Designing a World-Class Downstream Aluminium Plant

By Tom Farley, Managing Director, Innoval Technology Ltd.

Introduction

In this article, Dr Tom Farley, Managing Director of Innoval Technology discusses the value of bringing process and end-product expertise to the design of downstream aluminium plants. In his opinion, plants designed without a world-class technical partner are at risk of not achieving their intended financial returns.

World-class Technical Partners

Innoval Technology ("Innoval") is an independent company providing a unique resource of expertise to the downstream aluminium industry. It was formed in 2003 as a result of the closure of Alcan's world-class technical centre in Banbury, UK. Prior to its closure, this centre had developed its strength in support of semi-fabricated products and, in particular, had grown a process engineering team focussed on improvements to the rolling and finishing processes. In fact, this centre supported all of Alcan's semi-fabrication plants worldwide. Now most of this expertise is within Innoval Technology.

The 26 Innoval staff have approximately 600 years of combined experience within the aluminium industry, and many have held senior management positions in global aluminium companies. It is this experience that makes Innoval an ideal resource to provide support to the early-stage design of downstream aluminium operations.

Recently, the Innoval team has provided strategic technical support for potential investors in downstream fabrication businesses. Some of the knowledge gained is summarised in this article, including: Technical due diligence of existing plants; pre-feasibility studies for greenfield plant design; and plant investment and upgrade support.

A Methodical Approach to Plant Design

Innoval has developed a methodical approach to plant design, as illustrated schematically in figure 1. The flow diagram highlights the need to iteratively optimise the products and volumes, the product mix, in order to make best use of the chosen equipment and to increase the viability of the plant. This must be done with a good technical knowledge of product quality specifications, product margins and equipment capabilities. For example, the installed equipment to make a particular product mix (as determined by the market study) may result in some extra capacity to produce more products within the same mix or indeed to produce some different products. Consequently it is necessary to return to the market study to question assumptions within the study and to re-define the product mix, as appropriate.

When the product mix is defined, the plant equipment can be specified and the capital expenditure (capex) and operational expenditure (opex) data calculated for use in a cost model. The cost model is then used to evaluate financial performance and viability of the investment using metrics such as Internal Rate of Return (IRR) and Net Present Value (NPV) calculations. Clearly, if financial viability is not achieved then a more significant change to the product mix and equipment may be required to achieve the desired financial return on investment.

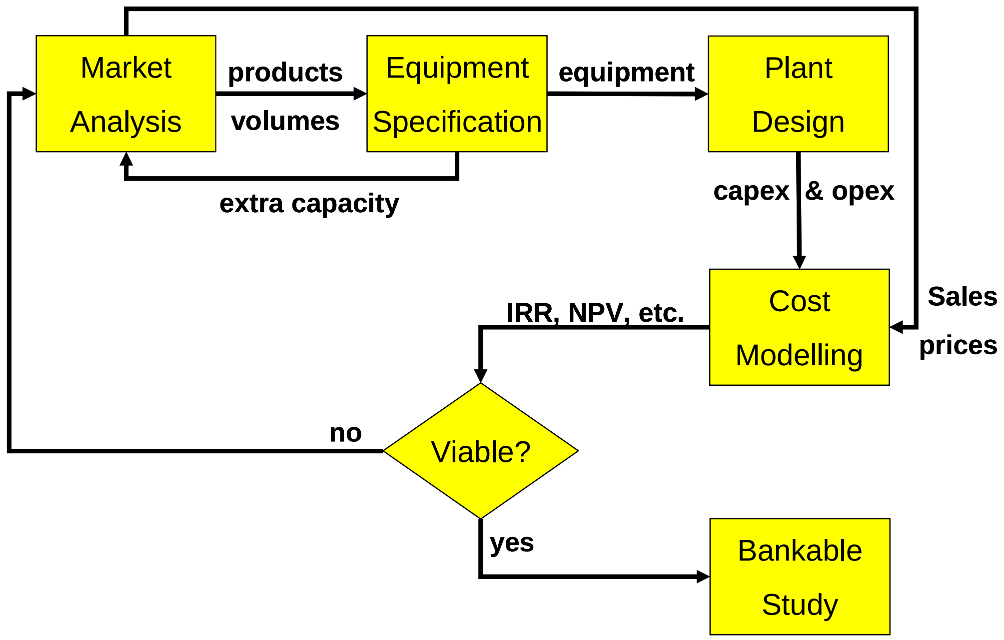

Figure 1: Schematic flow diagram illustrating the main process steps in designing a successful and viable plant

Each of the steps to achieving viability is described in more detail below.

Once a viable configuration has been achieved then the project can move forward to more detailed studies, such as the Bankable Study, and then on to construction and operation.

Market Analysis

The first step in designing a new downstream plant is a thorough analysis of the potential home and export markets for the plant products. Several professional organisations specialise in providing market surveys. A technical partner, such as Innoval, can add a useful end-user perspective to compliment this analysis by verifying any assumptions and ensuring logical conclusions are obtained.

Data on product sale prices must be gathered for use later in cost modelling. It is important to have an understanding of how the market price compares to the production costs for the different products. Some products cost more to produce and so a high sale price does not necessarily result in a high profit for the business.

The analysis must include an assessment of the competitors active within the same markets, either locally or abroad. Decisions to compete locally or within export markets can have an impact on the product quality standards required, and can affect the choice of equipment in the plant.

The final outcome of this analysis will be the proposed product mix for the plant.

Assessing Technical Challenges for Chosen Products

Products vary in their complexity and in their ease of manufacture. As stated above, the quality standards required for some products may also vary depending on the region. The exact product requirements will determine the choice of equipment and technology required in the plant. For illustrative purposes, the remainder of this article will focus on a rolling plant as an example. Table 1 shows different rolling mill configurations to produce hot band ready for cold rolling for various generic flat-rolled products. A state-of-the-art Hot Reversing Mill (HRM) followed by a 3 or 4 stand Hot Tandem Mill (HTM) is capable of rolling all products to world class quality requirements and has the largest capacity of all options. A coil-to-coil Hot Reversing Mill has a lower capacity and can roll all products with the exception of world-class can body stock which requires a Hot Tandem Mill to achieve the correct control of metallurgical texture. Insufficient control of texture in can body stock leads to a phenomenon of “earing”, as shown in Figure 2, leading to jamming of the can making line and rejection of the supplier’s material.

Continuous casting technologies, such as belt or roll casting, have lower capacities and present further limitations on the range of world-class products that can be produced.

Table 1: Rolling mill configurations for various aluminium flat-rolled products

		Hot Band Option			
		HRM + 4-stand HTM	coil-to-coil HRM	Belt Caster	Roll Caster
	Typical Capacity (tonnes pa)	700k	150k	120k	20k
Products	Can Body Stock (CBS)	✓✓	✓	✗	✗
	Can End Stock (CES) & Tab	✓✓	✓✓	✗	✗
	Foilstock	✓✓	✓✓	✓✓	✓✓
	Standards - Low Mg	✓✓	✓✓	✓✓	✓✓
	Standards - High Mg	✓✓	✓✓	✓✓	✗
	Surface Sensitive Products	✓✓	✓✓	✗	✗
	Thick Products	✓✓	✓✓	✗	✗
	Clad Products	✓✓	✓✓	✗	✗
	Others	✓✓	✓✓	✓	✓

✓✓ meets world class quality requirements

✓ can be made but does not meet all quality requirements

✗ cannot be made or fails to meet most quality standards.

Figure 2: Can after re-draw and wall ironing exhibiting severe "earing"

It is also important to make the correct technology choices for the sensors and actuators built into the equipment, especially where different technology options exist.
It should be noted that there can be significant variations in performance and price of equipment.

Consideration also should be given to 'future-proofing' the equipment to meet evolving customer needs, such as tightening of product specifications and, in the case of rolling, increasing coil widths and lengths.

Equipment Capacity Calculations

Clearly it is important to get the number of machines and size of each machine correct. This requires careful capacity calculations and the results are often dependent on the mix of products being processed. Because some equipment is only available in certain sizes, there can be spare capacity available and so it is important to assess this as an opportunity to process and sell more product volume if the market can sustain this. This is part of the iterative optimisation described above with reference to figure 1.

It is crucial to have a good understanding of the magnitude of process losses at every stage of the operation (recoveries) and how these will improve during the ramp up of a new plant. This knowledge will determine the product volumes which need to be processed to meet the customer requirements. For example, to sell 100ktpa of final product the DC casting centre may need to be capable of producing 140ktpa of cast ingot.

A rolling mill represents a significant component of the total investment Capex so it must be specified very carefully. Table 2 shows the overall capacity of a rolling mill for three different cases: A baseline case comprising a product mix of five products with various final gauges; a second case which is the same as the base case but without product 5 (the thickest final gauge product); and a third case that is the same as the second case but with a 10% increase in rolling speeds. From this example it is clear that the capacity of the rolling mill depends on the product mix, particularly the final gauges. The capacity also depends on rolling speeds, but the relationship is not 1-to-1 because of the handling time between rolling passes.

To calculate the correct inputs for a rolling mill capacity model, Innoval has developed complex physically-based models that can take account of the capabilities of the mill and the metallurgical and surface requirements of the products.

Table 2: Comparison of mill capacity for three different cases

Baseline case

Product	One	Two	Three	Four	Five
Final gauge [mm]	0.1	0.22	0.5	0.8	2
Percent of production	33%	23%	22%	9%	13%
Rolling time [min]	54	18	10	6	3
Handling time [min]	30	20	20	15	10
Overall capacity [ktonne/yr]					110

Removal of heavy gauge product

Product	One	Two	Three	Four	Five
Final gauge [mm]	0.1	0.22	0.5	0.8	
Percent of production	39%	28%	26%	7%	
Rolling time [min]	54	18	10	6	
Handling time [min]	30	20	20	15	
Overall capacity [ktonne/yr]					83

10% increase in pass speeds

Product	One	Two	Three	Four	Five
Final gauge [mm]	0.1	0.22	0.5	0.8	
Percent of production	39%	28%	26%	7%	
Rolling time [min]	49	17	9	6	
Handling time [min]	30	20	20	15	
Overall capacity [ktonne/yr]					87

Optimising the Layout of Equipment

Once the equipment is defined then it can be located within the constraints of the proposed site area. The layout is based on a combination of logic and a knowledge of world-class operations, taking into account many factors such as the need for safety, efficient process flow and potential future expansion. It is important that all ancillary equipment is also included at this stage.

The work in progress at all stages in the process can be estimated and provision made for storage in machine buffers and central storage regions within the plant. Figure 3 shows a typical cold rolling mill layout with good provision for coil storage and movement.

Once the layout has been finalised then the civil engineering costs for the plant can be estimated as part of the total capital cost for use in the financial modelling.

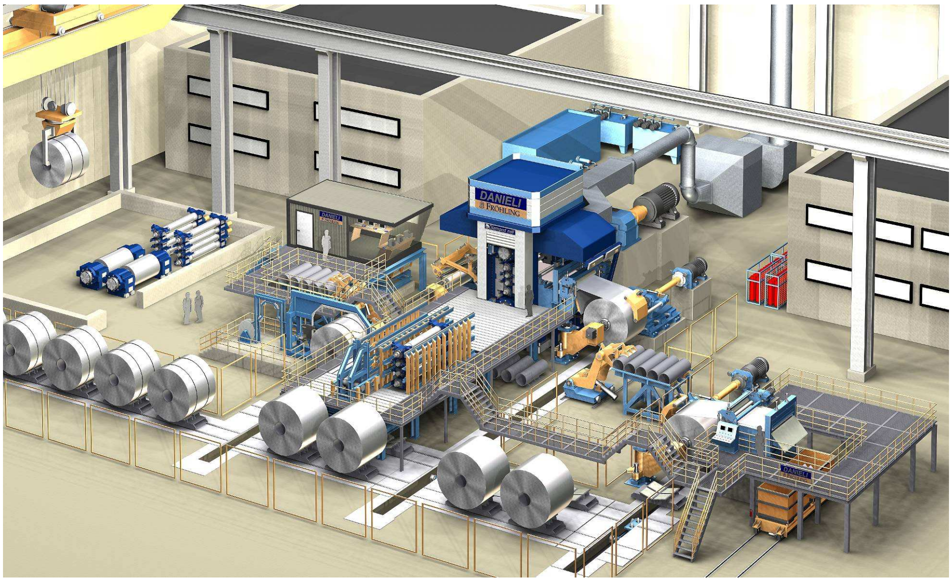

Figure 3: Schematic showing layout surrounding a single stand cold rolling mill (courtesy of Danieli Fröhling)

Advanced Financial Cost modelling

Simple spreadsheet-based financial cost models are adequate for predicting the main metrics used to assess the viability of an investment. However, as with all models, the quality of the results is only as good as the quality of the input data. Capital costs are available, to the desired accuracy, from the equipment suppliers. Fixed and variable operating costs can be more difficult to obtain and require a very good understanding of the operation of the equipment. Innoval's approach combines practical knowledge with computer models to predict energy and other utility consumption for all equipment, ensuring the values are consistent with the actual operation being proposed. Efficient staffing levels and labour costs are also determined based on practical experience of operations.

It is possible to incorporate more complexity within these models to allow more detailed analysis of the financial performance of the proposed plant. For example, with knowledge of the time that each product spends within each process stage, it is possible to attribute the correct proportion of the operating costs of that process stage to each product. This allows a more detailed analysis of profitability on a product-by-product basis which is crucial when trying to optimise the product mix to improve the overall financial viability of the plant. Figure 4 shows screenshots from an advanced financial model based on data from a hypothetical project.

Finally, more complex analysis tools can be used, as required, to fully understand the results of the financial model (e.g. Monte Carlo simulation).

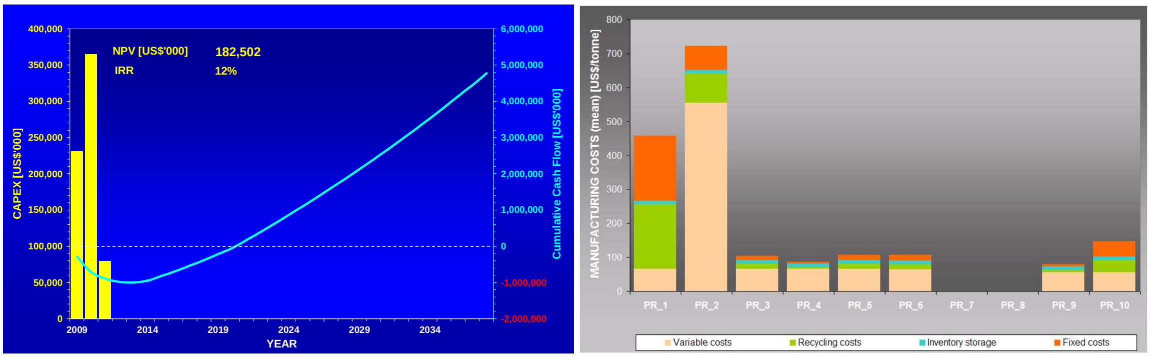

Figure 4: Typical financial cost modelling outputs for a hypothetical example showing common project metrics (left) and more advanced information by product (right).

State-of-the-Art Equipment Alone is Not Sufficient

Investment in world class equipment does not on its own allow the business to produce world class products. There are examples all over the world of new aluminium rolling and extrusion plants where the return on investment took longer than planned, or where the plant was unable to quickly match the quality of world-class products.

This is particularly the case when the plant does not possess the necessary range of expertise within the company. In general, the equipment suppliers posses sufficient expertise to achieve their guaranteed level of performance, but this is usually not enough to achieve world-class production standards. In these circumstances, companies need to bring in external expertise with a proven history of helping plants to achieve world-class product standards. Innoval Technology is one such company.

Summary

An efficient and viable downstream plant can be designed using Innoval Technology's methodical approach. This approach is based on understanding and knowledge gained from working with a wide range of world-class manufacturers of aluminium products. A key stage in the process is matching equipment specification to the optimum product mix in order to maximise the financial returns from the plant.

Achieving the anticipated financial returns requires more than just state of the art equipment and technology, but also input from people with world-class expertise and practical experience.

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