Igor Zelenovskiy and Ken Piper, Rexnord, USA, discuss the common causes of material handling bottlenecks in cement plants.

Finding the cause of a material handling bottleneck in a large plant environment can be akin to solving one of those old black and white movie murder mysteries. Usually, the first step in cracking the case is to gather as much evidence as possible at the scene. After that, interviews must be conducted with everyone involved.

Finally, an experienced ‘bottleneck detective’, in the form of an applications engineer, may be called in to evaluate the findings and point to the culprit.

Solving bottleneck ‘mysteries’ is crucial to maintaining high production levels within a plant. Just one backup can affect the performance of an entire facility. As all material handling within a plant is interrelated, sometimes solving one problem can lead to another. It is important, therefore, to take a systems-wide approach.

The good news is that most material handling bottlenecks have four common causes. By addressing these issues, it is possible to eliminate the vast majority of backups in a cement plant operation.

Mystery 1: surge loading of bucket elevators
Within the plant, it has been noticed that material has been piling up inside the boot of a bucket elevator and subsequent operations are running at less than full capacity because they are starved of material. What is happening?
This situation is typically caused by surge loading of a bucket elevator. A bucket elevator is designed to handle a set volume of material. If there is a major fluctuation in the system to cause this fixed capacity to be overfilled, a problem will result.

There are several factors that can cause surge loading. Quite often, it can be due to wide variations in the amount of material being fed into the elevator at certain times each day. It may also be the result of a recirculation load due to reprocessing requirements, or it may be caused by modifications or improvements to an existing process within the plant that increased the volumetric flow to this elevator. However, it is safe to say that this situation occurs somewhere in almost all facilities, whether or not it is openly admitted to.

Material delivery fluctuation is something that should be addressed at the design stage. Think of it this way: if the specifications for a plant say that an elevator must be designed to deliver 100 tph of material but all of the feed comes in a 15 minute period, the elevator will be overloaded. It should have been designed to handle 400 tph because that is the rate at which the material is being fed.

The proper way to design a bucket elevator is to ask the sort of questions that lead to the right answers, to understand how the system is being run or operated and then to propose an elevator that can handle what is believed to be the worst case scenario. If a designer just takes the specifications at face value, there is a chance of specifying an incomplete or insufficient solution.

Surge loading of a bucket elevator can also occur in existing plants due to an increase in capacity or a modification in system layout. When this happens, it is important to realise that there is nothing wrong with the elevator. It is just being asked to do too much and must be resized to fit the new parameters of the operation.

Mystery 2: spillage on clinker conveyors
Clinker conveyors are another common source of material handling problems. If clinker is being transferred onto a conveyor at a point that is too close to the tail shaft or otherwise in the wrong position, it may fall off the end of the conveyor because it has nowhere else to go, especially during surge feed conditions. This material will end up on the floor or on the ground, creating both a material handling problem and a potential safety problem. Not only is there lost time and expense for clean up, but there is a safety concern for anyone working around the equipment.

How much spillage is a problem? In a plant with a capacity of 200 tph, spillage of only 1% of the material being handled means 2 t of material must be cleaned up every hour. It does not take long to create a substantial pile that could eventually affect the performance of the conveyor and the productivity of the plant.

The solution in this case is a proper system design that will allow sufficient room for loading of the conveyor upstream of the tail shaft. In some situations, there may also be a need to increase the size and capacity of the conveyor itself.

Mystery 3: lower than expected finish cement capacities
Often, a plant manager is baffled when an elevator designed to handle a certain tonnage of finish cement each day fails to meet its capacity ratings. The cause of this problem is usually the material itself. During processing, air becomes trapped within finish cement and it becomes less dense and hence lighter by volume. Cement, as bought in a bag at a home improvement store, weighs 92 lb/ft³. The typical material handling density of finish cement, however, is approximately two thirds of that amount, or about 65 lb/ft³. This is often called the material’s ‘as handled’ condition.

Someone designing an elevator who is unaware of the ‘as handled’ condition of finished cement will likely propose equipment that is undersized compared with the volume of material that needs to be moved. In turn, this will create a production bottleneck that will seem mysterious except to experienced, knowledgeable product specialists.

The solution to this puzzle is to treat the finish cement volumetrically. Calculating the volume of
cement required to meet production tonnage goals will result in properly sized elevators and buckets.

A second, related problem with finish cement is its tendency to act more like a liquid than a solid. Due to its fine texture, it is often difficult to dump out of an elevator bucket in one or two seconds unless some air is allowed to enter in behind it.

Think of a large can of tomato juice – if you punch just one opening in the top of the can, the juice will pour slowly and unevenly. Punching a second hole to allow air into the can makes the juice flow more easily. The same is true with finish cement and other fine materials. By providing vent holes at critical locations in the buckets, the cement will both load and discharge more quickly.

Mystery 4: higher speed reduces performance

In many cases, plant operators attempt to increase productivity by speeding up conveyors and elevators in a plant. The problem is that increasing the speed of these systems usually does not work and may in fact have the opposite effect.

Equipment suppliers have gone back to installations that were working well for several years but are now having problems. Upon further inspection, it may be discovered that a drive shaft is running about 40% faster than when it was installed. At that point, someone usually steps forward to admit that they changed a sprocket to make the equipment run faster.

Just going faster does not necessarily improve production. It is similar to aiming a high-pressure fire hose into a bucket. That bucket will never fill up because the water will literally hit the bottom and fly back out again. The same thing usually happens with material handling equipment.

Increased speed reduces the time that the material has to load into and be discharged from the bucket. It also changes the trajectory of material during discharge, resulting in spillage. In some cases, the positioning of the discharge chute may need to be changed to make the equipment work properly.

On occasion, a small increase in speed will provide some improvement. Running equipment twice as fast, however, will not allow it to move twice as much material because it was not designed that way. The real solution is to determine if an increase in capacity can be accomplished with a retrofit or modifications to current components, such as buckets, chains and drives.

Making the best of the situation

Sometimes the only solution to a material handling problem is to make the best of the situation. For various reasons, often financial, a plant operator may decide to stick with what they have and try to minimise the impact on productivity and profitability.

It may be that the componentry is being asked to operate in a corrosive, abrasive or high heat environment for which it was not intended. Or it may be that it is being subjected to higher capacities than those for which it was designed. If the operator decides to accept the situation, it may be necessary to replace the component more frequently than normal. On the other hand, it may be possible to redesign or customise some of the componentry in order to make it last longer or perform better.

This last point demonstrates how developing close relationships with the people who actually operate the plant is critical in designing a facility that can run productively for 40 or more years. It may not be possible to win every job with this approach, but it generally delivers the best results for the plant owner in the long run.

While some material handling mysteries can be traced to problems with the original plant design, some to changes in plant capacity or modifications, and others to the intrinsic properties of cement itself, nearly all can be solved by careful sleuthing and with the experience and knowledge to ask the right questions.