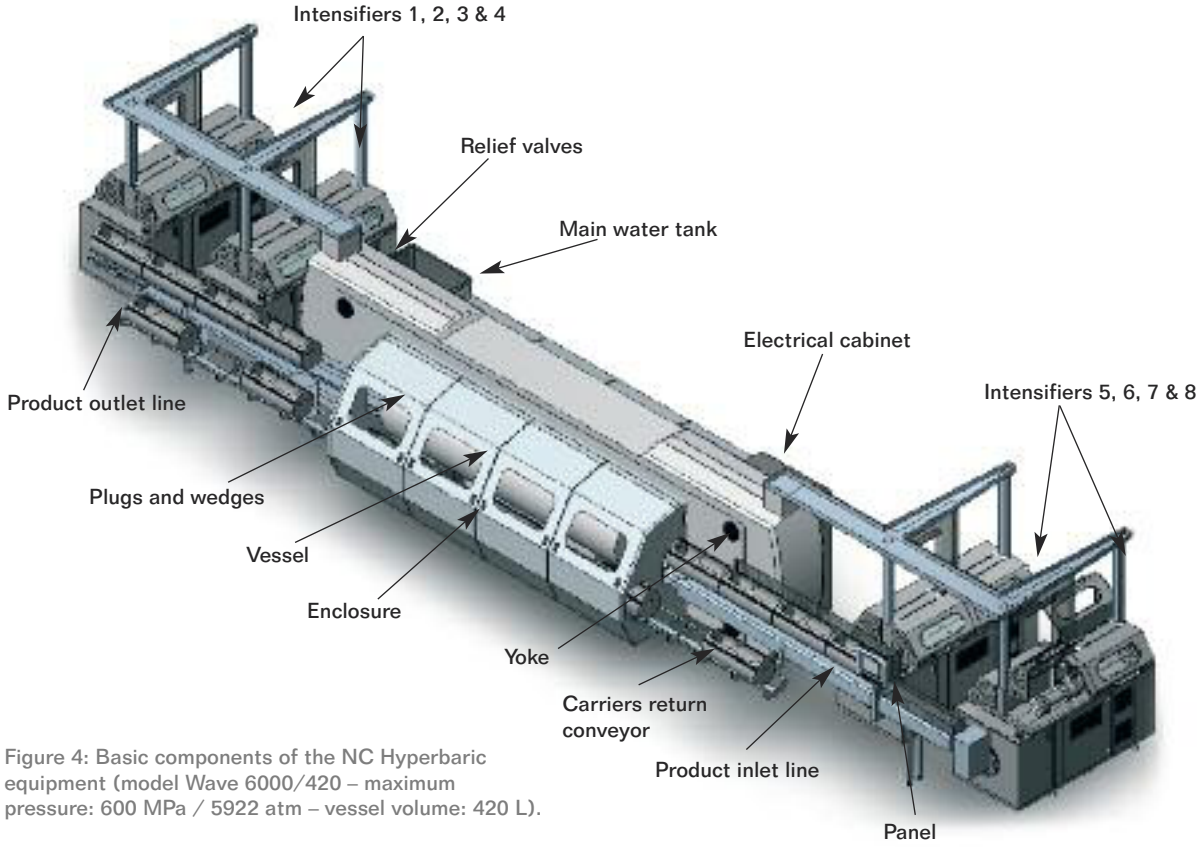

Figure 4: Basic components of the NC Hyperbaric equipment (model Wave 6000/420 – maximum pressure: 600 MPa / 5922 atm – vessel volume: 420 L).

2. Development of high pressure intensifiers

Nowadays, high pressure intensifiers include many new developments in parts of utmost importance such as the HP seals, check valves, HP bodies, etc. Endurance of these components is being constantly improved through the design and study of materials. This is a critical point for the reliability and productivity of HPP equipment and one of the biggest reasons for a cost reduction in the process.

Costs of HPP

HPP has historically faced limitations such as high running costs and low production per hour. Though it cannot yet be seen as a way to decrease the processing cost of a regular product, it has nevertheless experienced great improvements over the last few years. Nowadays we can find equipment capable of processing more than two tons of product per hour* at a cost of €0,06 per kilogram**. Such high productivity and low costs are exponentially better than anything seen 10 years ago and are one of the most important reasons for the increase in the number of HPP products marketed around the world.

> **It has room for continuous improvement as it keeps on being a technology only affordable for premium, high quality or specialist products**

Still, there is room for continuous improvement, as it remains a technology only affordable for premium, high quality or specialist products.

Conclusion

The food industry nowadays has a large choice of production capacity for industrial machines: from 200kg/h up to more than 2000kg/h for single vessel equipment working at 6000 bar. This can satisfy the needs of niche markets as well as those of large volume productions. HPP is an emerging non-thermal technology that is being successfully implemented in food industries that look for innovation, safety, export development and higher quality as key tools for the improvement of competitiveness and profitability in global markets. It is an especially powerful tool for new product development, principally for the safe commercialisation of natural, organic, preservative-free ready-to-eat products; for maintaining freshness of fruit and vegetable products; and for the automation of some processes in the seafood industry. ■

*Estimation based on product processed at 6000bar during 3 minutes
**Including depreciation charge, wear parts and energy.

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Innovation Through Pressure

HPP High Pressure Processing

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