Pressure vacuum mixing
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High energy or Chorleywood Bread Process (CBP) mixing was introduced in 1961 by the British Baking Research Association at Chorleywood, subsequently the Flour Milling and Baking Research Association (FMBRA) and now the Campden and Chorleywood Food Research Association (CCFRA).

The main features of the process were:

1. Development of a dough by mechanical work input at nominally 11 watt hours/kg in approximately three minutes 2 Addition of an oxidising improver
2. Addition of an emulsifying agent
3. Addition of extra water. This was necessary to deal with the retention of flour solids normally lost during bulk fermentation and the absence of dough softening which would have taken place during this time
4. Addition of extra yeast which ferments less rapidly during the early stages of final proof
5. Reduction of flour protein to compensate for the increase in specific volume compared with bulk fermentation
6. Use of a partial vacuum in the mixing chamber to reduce the size of and control the crumb structure.

To meet these requirements a specifically designed high powered mixer was necessary and the Tweedy mixer was born.

Fundamentally, the CBP has changed little over the years. Mixing times have been marginally reduced by impact plate and stator development. It is now possible to mechanically develop a dough in 21/2 minutes. Water levels have been further increased by the use of starch damaged flours; more sophisticated improvers have been introduced and delayed vacuum has improved dough development. Final proof times have been increased and temperature and humidity profiles created, which has helped reduce the increased yeast addition levels.

Of course, as with any process, the vastly reduced dough development times compared with traditional fermentation methods have made dough mixing more critical, even more so with reduced tolerance and more variability in flour quality. It should be remembered that at the introduction of the CBP, the majority of breadmaking flour was derived from wheat imported from North America, with high flour protein content and quality.

The critical nature of the process has been largely offset by the significant improvement in ingredient weighing and metering systems, blending and proportioning and energy control through PLCs.

The combination of controlled mechanical energy input, appropriate oxidising improver, suitable crystalline fat and the ability to maximise the use of readily available flour has been responsible for the wide acceptance of the CBP with the result that it is used almost exclusively by industrial bread manufacturers in the UK, Ireland, South Africa, Spain, Israel and New Zealand and extensively by tin bread producers in Australia, Germany and Sweden.

Unfortunately, the requirement - or the ability, depending on your point of view - to use lower protein quality flour, increase water content and eliminate chemical development and fermentation has had an effect on overall quality and flavour, added to which baking times have been so reduced that there is very little flavour development in the crust. Thus to many people the CBP has become synonymous with a very soft and tasteless commodity.

Personally, I believe that this is too simplistic a view. It has been proved that where flour protein levels and water content have been maintained at optimum rather than maximum levels and with appropriate proof and bake times, excellent quality bread can be and is being produce.

However, following the withdrawal of potassium bromate as a permitted additive, it has become more difficult and more expensive to maintain bread quality, especially where ascorbic acid is used as the only oxidising agent.

In an attempt to overcome this problem, the then FMBRA explored the idea of developing a new high energy mixing process, whereby pressure and partial vacuum are applied sequentially during an otherwise standard mix cycle. A new mixing machine was required and this was designed and engineered by the Tweedy division of APV Baker. A patent was filed and subsequently granted.

The photos show the effect of the application of pressure/vacuum at various settings. All the breads illustrated can be made using a Tweedy mixer with this facility, and the illustrations and comments are taken from our article published in the FMBRA Digest in September 1994.

Effect of Mixing - CBP

Effect of structure and volume on four piece 800g white tin bread under a variety of pressure/vacuum conditions.

The two loaves on the left were mixed entirely under pressure at 1.5 bar absolute and 1.2 bar absolute respectively. This produced an open structure with varying sized holes.

The centre loaf was made under a pressure of 1.5 bar absolute for half the mix cycle and atmospheric pressure for the second half. The structure is not quite as open as the two loaves on the left hand side.

The second loaf from the right was mixed under a pressure of 1.5 bar absolute for half the cycle and a partial vacuum of 0.34 bar absolute for the second half This shows clearly improved structure and uniformity. Note the increase in volume.

The loaf on the far right was mixed under a partial vacuum of 0.34 bar absolute. The removal of too much of the air restricted the performance of the ascorbic acid with a consequent reduction in volume. As this loaf was made under typical CBP conditions the claim that additional volume can be achieved using sequential pressure and vacuum would seem justified.

From the examples here, one can see that the pressure applied and its duration during the overall mix cycle can vary depending on the required characteristics of the end product. Optimum results have been achieved with an ascorbic acid level of 75 parts per million, an absolute pressure of 2 bar gauge and a work input level of 11/12 watt hours per kg.

Farmhouse, bloomer and coburgs: The first half of the mixing was at a 1.5 bar absolute flow through pressure with the remainder at atmospheric pressure.

These conditions enhanced the performance of the ascorbic acid in the pressure cycle and allowed a more open structure to be retained in the dough during the atmospheric phase. The final loaf had a more open crumb and was less uniform than standard tin bread.

Vienna sticks and crust rolls: 1.2 bar absolute flow through pressure was applied throughout. Moderate pressure again enhanced the performance of the ascorbic acid, creating a more open structure.

French baguettes: 1.5 bar absolute flow through pressure was applied throughout. You can see the effects of the higher pressure to create an open and more random structure.

These results were recently confirmed following extensive trials at the German Food Technology Institute (BILB) at Bremerhaven.

From the experience of mixers on industrial production lines in the UK and Ireland, there is no doubt that the higher the protein quality of the flour, the more advantageous the application of sequential pressure/vacuum.

The potential benefits to be derived include:

- finer texture
- whiter crumb
- increased crumb softness
- increased volume
- reduced dough stickiness
- improved divider scaling accuracy
- longer shelf life
- reduced ingredient cost.

In Germany it has been found that there is potential for an increase in yield of up to 4%.

The ability to vary texture by applying pressure at different values enables a more open structure if desired than has been available previously on a vacuum only system.

With so many potential benefits you may be wondering why every plant bakery has not invested in pressure/vacuum. There are a variety of reasons why the technique has not yet become widely established in the UK market. These are essentially:

- general use of low protein quality flours
- additional capital cost of pressure vacuum mixing
- additional maintenance and hygiene costs
- inability to obtain a higher price for an improved quality of standard bread
- insufficient on-line experience to establish the true return on investment of the benefits described above.

Flour protein

To minimise total manufacturing cost there has been a gradual reduction in protein quality in recent years. There is no doubt that pressure vacuum performs best on higher protein levels - 11% and above.

Capital cost

There is an on-cost of approximately £35,000 to provide the appropriate certified pressure vessel, bowl clamping arrangement, pumps and valves and safety requirements.

Maintenance/hygiene

It is self evident that the additional equipment requires more attention.

Retail price

In the current very competitive market it is difficult for producers to persuade major retailers to pay a higher price for standard own label breads.

On-line experience

To establish optimum results requires a dedicated expertise to balance recipe process parameters and precise auditing. When this has been carried out the increased capital and revenue costs of pressure vacuum can be justified. In other words there is a prize to be won but it is not necessarily an immediate one.

My personal view is that more immediate returns are available in the area of speciality breads and morning goods. The ability to vary the crumb structure and increase volume are clearly desirable and to process less sticky doughs, particularly through roll make-up plants should improve overall efficiency. However, we also have to be able to provide flavour comparable with bulk fermentation.

This can be achieved by interfacing the mixer with a liquid sponge system whereby up to 40% of the flour recipe can be made into a brew and following a fermentation time of up to 2.5 hours is pumped to the main mixer. By incorporating a heat exchanger, the liquid sponge can be fed at a temperature as low as 60°C enabling better control of the final dough temperature.

A cheap, simple alternative method is to produce a sponge, hold it in a controlled environment for 12/18 hours and feed it into the main mixer. The final dough can incorporate up to 25% sponge.

At this point it may be worth reflecting on the position of continuous mixing. When the Chorleywood Bread Process was developed in 1961 it was by no means the first automated mixing system. At that time there were already a number of continuous mixing systems available, such as Wallace & Tiernan, Straughman, Baker Iverson and Oakes.

Why were these systems removed and why have they not returned in any significant numbers? There seems to be a certain logic that a continuous process plant should be fed with dough also made on a continuous process.

Periodically, enquiries are made about continuous mixers and there are certain applications which lend themselves to this process such as pastry, cookies and bread crumb. However, within the industrial baking industry in the UK there seems little serious interest and it is important to understand why.

If one reads North American literature on the subject the main benefits of continuous mixing are perceived as:

- increased automation
- reduction in fermentation and floor time
- increased productivity
- improved consistency.

The disadvantages are perceived as:

- inflexibility of product change
- higher yeast levels
- lower water absorption.

So it is not difficult to understand why the industry in the UK has shown little enthusiasm.

Modified post mixer processing might reduce the increase in yeast levels as it has done in the case of CBP. A longer residence time in the mixer, typically 100 seconds, could improve water absorption but without an expensive clean in place system and quick change mixing screws it is unlikely that continuous mixing will be as flexible as the almost continuous batch process we have today.

However, it is important to keep up to date with the developments in ingredients, feeds, process and control systems, and continuous mixing should not be written off. As I mentioned in my paper to you last year, it is possible that a system of continuous dough extrusion and packaging bread by multiples of slices to achieve the required end product weight may be an alternative to present techniques at some future date; in which case continuous mixing will become a very proposition.