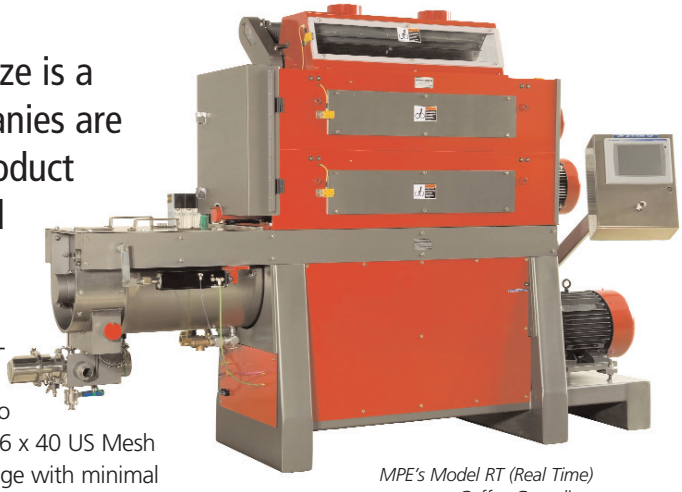
Ensuring precision in the grinding process

Exact control of the grinding process and of particle size is a pre-requisite for good quality coffee, but coffee companies are also seeking a competitive edge through improved product characteristics, higher process efficiencies and reduced energy usage



MPE's Model RT (Real Time) Coffee Granulizer

The earliest coffee grinders consisted of stones that were mashed together, by hand, to grind coffee beans. Later, during the 19th century, soldiers actually used their rifle butts to grind coffee for a brew that was often referred to as "strong enough to float a bullet". Coffee grinding technology has developed continuously since that time to keep pace with development of brewing technologies. In the 20th Century, brewing technology evolved from percolator-style to the drip, or filter, method of brewing, and more recently, we have seen an evolution into pods, capsules and other sophisticated brewing technologies, and to meet these new technological developments and demands, coffee grinding technologies have evolved as well.

Grind size is crucial to the quality, taste and aroma of coffee, and without the right particle size distribution, coffee will be over or under-extracted. Manufacturers note that, for a filter coffee a coffee bean has to be ground into approximately 500 to 800 particles; for an espresso grind a bean needs to be ground into approximately 3,500 particles; and the optimal grind size for each type of coffee and each machine needs to be determined on an individual basis.

The size of the particles produced by the grinding process is all important, but other factors weigh heavily in the process too, and a grinder also needs to be assessed for features such as noise levels; ease of use; the 'feel' of the grind; the look of the extraction/brew; the temperature of coffee and grinder; and of course, the taste of the product in the cup.

As Modern Process Equipment (MPE) in the US notes, in many particle reduction applications, such as grinding coffee, the single most important objective is maximizing particle uniformity. In the US, coffee is typically ground to achieve maximum yield on a 16 x 40 US Mesh (1170 to 590 microns) size range with minimal 'fines' (in this case, particles below 40 Mesh). After grinding, the coffee is not classified (unlike some other products that are ground); rather, it proceeds directly to packaging, and this type of streamlined process demands both grind uniformity and product consistency. If the grind size varies or additional 'fines' (or dust) are created, the coffee over-extracts during the brewing process, and over-extraction increases the bitterness in coffee – a characteristic that producers try to minimise.

In other particle reduction applications, strict particle size requirements must be met and, therefore, product classification is required. When this is the case, 'fines' are often thrown away, reprocessed or used in a secondary market, and in either case, money is lost and energy is wasted.

MPE highlights the uniform grind and product consistency of its Gran-U-

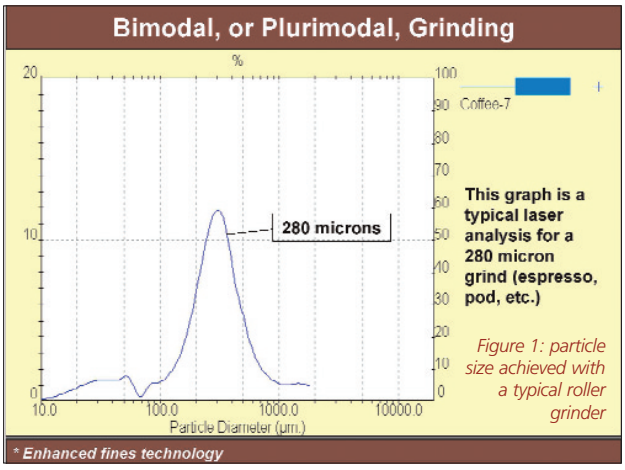


Figure 1: particle size achieved with a typical roller grinder

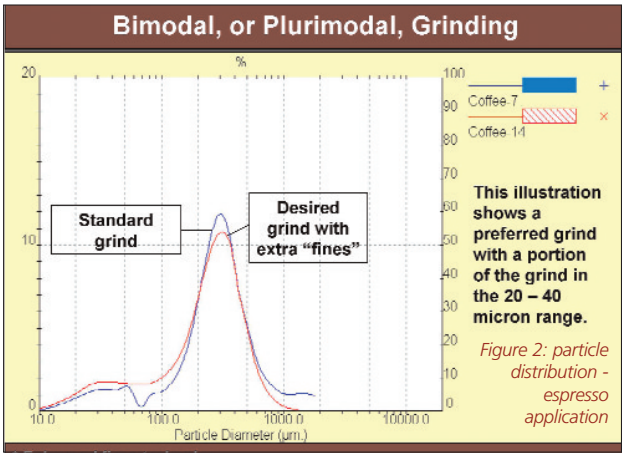
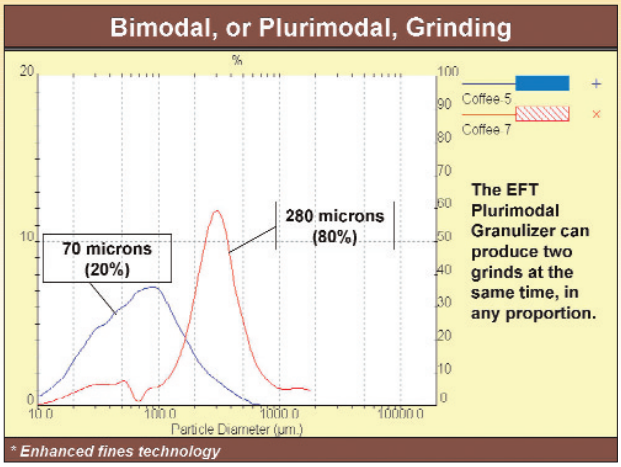
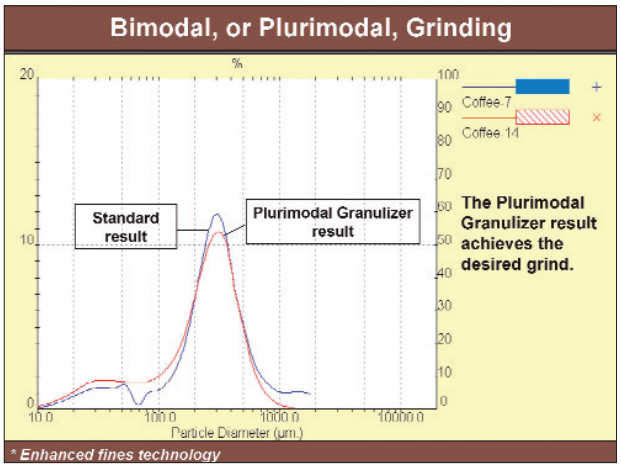


Figure 2: particle distribution - espresso application





TOP: Figure 3: bimodal method of the EFT Granulizer

BOTTOM: Figure 4: natural blending of the two modes within the grinder

High tech grinders from Neuhaus Neotec

Neuhaus Neotec in Germany notes that its WMC 152 grinders have some unique features, including the fact that the drive is separated from the rollers by a cardan shaft. The completely stainless steel-lined grinding chamber ensures minimal adhesion.

The company's WMS series of grinders covers the capacity range 200-1,500kg/hr, and the WMK series the range 2,000-5,000 kg/hr. During the course of 2005, a total of 15 WMC 152 grinders for a single customer in the US were manufactured by Neuhaus Neotec.

Cafes Liegeois, a medium size roaster in Belgium that specialises in the production of pods, recently invested in a new grinder to replace an older machine, choosing to acquire a Neuhaus Neotec WMS 23, a low capacity roll grinder with three grinding stages, the upper two stages producing filter grind, and the lower stage being used only when espresso grind is required.

Water cooling of the compacting unit results in a particularly fresh product, notes the company.

reduction method for any application: if the product to be ground is not friable or fragile/breakable; and if there is no value to be gained from maintaining a uniform particle size with minimal 'fines'.

However, if both conditions mentioned above are met, the Gran-U-Lizer will provide superior particle reduction results, particularly in applications where the desired average particle size range is 100-1,500 microns.

MPE's Gran-U-Lizer utilizes roller mill technology and adheres to three core principals in order to maintain excellent size distribution. First, the rollers that are used are, typically, not smooth. They are, in fact, custom corrugated (or grooved) to suit each specific application. There are literally thousands of different corrugations that might be applied to a given roll. By performing real-world environment lab tests, the best configuration for a given application can be determined. Rolls can be grooved with corrugations that run either along the length of the roll (longitudinal) or around the roll's circumference (circumferential). Flutes within each corrugation can vary both in terms of shape as well as in size. For example, some products require eight flutes per inch, while others use 30 flutes, depending on variables such as material hardness and specified size.

The second important differentiating variable is relative roll speed ratio, or differential roll speed. Running the rolls at the ideal relative speed as the material passes through them will achieve the desired shearing effect. For example, if one roll rotates at 500rpm and the other 1000rpm, the relative roll speed is defined at 2:1 (1000/500). The relative roll speed ratio is proportional to the amount of shear placed upon a particle passing through the 'nip' point of a roller. The higher the shear, the more tearing the crushed particle receives. Depending on the material properties and roll cuts being utilized, this relationship has a definite impact on the particle size distribution.

Thirdly, the operator has the ability to control the product size by widening or narrowing the gap between the rolls. The roll gaps can be adjusted on the fly to alter particle size distributions 'on the fly' in seconds, eliminating the need to shut down a continuous process and allowing fast changeover times between various grind settings. The most critical element of this fine-tuning capability is the need to keep the rolls parallel. Perfectly parallel rolls are a cornerstone of this roller mill technology.

Roller technology has evolved and become much more refined over the past 50 years. Some may still think of roller technology in its crudest form, with 'crushers' haphazardly pulverizing friable materials down to a reduced size, but products like the Gran-U-Lizer have been designed to produce 'controlled explosions' that achieve a completely controlled and highly-engineered particle reduction. Friable materials – basically any materials that can break as opposed to flatten under pressure - can thus be reduced in size with less dust, less 'fines' and greater uniformity.

MPE claims that when compared with alternative methods of grinding, the advantages of this kind of roller mill technology become clear. For example, compare roller mills with hammermills, or Fitzmills, which grind by impact at high speeds and rely on a perforated sizing screen to control particle size. Roller mills typically create 50-75 per cent less dust

or fines, and improve desired particle uniformity by 50-100 per cent.

Since hammermills and other attrition milling methods rely on multiple impacts, they typically require a relatively higher energy usage. Energy savings can be a primary reason to go with roller mills over more traditional methods. In fact, because of their efficient reduction action, roller mill grinders will produce 15-40 per cent more tonnage/hour, at a given horsepower, than hammermills.

Roller mill technology is not necessarily the best technology for every application. If you're looking to produce very fine grinding with final particles in the 40 micron range, pinmills may be your best option, even though pinmills have some inherent disadvantages including relatively low capacities with fairly high operating and capital costs. But if you're looking for superior, controlled reduction for distribution targets ranging from 100 to 1,500 microns, and you're working with friable materials, roller mill technology may be your best option.

MPE says demand for precision particles is growing as companies strive to improve product characteristics, achieve higher process efficiencies and use less energy, the utilized roller mill technologies become ever more important.

At this year's Tea & Coffee World Cup in Hamburg in Germany in September, MPE unveiled the latest addition to its product range, the Model RT (Real Time) Coffee Granulizer, which measures ground coffee size and density immediately upon exiting the grinder, thus eliminating the need for plant personnel to capture samples, perform lab analysis and make manual adjustments. "Most importantly, since the data is captured in 'real time,' the level of control is 99.5 per cent accurate all of the time," notes the company.

As MPE also notes, coffee grind size and density requirements are particularly important in the pod industry, where short extraction times and demanding packaging systems require increased levels of grind control, and with the Model RT, producers can increase product consistency, reduce 'off-spec' material and improve coffee characteristics.

Another well known manufacturer, MAHLKÖNIG, said it believes one of the key trends in grinding equipment is 'grind on demand' grinding for espresso coffee. As the company points out, the finer the grind, the more aroma is released - espresso coffee releases 60 per cent of its aroma in 15 minutes, and exposure to oxygen kills aroma – but using the grind-on-demand technique ensures maximum retention of aroma in the cup.

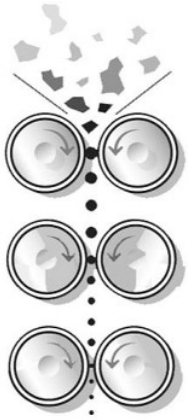
Another development highlighted by MAHLKÖNIG is the trend in some countries for fresh grinding in supermarkets. This has been the case for some time in Germany, but, notes MAHLKÖNIG, in other countries supermarket chains are also adopting the process. MAHLKÖNIG cites Auchan in France, Loumidis in Greece, Coop in Denmark and Somerfield in the UK as examples.

Fresh grinding means setting up self service grinders in supermarkets that enable the customer to choose the bean desired and choose his or her own grind on the grinder. The grinder is easy to use and has a bag holder. The customer puts the beans in the hopper, clutches the bag and starts the grinding process after choosing the degree of grinding he or she requires, enabling customers to purchase freshly ground coffee. MAHLKÖNIG has responded to this trend with a range shop grinders with special self service functions.

As MAHLKÖNIG also explained, like MPR, it believes that grinding coffee for packaging in pods demands a particularly sophisticated machine, such as its DK27 industrial grinder, a grinder that can be mounted on top of a packaging machine, has a high level of flexibility, and is quickly and easily adjusted to different coffee types and brands. Another advantage of the DK27 pod grinder is that on-top installation means that it requires very little space, and there is very little loss of aroma/taste due to a very short time between grinding and packaging.

Also new from MAHLKÖNIG is the K30ES, a grind-on-demand espresso grinder K30ES, which was awarded this a Red Dot design award earlier this year. CCI

Plurimodal grinding

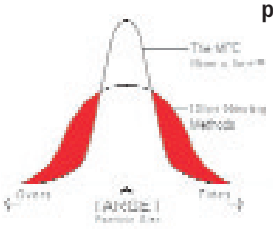


Roller mill or Gran-u-Lizer principle of operation

One of the most recent advances in coffee grinding is the development of a bimodal, or plurimodal, coffee grinder. This grinding methodology provides a grind, or particle size distribution, that allows users to control not only the average grind size, but also to introduce a percentage of smaller particles, or fines, into the grinding process to improve coffee extraction characteristics.

It is, for instance, advantageous in espresso and pod manufacturing to produce a plurimodal particle size distribution, or grind, where the finer particles enhance the exposed extraction surface and the coarser particles allow for the water flow. For instance, in espresso coffee, a concentration of 20 micron-type particles is essential to producing the ideal cup of espresso.

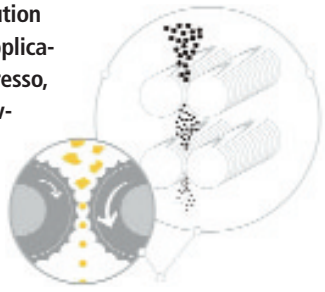
Of the graphs used in this article, Figure 1 shows a typical 280 micron particle size achieved with a roller style grinder. As you can see, the classical, defined particle distribution is one that could be expected with a well-maintained grinder. Figure 2 shows the particle distribution that might be desirable for an espresso application. It would consist of not only a relatively defined particle distribution, but also a preponderance of smaller (20 micron) particles to provide the chemical need required to produce a proper cup of espresso, pod or other single-cup extraction process.



Particle size distribution curve

Figure 3 shows the bimodal method of a grinding machine, which produces a defined amount of the finer, 20 micron particles while, at the same time, producing the primary grind, which has an ideal, uniform, average particle size with a minimal amount of variance (overs and unders).

The natural blending of these two modes, instantaneously within the grinder, is shown in Figure 4, where the blending achieves the desired plurimodal particle size distribution desired for these applications, including espresso, pods, cartridge delivery systems.



Critical design elements: roll cut; roll speed; roll gap