Optimising plant design using plant feed and LD core data

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Abstract. A key requirement when designing a Coal Processing Plant (CPP) is for all process units to be sized to efficiently process the full range of expected feed types at design throughput. Conventional CPP design typically uses large diameter bore (LD) core samples to develop design windows that define the full range of size distribution and circuit yields. Application of these design windows applies the highest and/or lowest yields for each circuit with the coarsest and/or finest feed types to ensure that all circuits can handle all feeds that conceptually lie within the design windows. However, this may result in design unit capacities for some circuits that will never likely be required in practice, and hence over-design of certain circuits, which can significantly increase capital and operating costs. This paper will discuss the application of an innovative approach, which involves the development of customised graphics that super-impose the results of Limn simulations for all feed samples onto a 2D graphic of feed size distribution and yield. This highlights non-populated or very lightly populated areas of the design windows that can be selectively excluded, resulting in a reduction of required process unit capacity for specific streams and equipment.

1 Introduction

A key requirement when designing a Coal Processing Plant (CPP) is for all process units to be sized to efficiently process the full range of expected feed types at design throughput. Conventional CPP design typically develops a set of design windows that define the range of plant feed size distributions that can be handled, and the range of yields for individual plant circuits.

If the plant is an expansion of an existing mining operation or is to be built in an established coal field with existing neighbouring CPP's processing the same seams, production data in the form of representative topsize plant feed samples from these plants may be used with confidence.

Alternatively, representative large diameter bore cores, which include samples of expected dilution can be used to provide reliable plant design data. Well-established and proven Australian Standard (AS) procedures [1,2,3] have been developed that clearly define the pre-treatment procedures of drop-shatter and subsequent wet tumble, which emulate the natural breakage that occurs during mining and coal handling, and the subsequent effects of abrasion and wetting as the raw coal is pumped through the plant circuits. The wet-sized feed samples are then subjected to a comprehensive suite of float/sink densities over a range of size fractions to determine the change in washability for different size fractions. This pre-treated sizing data is used for developing accurate design envelopes. Limn^{TM} modelling of the required plant circuit using the pre-treated washability data is then used to determine the yield windows for individual circuits for the expected operating ranges in terms of cutpoint and/or product ash.

Depending on the specific mining, stockpiling, and coal handling procedures that will be used to feed the CPP, additional size distribution adjustments may be required prior to determining the design windows.

The conventional approach of applying the resultant design windows consists of applying the highest and/or lowest yields for each circuit with the coarsest and/or finest feed types to ensure that all circuits can handle all feeds that conceptually lie within the size distribution and yield design windows. However, this may result in required unit capacities for some circuits that will never likely be required in practice, e.g., if the dilution component consists of high levels of fine clays, it is highly unlikely that the finest feeds will coincide with the highest fine circuit yields. This results in over-design of certain units, which can significantly increase both capital and operating costs.

An innovative approach to address this problem involves the development of customised graphics which super-impose the results of Limn simulations for all feed samples onto a 2D graphic of feed size distribution and yield. This highlights non-populated or very lightly populated areas of the design windows that can be selectively excluded, resulting in a reduction of required process unit capacity for specific streams and equipment.

2 Australian standards bore core pre-treatment and analysis procedures

During the rapid expansion of the Australian coking and thermal coal industry during the latter part of last century, it was identified that the existing technology of bore core analysis was under-estimating the generation of fine coal. This often resulted in coal preparation plants with fine circuits, especially for the friable hard coking coal mines, that were substantially undersized, resulting in significant losses in the fine circuit and so total plant yield.

A series of major industry sponsored Research and Development (R & D) programmes were therefore undertaken. These were initially funded by NERDDC (C1209) [4], and then subsequently completed under Australian Coal Association Research Program (ACARP) funding (C3004) [5,6]. These studies incorporated extended field sampling and laboratory testing from a number of sites across the Australian industry, and included representatives from a number of operating companies as well as industry service groups.

The outcome from this work is essentially encapsulated in two current Australian standards:

- AS4156.8-2007 Coal Preparation Part 8: Sample pre-treatment – Drop-shatter [1]
- AS4156.1-1994 Coal Preparation Part 1: Higher rank coal – Float and sink testing; Appendix E "Simulation of Plant Environment by Wet Tumbling" [2]

These standards should be used in preference to the earlier sizing and wet tumbling procedures in AS2159 [3]. In addition, C3004 introduced the concept of an additional pre-treatment stage of dry tumbling (without cubes) prior to wet tumbling to account for additional fines generated by abrasion, which allows for better matching of fines content between the bore core samples and sampled plant feeds. Please note that there are similar standards and practices in a number of countries, such as the Attrition Testing concept for bore core pre-treatment conducted in North America.

2.1 Selection of core size

Table 1 shows the estimated masses of coal samples for each metre of core for different diameter cores, assuming a density of 1.45 RD. The industry standard plant feed topsize is widely accepted as 50 mm for dense medium plants, although the size may be coarser if dense medium baths or jigs are used. In such cases, the product is typically reduced to 50 mm topsize which is a typical maximum size for international trade. Finer top sizes may be considered in special cases to improve liberation or for feeding small capacity plants fitted with smaller pumps and cyclones.

Table 1. Estimated sample mass from different core sizes (assume RD 1.45)

Core Diameter mm	100	150	200	250
Mass per 1 m thickness (kg)	11	25	44	69
Thickness for 50 kg sample (m)	4.5	2	1.1	0.7
Thickness for 30 kg sample (m)	2.7	1.2	0.7	0.4

AS 4156.1-1994 [2] on float/sink testing indicates that a total sample mass of several hundred kg will be required for float/sink testing of 50 mm top-size material, depending upon the proportion of feed reporting to the coarsest size range for testing. According to Table 1, even the use of expensive 200 mm cores will only result in 44 kg / m, requiring 5 lineal metres or more of core for each sample to abide by the standard. This is clearly not practical with most seams or nominated working sections being considerably less than 5 m. In practice this is alleviated considerably by the nature of cores which accurately intercept a series of plies with representative weighting to each. Washability and other coal quality parameters typically vary on a ply by ply basis within a seam but tend to change only gradually along strike or down dip within each ply. Therefore, statistically a core intrinsically generates a more representative sample of the block of coal being targeted compared with the random nature of sampling from moving production streams, which is what AS 4156.1 is primarily focussed on.

In practice, a minimum sample mass of 50 kg has proven to provide reliable, reproducible simulation results when applied to cores, and in many instances acceptable results are achieved with 30 kg or less. If the mass is less than 30 kg, a useful compromise is to reduce the topsize to 32 mm prior to sub-division for float/sink analysis, as the impact of reducing the top size on the amount of fines (perhaps 1 or 2 %) is more than offset by the much improved statistics of reduced topsize from 50 mm down to 32 mm, which corresponds to a four-fold reduction in minimum mass requirement.

2.2 Bore core pretreatment and breakage

The R & D programme described above [4,5,6] quickly identified that simple crushing of the core in either jaw crushers or roll crushers resulted in a sizing that was much coarser than typical plant feed. The AS2519-1993 Guide to the technical evaluation of higher rank coal deposits [3] references Stage II drilling (out of 3 stages) which is focussed on raising “the level of confidence in the drilling results, and involves a greater number of cored boreholes once the general “geology structure is delineated, and seams are correlated”. Typically only slim cores with no pre-treatment and limited float/sink testing are used in this stage.

However at one Central Queensland site, even when 150 mm cores are drilled to increase sample mass but the cores are still simply crushed to 12 mm top-size with no pre-treatment similar to Stage 11 drilling for mine planning purposes, the typical percentage passing 0.5 mm ranges from about 8 to 13%. When the actual plant feed is sampled for that site, the average percentage -0.5 mm in the dry plant feed is in the mid-20's and increases to approximately 30% after wet tumbling. At times the plant feed size distribution may be finer if subjected to excess re-handle in the field. In addition, there is an increased proportion of the more friable, lower ash, vitrinite rich components that report to the fine circuits compared with the Stage II style bore core data.

After considerable trial and error, a standard procedure was established of passing the core through a series of drops onto a steel plate from a standard height. This effectively emulated the series of low energy steps in the mining and coal handling train as the coal is dropped from a shovel bucket into the back of a truck, from the truck into a dump hopper, through transfer points, across a sizing screen and through a series of drops in a rotary breaker. This was the most common plant feed sizing unit in practice in Central Queensland at the time.

During the early research, the final size distribution was found to be well correlated with the Hardgrove Index (HGI), and in fact the procedure originally adopted was one that predicted plant feed size distributions based on the HGI. As discussed above, however, subsequent extensive site-based sampling programme (ACARP C3004) [5,6] tended to discredit this approach. The current practice is to conduct a series of tests with an initial representative sample typical of the resource, and incrementally increases the number of drops until a point is reached where the generation of additional fines becomes minimal. This is considered the "natural endpoint" equivalent to normal mining and coal handling practice, and this number of drops is used for the remainder of the core programme.

Common practice in the Australian industry is to now specify a standard number of drops, typically 15, although this may vary for different practitioners from 10 up to 20, depending upon their experience or the specific nature of the coal mining and handling procedures at a particular site. Use of a fixed number of standard drops has the additional advantage that it differentiates between different feeds within a particular mine-site, which provides a "design window" for that site once a representative range of feed samples has been collected and analysed.

Of importance is attention to control of dust during the testing, both from an HSE viewpoint for the laboratory personnel, and to ensure that all fines are recovered. Good practice demands recording of the sample mass before and after drop shatter testing, and it is quite common practice to allocate any losses to the finest size fractions.

It is recommended that two steps of dry sizing be undertaken on cores of 150 mm or larger:

- Initial dry sizing down to 1 or 2 mm after the drop shatter process is complete, but prior to knapping of the remaining +50 mm material. This will provide useful sizing data for designing the secondary / tertiary sizing stages of the coal handling plant (CHP).
- Dry sizing down to 1 or 2 mm after knapping of oversize, but prior to dry tumbling.

The initial phase of the ACARP study [2] involved interviewing various industry parties to obtain an opinion as to the efficacy of the existing standard procedures for drop shatter, and if they were considered to generate samples that were representative of actual practice. It was widely noted that in many instances the amount of ultrafines was often still under-represented by the drop shatter technique. Simply increasing the number of drops did not tend to create additional ultrafine material, and it was assumed to be due to the abrasion of the dry coal as it travels in the back of trucks, cascades through dump stations, and is transported along conveyors and through transfer points, etc. being under-represented by the drop shatter technique alone. Hence, an additional step of dry tumble of the coal in a standard wet tumble drum was then applied.

This step has not been uniformly introduced into Australian coal preparation practice, and creates discrepancies when comparing data generated from different sampling programmes from the same coal measures.

An additional step of wet tumble was introduced along with the drop shatter techniques to reflect the additional abrasion and generation of fines that occurs within the coal processing plant once the feed is wetted, and passed through a series of pumps, across screens, through cyclones, etc. Such a technique also identified if any fine clays present in either fine stone bands within the coal plies, or within the roof and floor material, is prone to slake and break down in the presence of water.

AS4156.1 [2] prescribes 5 minutes of tumbling in a standard-sized drum with a standard quantity of water and a number of 50 mm steel cubes. These are proportioned to the amount of feed solids if < 50 kg is being processed.

For coals such as those from the Surat Basin and Hunter Valley that may contain relatively high levels of fine clays, the amount of fines present in the discharge stream from the wet tumble procedure is substantially greater than those present in the original dry feed. This highlights the importance of such a step in preparing the sample to accurately represent the "run of plant" size distribution that the plant will have to process. Note that much of this material will initially report to the coarse circuit and many of the fines are generated within the coarse circuits of the CPP itself. However, these fines will ultimately report via drain & rinse screens through the magnetic separators back to the desliming screens and ultimately the fine circuits, so it is important to make allowance for these fines when designing all parts of the circuit.

It should be noted that the Australia Standards referenced in this paper are based on good mining and coal handling practices. Those sites that indulge in practices that generate excess fines such as excessive blasting of the coal on wide patterns rather than closer spacing with lower powder factors to save on drilling, or where a significant proportion of the coal is stockpiled on the Run-of-Mine stockpile (ROM) and subjected to excessive dozing prior to processing will experience finer feeds than predicted.

Feed from underground mines is a particular issue. Conventional wisdom is that underground mining generates excessive fines compared with open-cut mining, especially during the initial development phase. Once long wall panels become established, while there is a reduction in the coarsest size fractions, the wet tumble generated size distributions align at about the 1 to 2 mm mark, resulting in similar loadings in the coarse and finer circuits.

2.3 Float/sink testing

The basic objective of float/sink testing of the feed is to define the coal quality of the feed in terms of a two-dimensional array of size by density, because with the exception of flotation, all conventional coal preparation processes are "gravity" or hydraulic processes which operate according to differences in density and/or size of the individual particles. Ash is the most important parameter to measure, as it increases with density. Other parameters that may be measured for each size by density fraction include Total Sulphur (TS), phosphorus, and coking properties, depending upon the particular coal quality constraints when processing a particular feed, as these properties also vary according to the particle size and density.

Specific Energy (SE) is commonly measured on individual size by density fractions, although a much more cost-effective approach is to develop a regression of SE_{gad} versus ash at constant air dry moisture, and apply the regression to any particular parcel of coal. Care needs to be taken when measuring SE on float/sink fractions for lower rank bituminous coals as the SE value has been observed to be depressed significantly for such coal types due to extended exposure to float/sink liquids and laboratory handling. The authors do not recommend analysing SE on individual float/sink fractions for these coal types.

When conducting Stage I and II analyses for exploration of slim cores [3], the core samples are usually crushed to about 12 mm topsize and either the full size range is analysed in a single float/sink process, or perhaps the -0.5 mm fraction is removed prior to float/sink testing. Either procedure is suitable for Stage I and II testing where a general understanding of yield / ash relationships for various seams throughout the resource is all that is necessary.

For Stage III testing when the washability data is to be used for plant design and plant simulations, it is essential that after appropriate pre-treatment the feed be divided into a minimum of 3 and ideally more size fractions with float/sink analysis carried out on individual size ranges. There are a number of reasons for this:

- The washability characteristics usually change with size, with coarser size fractions typically containing an increased proportion of unliberated middlings material.
- When used for simulations, the modelling parameters such as Rho50 and Ep for density processes change significantly with size. Hence it is important to carefully match the changing washability pattern of different size fractions with the relevant process parameters when using different processes to treat different size fractions. This allows for modelling the process efficiency changes that occur with particle size within each process unit.
- The efficiency of the float/sink process is not perfect, and when analysing a very wide size range in the same float/sink vessel, it is inevitable that fines will be entrained with coarser particles. Hence, more precise float/sink results can be achieved when analysing different size ranges separately, and if necessary, processing the fine coal in smaller float/sink vessels.

When float/sink testing a 50 mm topsize feed, it is recommended that the feed be sized at 4, 1.0 and 0.25 mm as a minimum. If it is likely that the coarsest coal fraction will be processed in a different unit such as a dense medium bath, or if product sizing is required for splitting out a coarse, low CSN PCI product from a finer hard coking product, an additional coarse sizing at say 12 to 16 mm will be necessary. Float/sink testing of feed finer than 0.25 mm can be carried out, but with poorer accuracy at finer sizes due to back mixing of the finest near gravity particles. Such material is usually subjected to flotation testing. The authors also recommend measuring the raw ash of the individual fine size fractions that were not subjected to float/sink analysis, and applying a suitable algorithm using input washability data from the finest size fraction analysed (say -1.0 + 0.25 mm) that adjusts the relative masses of the lowest and highest density components to maintain a mass and ash balance for the individual size fractions. This allows for the full-size range of the feed to be modelled consistently by density and hydraulic-based simulation models, even when the same size fraction reports to different process streams.

The range of float/sink liquids needs to extend well beyond the expected operating cutpoint to allow for alternative processing scenarios over a wider range of operating cutpoints, and to allow for modelling of the impact of process efficiency over a wide range of densities. The typical range should cover from say 1.30 to 2.00 as a minimum, with the lower or upper range being extended depending upon the particular coal type and expected operating cutpoint. Typically float/sink fractions are in 0.1 increments for lower densities with perhaps 0.2 increments for higher densities, especially when processing feeds for coking coal production with expected cutpoints at a maximum of 1.50. Intermediate 0.05 increments may also be included when analysing coals with a large proportion of mass over a narrow density range. If applied generally, however, the small masses present in many increments renders such an approach expensive and ineffective with "noisy" incremental results due to lack of sample mass in many of the density fractions.

2.4 Coal loss and dilution

Modern open cut mining practices use a scale of gear that inevitably includes significant amounts of out of seam dilution if high recoveries of in-situ coal are to be realised. Reconciliations at a number of Australian sites indicate that dilution is of the order of 7% when mining seams 2 to 3 m thick, but dilution levels may range from less than 2% when mining thick seams > 7 m thick up to >20% when mining thin seams < 1.0 m thick. In addition, if intermediate partings are <0.3 m thick, it is normally considered ineffective to remove them in a separate mining pass, so they will also be included in the plant feed.

Underground dilution allowances will depend upon cutting height versus seam thickness, use of top-level caving techniques to maximise coal recovery from thick seams, and any structural features to be encountered.

This dilution material can have very different size distribution characteristics compared with the in-seam coaly material, so will have different impacts on the various in-plant circuits. In particular, it will largely report to the reject and tailings streams, so for high yielding coals in particular, it may significantly increase the relative loads on these waste streams. This is particularly important when designing for mechanical dewatering of fine tailings streams where the available gear has very low unit loadings, so circuit capacity will be constrained if an insufficient number of units have been installed to handle all expected feed conditions.

It is therefore important to sample the roof, floor and any intermediate partings. Approximately 150 mm is collected to provide adequate sample mass, although samples from adjacent cores when analysing the same seams may be composited prior to analysis to increase sample mass and save analytical costs if the samples have similar geological classifications.

It is important to treat these samples with exactly the same pre-treatment techniques of drop shatter, dry and wet tumble as the in-seam coal so that the distribution of dilution and partings to the various coarse and fine circuits is accurately modelled and allowed for in the CPP design.

If the raw ash of the dilution and partings is greater than about 80% (ad) ash, then it is very unlikely to contain significant amounts of F1.80 RD material and can safely be assumed to report to the highest density fraction for each size range when modelling the diluted feed. Float/sink testing of the sample should be carried out if the raw ash is < 80% (ad), but at a limited range of densities, say 1.40, 1.60, 1.80 and 2.00 RD to ensure adequate sample mass for testing in each density fraction, and to save costs on unnecessary float/sink testing. In the case of feeds for plants that are likely to be processing the feed at higher cutpoints close to 2.00 RD such as many South African and Indian thermal plants, then more comprehensive analysis of such partings is justified.

3 Plant design

If the bore core samples have been pre-treated and float / sink tested according to section 2, these data may then be used to generate the size distribution and yield design windows which define the range of feed types that the coal preparation plant is designed to handle efficiently at the nominated feed rate as follows:

- Size distribution window, which determines the proportions of the feed that will report to the various coarse and fine circuits for each feed type.

- Dry "Plant Feed" size distribution after drop shatter (and dry tumbling) but prior to the wet tumbling stage, which reflects the size distribution reporting to the plant feed head-chute, and
- Wet "Process" size distribution after wet tumbling which determines how the feed will ultimately proportion itself between the various size circuits within the plant.

- Yield window for each circuit, which will also change with operating conditions of the CPP such as Dense Medium Cyclone (DMC) cutpoint, so simulations are typically carried out to cover the expected range of operating conditions for each feed sample to determine the range of yields for each circuit.

3.1 Size distribution window

Figures 1 and 2 show typical plant feed and process sizing graphs using Rosin-Rammler probability plots for a high rank coking coal. In each instance, all the working sections have been plotted on the curves, and the design window is then superimposed to ensure that at least 95% of the feed samples can be efficiently processed if the plant is designed according to the design window.

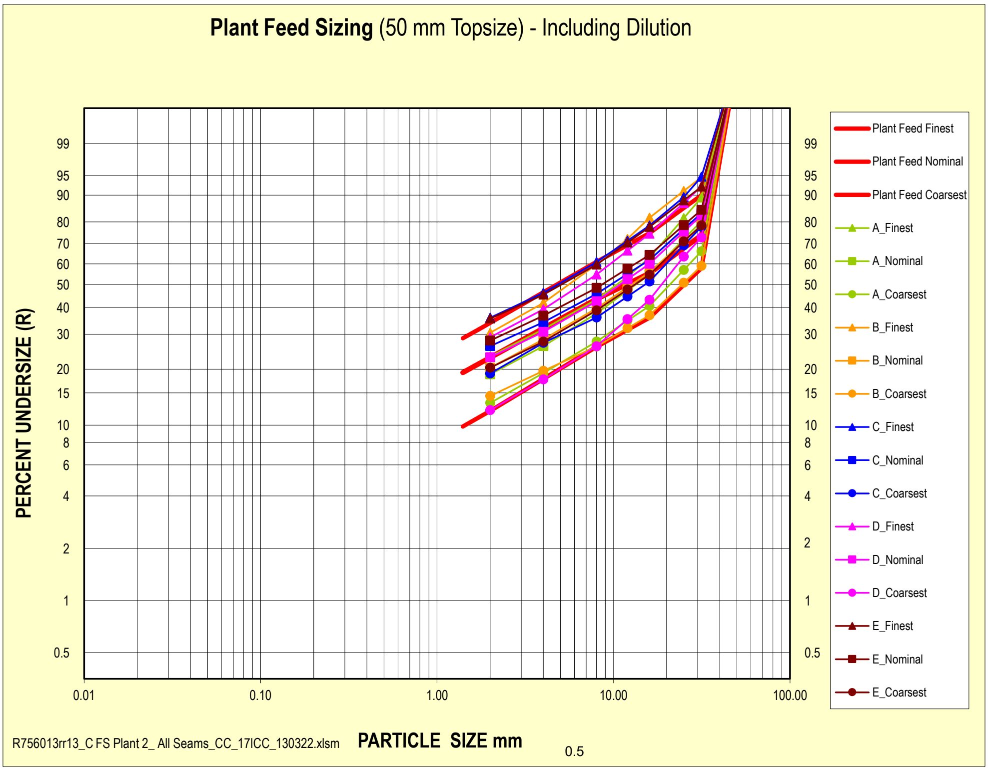

Fig 1. Plant feed size distribution window (dry sizing prior to wet tumble)

In practice, unless outliers are representative of a significant proportion of the plant feed, it is seldom cost-effective to design a plant that encompasses the full range of data if a large range of working sections has been analysed (say > 50).

Often extremes in size distribution relate to a specific ply or working section that may readily be blended with other sources of coal when fed to the plant, so that the combined blend lies within the window. At worst, the plant may have to be de-rated when processing that particular feed. If the plant is designed to encompass 100% of the feed, it means that most units and circuits within the plant will be under-utilised for much of the time, resulting in a higher Capex per unit tonne compared with a plant designed to accommodate 95% of the feed samples. This may appropriately be an area for compromise for underground mines where all the plant feed is sourced for prolonged periods from a limited area which is often only represented by only a few, if any cores.

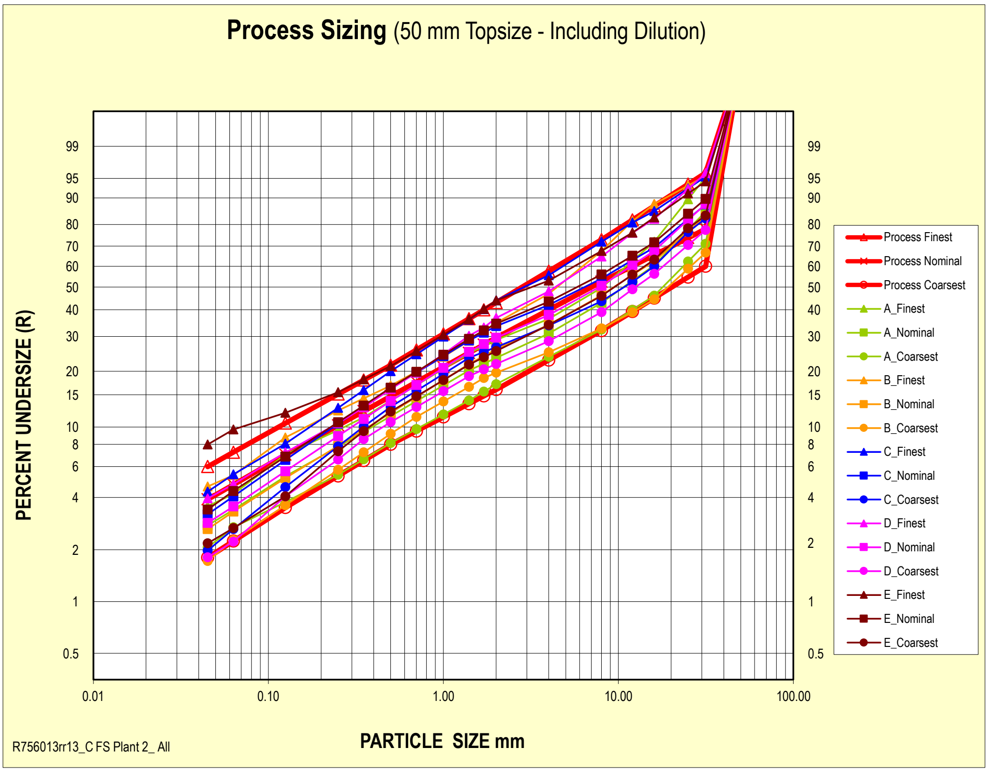

Fig 2. Plant process size distribution window (wet sizing after wet tumble)

Table 2 shows a typical Size Distribution Design Window based on the process sizing graphs in Figure 2.

Table 2. Size distribution window

Circuit	Size Range	Finest	Nominal	Coarsest
DMC	+2.0 mm	56.5	69.5	84
Spirals	-2.0 + 0.25 mm	28	19.5	10.5
Flotation	-0.25 mm	15.5	11	5.5

3.2 Yield window

The washability data may then be used to determine the range of expected yields for each individual plant circuit. Allowance should also be made for plant efficiency, both for the classification circuits and the beneficiation processes within each circuit such as dense medium cyclones for coarser size fractions, spirals or reflux classifiers for mid-sized fraction, and flotation for the finest fractions, especially for coking coals.

Accurate modelling of the plant efficiency can most readily be achieved using plant simulation models such as Limn^{TM}. It operates within the Microsoft Excel spreadsheet environment, and a component of Limn called the 'Coal Wizard' is specifically customised for simulations of coal preparation processes. A key feature of Limn, making it ideally suited to this type of investigation, is that all unit models are readily customised by the user. Partition numbers and other model parameters are calculated in standard spreadsheet tables by built-in or user defined functions.

Specific parameters are benchmarked against plant data obtained from a wide number of plant audits at a number of different sites. These parameters may be adjusted to customise the model for a specific site based on local plant audit data, or else a standard suite of parameters drawn from an in-house data base can be used to represent "good practice" performance when the actual unit efficiency data for a specific plant is unavailable, or when designing a new preparation plant.

Table 3 shows a typical yield design window derived from the simulations on a wide range of core data for a 3-circuit plant with the size ranges as shown.

Table 3. Yield window

Circuit	Size Range	Lowest	Nominal	Highest
DMC	+2.0 mm	40	72	85
Spirals	-2.0 + 0.25 mm	52	75	83
Flotation	-0.25 mm	35	55	70

3.3 Comparison of design windows with simulated unit loading data

It is important to understand that the design window refers to the range of feed types that the CPP can handle efficiently. The final definition of the design window should be an iterative procedure with feedback from the design calculations.

A limitation of applying conventional size distribution and yield design windows for green-field design to determine the required capacity of all process units and streams is that it can result in designing for a much wider range of feed types than are likely to be encountered in any part of the lease.

For example, applying the coarsest size distribution together with the highest and lowest yields may result in a coarse circuit capacity that can process much higher tonnages of coarse product or coarse reject than is likely to be encountered. At the same time, applying the finest size distribution together with the highest and lowest yields may result in a fine circuit that can process much higher tonnages of fine product and fine tailings than is likely to be encountered.

This results in a much more expensive CPP than is required, with higher Capex and Opex costs to operate and maintain the larger quantity of equipment and high circulating slurry volumes, which for much of the time will only be lightly loaded, and may never be utilised at maximum capacity.

When a suitably pre-treated bore core database is available for Limn simulations of a statistically significant number of feed samples, this allows for an accurate estimate of the range of all individual unit and stream loadings for a specific plant design and operating cutpoint range. Specific "hard-wired" tonnage limits (or volumetric limits where more appropriate) may then be applied to all key process units and process streams. This ensures that all process units are sized appropriately to process the range of feeds that are expected from the resource.

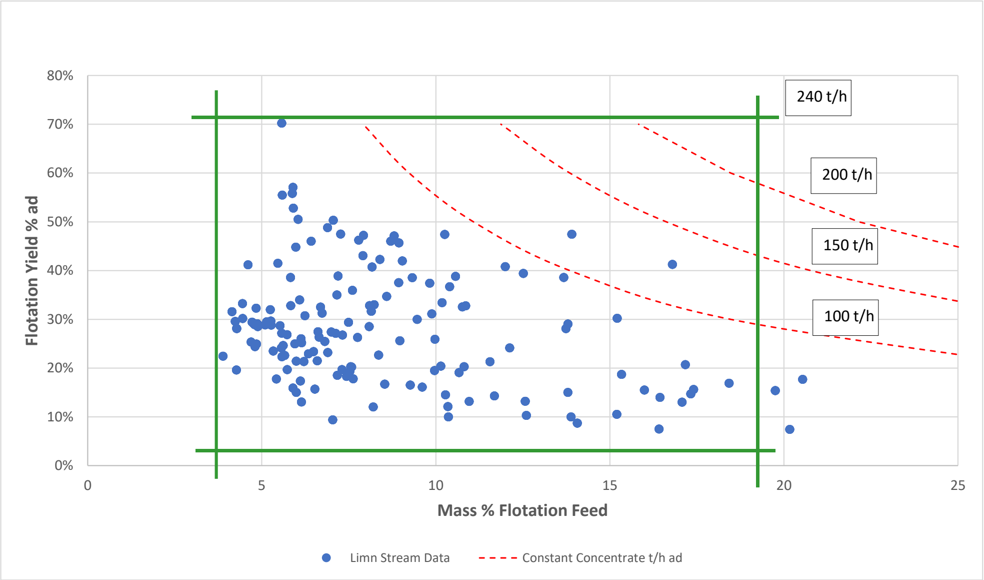

Fig 3. Design window versus Limn simulated data for the flotation circuit

Figure 3 shows a schematic that visually demonstrates this principle for the flotation circuit, and how the full range of possible design outcomes from applying the full range of the sizing and yield windows requires CPP processing capacity that is never likely to be utilised.

The green square in Figure 3 is based on the size distribution window to determine the expected range of the mass percentage reporting to flotation feed and the the expected range of flotation yield% (ad). A key loading parameter for the fine circuit design in any plant is the expected maximum rate of flotation concentrates, as this determines:

- Flotation cell capacity in terms of area based on limiting froth carrying capacity criteria, and
- Flotation concentrate dewatering capacity.

Both of these process circuits represent a disproportionate Capex and Opex component of the CPP cost structure due to the relatively low specific capacity of such units to efficiently process the fine particles that report to flotation.

The series of red dotted lines (Figure 3) shows the concentrate capacity corresponding to the flotation feed rate and yield. Superimposed on the plot is the expected flotation performance (blue dots) for each bore core sample using the wet tumbled washability and laboratory flotation test results on the core samples when available.

These show that virtually all the data lies solely within the lower and left-hand regions of the window, which correspond to much lower concentrate production levels for all data points compared with the maximum 240 t/h (ad) predicted by applying the size distribution and yield design windows. This is consistent with common flotation experience where the feeds with higher tonnages of fines, due to increased levels of fine silt and clay reporting to the fines circuit, will experience lower yields.

Applying this approach to the CPP design, the following would be the recommendations:

- Design limit on flotation product of 100-125 t/h (ad) rather than design window of 240 t/h (ad)
- Design limit on tailings of 400 t/h (ad) rather than design window of 486 t/h after consideration of both the flotation feed rate and yield data

An alternate representation of plant circuit loading across a resource is where each simulated data point is displayed as a bubble, the size of which reflects the tonnage weighting. This allows data points with small bubbles to be ignored if there are very few of them in a specific area of the design window. If the feed representing different sources, such as different seams, is coloured, it can assist in understanding the impact of each seam on the design window. For example, Figure 4 shows that the feed from Seam 1 in this instance is higher yielding but coarser compared with the feed from Seam 2, which is relatively lower yielding but finer.

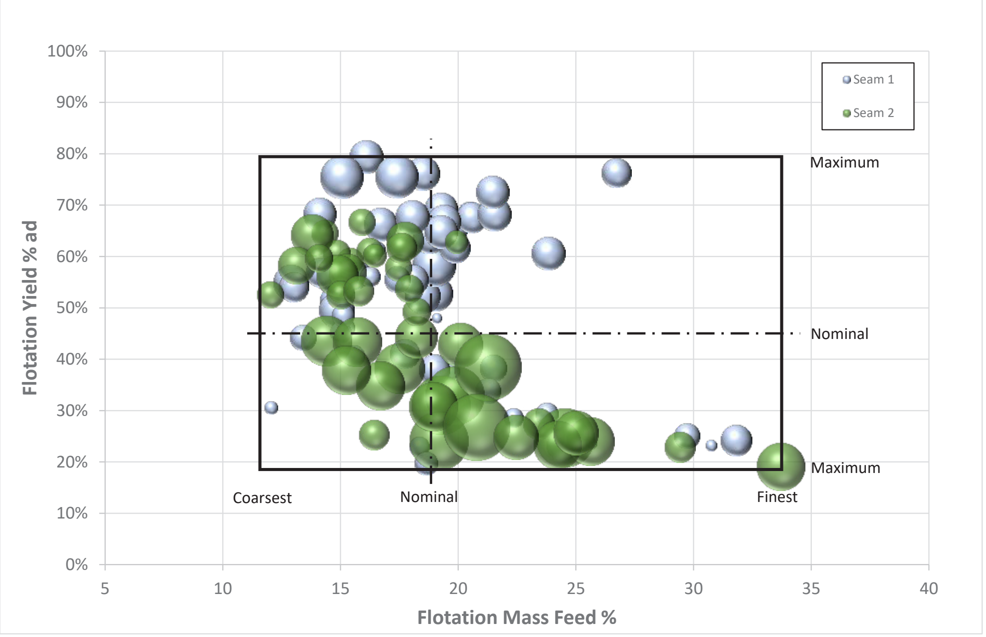

Fig 4. Relative weighting of ROM feed for each data point can be represented by different sized bubbles.

4 Conclusions

Conventional industry practice of using size distribution and washability data generated from appropriately pre-treated and analysed LD core data to generate expected plant feed sizing and yield windows is a proven procedure for reliable plant design purposes. There is an opportunity, however, to further optimise the design procedure and better tailor the individual unit capacities to the range of feeds that are likely to be encountered by comparing the conventional design window with simulated unit loadings for all key process units. This confirms that not only all key process units have sufficient capacity, but may also identify excess capacity that is never likely to be utilised, so minimising both Capex and Opex.

The authors would like to thank all the many participants in the various R & D programs that developed the current Australian Standard bore core treatment procedures as referenced in this paper to provide the industry with the tools to undertake best practice coal preparation design. In addition, the authors wish to thank Sedgman Ltd for the opportunity to publish the supplementary design procedures discussed in this paper that have been developed over various plant design studies with which the authors have been involved.

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