Hyundai Steel’s Ramp-up Strategy and the Learning Effect

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Abstract: Once a company begins its development process, putting products into the market as quickly as possible to get a return on investment is the fundamental corporate activity. A product’s time to market can be categorized into the development time for the product and production processes and production ramp-up time. Existing studies have focused on reducing development time by primarily increasing efficiency. However, no matter how much a company shortens its development time, there may be a delay in the return on investment if production ramp-up takes too much time. This paper analyzes the processes of Hyundai Steel, a major Korean steel manufacturer. Moreover, it examines the process of its implementation of blast furnace technology through mass production. The company used a strategy that maximized the learning effect by implementing three blast furnaces with the same specifications in succession and without delay. They planned to implement the blast furnaces with no overlap in the implementation schedule, which enabled the same ramp-up team to start up production successively. Thus, the team was able to leverage the experience gained in ramping
up one blast furnace for ramp-ups of subsequent blast furnaces. This learning effect enabled them to successfully reduce the ramp-up time linearly, as shown on a semilog graph.

Keywords: production ramp-up, blast furnace, Hyundai Steel, semilog graph

Introduction

Once a company begins its development process, putting products into the market as quickly as possible to get a return on investment is the fundamental corporate activity. Leveraging operational knowhow and reducing costs are critical for maintaining a company’s competitive advantage although these begin after a company has begun production. In other words, once a product and process design has left the engineering division and after test production runs have begun, all that is left is to put everything together and determine whether the product can be produced as designed. Once the design stage is completed, commercial production runs begin. In other words, the production ramp-up begins with a gradual ramp-up toward mass production. Thereafter, products are delivered to customers and the company begins to recoup its investment.

The entrance to automotive expressways is often called rampways, shortened to “ramps.” This word has a similar meaning in the production activities of manufacturers. A ramp-up refers to the period in which a company starts its production activities, eventually arriving at its production quantity, quality, and cost goals (Wheelwright & Clark, 1992).

Given the time taken by a company to deliver a product to a customer as the total lead time, it goes without saying that both development time and ramp-up target time reductions. A product’s
time to market can be categorized into the product and production process development time and production ramp-up time. Numerous studies have focused on reducing the development portion of time to market. Concurrent engineering and innovations such as overlaps in the design cycles of products and production processes have been observed in the automotive industry (Clark & Fujimoto, 1991; Itohisa, 2013). In addition, in the case of the semiconductor industry, after new manufacturing equipment begins operating, the initial yield may be less than 5 percent, although that increases to 80 percent after seven to eight months (Appleyard, Hatch, & Mowery, 2000). Thus, this paper focuses on the importance of reducing the ramp-up time, which has been a subject of attention to date.

A ramp-up is necessary for two reasons. First, as operators become familiar with new equipment, they climb the so-called learning curve and are able to perform their work with greater efficiency. Next, they discover new problems that were unimagined in the development stage and work on resolving them. Just as they view development as a problem-solving process (Clark & Fujimoto, 1991; Kuwashima, 2015), ramp-ups can also be understood as problem-solving processes (Hayes, Pisano, Upton, & Wheelwright, 2005; Wheelwright & Clark, 1992).

Why are rapid ramp-ups important? First, they enable recovery of funds invested in development by beginning production per commercial goals as quickly as possible. In doing so, a company improves financial metrics such as return on assets and return on investment.

Second, a rapid ramp-up is vital not only for financial reasons but also for a competitive strategy. If a company can ramp-up faster, it can shorten the time it takes to permeate a market. A company can also achieve mass production faster and reduce manufacturing costs. There is no shortage of cases where a company wishes to take an innovative product to market as soon as possible, but problems
such as poor quality and taking too much time to reach mass production cause the company to end up losing to competitors. Industries with short product life cycles can use quick ramp-ups as important competitive weapons.

**Critical Issues in Production Ramp-up**

What are the critical issues in ramp-ups? First is to achieve mass production targets in a short time and at the required cost and quality levels. A conflict exists between the low levels of production prior to beginning commercial production and high levels of demand (Terwiesch, Bohn, & Chea, 2001).

Second, a company must resolve issues that arise in production by scaling up according to the drawings and manufacturing methods created in the development stage. Certain gaps exist between the initial drawings and manufacturing methods and mass production, and companies must fill those gaps. Zangwill and Kantor (1998) and Terwiesch and Xu (2004) identified these gaps as discrepancies. They viewed the resolving of these discrepancies by building up operational knowledge as “learning.” If a ramp-up is viewed as a learning process, then there are two options for learning strategies. One is the “copy exactly” strategy where a company ramps up according to recipes. If a company modifies recipes in the ramp-up stage, they may reduce productivity in the short term (Carrillo & Gaimon, 2000; Terwiesch & Xu, 2004). The second option is to ramp-up by modifying recipes. However, there exists the risk of low levels of knowledge within a company with regard to the technology it has implemented.

In addition, ramp-ups for new products sometimes require switching from old products. When doing so, a company has several options, and companies can choose to switch all at once, in stages, or continuously (Clark & Fujimoto, 1991). Finally, ramp-ups are critical
to stable operations in process industries. For example, blast furnaces that melt iron ore at higher temperatures to make pig iron can help produce at stable quality and cost with stable operations by producing at volumes in line with the capabilities of their equipment. In process industries such as steel, reducing ramp-up time enables the faster achievement of target production volumes, and it is closely tied to attaining quality and cost goals.

Effective ramp-ups require more than speed. Specifications decided during product and production process design must be accurately replicated (the ramp-up condition “Q,” for quality), and products must quickly be delivered to the market (the ramp-up condition “D,” for delivery) in a way that does not exceed the initially assumed costs (the ramp-up condition “C,” for cost). This paper focuses on production ramp-up in steel manufacturers to clarify the processes of meeting quality, cost, and delivery criteria as well as the learning strategies and learning effect for doing so. The research theme is exploratory, and the subject of the research is dynamic; thus, case studies are used for the research method. Specifically, the case of the major Korean steel manufacturer Hyundai Steel Company and their ramp-ups of blast furnaces that began in 2010, along with their strategy for managing those ramp-ups, will be considered as this case study meets several criteria. The company implemented three blast furnaces of similar specifications (volume of 5,250 cubic meters, with annual production capacity of four million tons each) in succession and with no gaps in-between, enabling the observation of the learning effect in ramp-ups.

**Hyundai Steel and Its Blast Furnace Business**

Hyundai Steel is one of the world’s youngest integrated steelworks and ranked 14th in the world as of 2015. The company began blast
furnace operations in 2010, becoming an integrated steel manufacturer that controlled everything from the upstream processes of the blast furnace to the downstream cold rolling processes. They gained attention with the speed of their ramp-ups. Table 1 presents the “date of accomplishment of targeted operating level,” which is the number of days from the starting day of the operation to the final day of ramp-up.

The starting date of operations in Table 1 refers to the date after the construction is completed and the blast furnace started operations (also known as the “blow-in day”). The date of accomplishment of targeted operating level is the number of days taken for the completion of the ramp-up, that is, it refers to the number of days from the blow-in day to the day when target production volumes are

| blast furnace | Construction period (number of months and start date) | Starting date of operations | date of accomplishment of targeted operating level |
|---------------|--------------------------------------------------------|----------------------------|-------------------------------------------------|
| Blast Furnace No. 1 | 30 (2007.7–) | 2010.1.5 | D + 25 |
| Blast Furnace No. 2 | 29 (2008.7–) | 2010.11.23 | D + 12 |
| Blast Furnace No. 3 | 28 (2011.4–) | 2013.9.13 | D + 6 |

Source: Compiled by the author based on Hyundai Steel interviews
Hyundai Steel’s ramp-up strategy and the learning effect

reached. For example, Blast Furnace No. 1 had a date of accomplishment of targeted operating level of D + 25, which means that the furnace reached its production volume goal 25 days after the blow-in day (D). The production volume goal is set on the basis of the volume of the blast furnace. Hyundai Steel set their production to a daily volume of 10,500 tons on the basis of a furnace volume of 5,250 cubic meters. In other words, the production volume target is double the blast furnace volume. This is also known as the productivity of blast furnace, which is 2.0 (tons/day) in this case.

The construction of Hyundai Steel’s Blast Furnace No. 1 was completed within 30 months, beginning construction in July 2007 and having a blow-in day in January 2010. Blast Furnace No. 2 went into operation in November 2011. In the global steel industry, no steel manufacturer had ever brought multiple blast furnaces in operation within a year. Moreover, Hyundai Steel began operating Blast Furnace No. 3 in September 2013, and it became the 14th largest producer in the world within less than five years of starting operations. Rather than the reduced construction times, particularly

![Figure 1. Ramp-up times reduced linearly on a semilog graph](image-url)

169
important are the periods until ramp-ups were completed or the “date of accomplishment of targeted operating level.” As illustrated in Figure 1, the ramp-up period from Blast Furnace No. 1 to Blast Furnace No. 3 was reduced to half, and the ramp-up of Blast Furnace No. 3 took only one-fourth the time of that for Blast Furnace No. 1. Ramp-up times were reduced linearly on a semilog graph. An explanation of the factors making these reductions in ramp-up time possible require an examination of Hyundai Steel’s learning strategies and the learning effect.

**Ramp-up Strategy and the Learning Effect**

The construction period and starting date of operations shown in Table 1 confirms that there are overlaps between the construction period and operations of blast furnaces 1 and 2. In other words, the construction periods overlapped as much as 18 months, and the construction experience and knowhow gained through Blast Furnace No. 1 was quickly rolled out to the other blast furnaces. Moreover, Blast Furnace No. 1 was in operation for approximately 10 months, up to November 2010, prior to Blast Furnace No. 2 beginning operations, which enabled the company to accumulate operations experience. During the ramp-up of Blast Furnace No. 2, Blast Furnace No. 1 was already in stable operation.

Thus, Hyundai Steel was able to leverage the experience gained in the ramp-up of one blast furnace for the subsequent blast furnaces, which can be considered to be the company’s strategy for increasing the learning effect. This strategy of overlapping reduced the ramp-up time for Blast Furnace No. 2 to half of that required for Blast Furnace No. 1. Blast Furnace No. 3, which went into operation in September 2013, had a ramp-up time again half that of Blast Furnace No. 2 or one-fourth that of Blast Furnace No. 1. The composition of the equipment in part enabled the learning strategy of
rapid roll-outs. All three of Hyundai Steel’s blast furnaces were the same, and all equipment was going into the same location. Consolidating the blast furnaces and peripheral equipment, the company prioritized the maximization of the learning effect for operations technology.

There are two explanations with regard to ways in which Hyundai Steel ensured product quality. In the case of blast furnaces, once a furnace enters stable operations, quality tends to be stabilized within a certain range. Stabilizing the composition of the pig iron produced in the blast furnaces, the ingredients and coordination of the downstream steelmaking process became easier. Further, Hyundai Steel aggressively incorporated feedback from customers. Based on customer feedback gained through early deliveries to Hyundai Motors, Hyundai Steel coordinated knowhow regarding the blast furnaces and converter operations. They aggressively incorporated product evaluations from Hyundai Motors, who were already using products from other companies, and worked on improving quality. For example, they had Hyundai Motors use high tensile strength steel, using a strategy to compensate for quality by quickly reflecting quality assessments back into manufacturing processes. Leveraging a customer within the same corporate group further accelerated Hyundai Steel’s ramp-ups. Furthermore, they improved the cost of raw materials per ton as they increased production volumes.

Finally, Hyundai Steel narrowed their product mix to catch up with their operations in a short period of time. They were able to reduce downstream ramp-up times as they concentrated on auto sheets, heavy plate, and steel rod. From the aspect of learning operations technology, identifying “what is to be learned” is a given although one can also see the importance of clarifying “what should be learned.”
Conclusion

This paper focuses on production ramp-ups after the development and design of products and production processes. It further analyzes corporate efforts to reduce ramp-up times.

Quicker times to market have competitive benefits and lead to returns on resources invested. Moreover, the steel industry has economies of scale, and ramp-ups in that industry are effective in reducing per product costs and are critical stages for achieving stable quality.

To quickly start up their blast furnace technology, Hyundai Steel was able to maximize the learning effect by shifting engineers working on the ramp-ups, as their blast furnaces had the same technical specifications. When implementing different types of blast furnace equipment, it takes time to understand the characteristics of each type of equipment. Further, Hyundai Steel limited their product mix and was therefore able to reduce the amount of knowledge they were required to learn. By simply focusing on auto sheets, heave plate, and certain construction steel, their fast ramp-ups turned into a benefit. This helped the company construct two blast furnaces within a year in 2010.

This paper provides a case study analysis of the steel industry and suggests strategies for reducing ramp-up times applicable to other industries. However, the efforts of Hyundai Steel in reducing ramp-up times are likely not the only strategies. More detailed examinations of the relation between ramp-up time reductions and performance are necessary.

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