The Driverless Alumina Refinery

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Abstract

Since the 1950s, process industries of all varieties have gradually adopted automation to achieve simple process goals. In recent years, industries like mining have extended this principle to the complete replacement of human operators with technology. With the rapid advancement in artificial intelligence and machine learning, it appears likely that this trend of automation will continue, with computers gaining the capacity to perform complex tasks which previously required the watchful eye of skilled operators. Within the alumina industry, the benefits of "going driverless" are clear: an operator-free refinery offers improved safety outcomes, higher labour productivity and better equipment efficiency. On the other hand, it presents an enormous technical challenge, demands more intense capital investment and risks community backlash. This paper imagines an operator-free alumina refinery, and contemplates which economic and technical conditions, if any, would make it a favourable investment.

Keywords: Autonomous systems, Alumina, Labour.

1. Introduction

The advent of simple programming techniques in the 20th century brought with it an industrial drive to create automated systems. These automated systems are able to interpret simple inputs and can actualise a response from a set of pre-defined options to achieve well-defined goals. In some applications, these automated systems can respond more quickly, more consistently and more effectively than a human tasked with achieving the same goals.

As a consequence, this trend of automation has brought with it both improved performance and a gradual improvement in the labour productivity of all industries, including mineral processing and alumina refining.

The revolution of the 21st century will move beyond the *automated* system to the *autonomous* system. Unlike automated systems, autonomous systems interpret more than simple inputs; they collect and interpret data from whole systems, and then devise complex responses which consider the impacts upon the entirety of that system. In so doing, they offer immense potential to expand the scale, and hence the benefits, of automation.

The instance of technological autonomy with which the public is most familiar is the driverless car. It is the most prominent among many examples of systems where the entirety of decision-making authority is left to the hands of a computer.

But, to state the obvious, an alumina refinery is not like a car. Its capital cost is in the order of 100 000 times greater, and its average life span is much higher. And thus, the cost of a "driverless" refinery is much greater than that of a car, although its benefits can be reaped for far longer. On the flipside, a non-autonomous car bought today may still be useful for the entirety of its ~10 year life span; a non-autonomous alumina refinery built today risks looking antiquated well before it reaches middle age.

Naturally, for a system to be autonomous, it also needs to be automated to a significant extent. This paper does not seek to provide detailed answers to the question of how one might go about automating every task in a refinery that an operator might perform. Rather, it considers the characteristics of autonomous systems in order to identify the opportunities and challenges facing the alumina industry as it looks toward a driverless future.

2. Industrial Automation

2.1. The Journey to Autonomy

Many of the world's large industries are already making the transition to autonomous systems. The transport industry is a clear example. 100 years ago, when trucks were first used for material transport, they required expertise and system understanding to handle the truck safely, and perform the frequent maintenance required. Modern trucks demand less from their drivers – from bifocal mirrors to automated gearboxes, satellite navigation and rear-view cameras, the task of driving and maintaining a truck is far easier than it used to be. The industry has now reached a point where the truck itself is so sophisticated that none of the driver's knowledge is required at all to maintain normal, safe operation.

In other words, for processes in which any form of decision making is required, there is a gradual progression from "art" to "science". Nascent processes tend to be artistic, meaning decision making is entirely left at the hands of an operator, who interprets information and makes decisions based largely on personal experience. By contrast, in well developed, scientific industries, the task of gathering information and formulating responses has been well codified, and more responsibility can be left in the hands of a computer. The journey from art to science has been made for challenges as outlandish as space travel and as mundane as baking a cake.

With autonomous decision making yet to be present to a significant extent in most industries, humans are still considered a necessary part of the safe and effective operation of scientific processes. This is because humans can be trusted to provide a system with resilience. In an autonomous system, we must instead trust the computer to provide such resilience. This industrial progression is summarized in Figure 1.

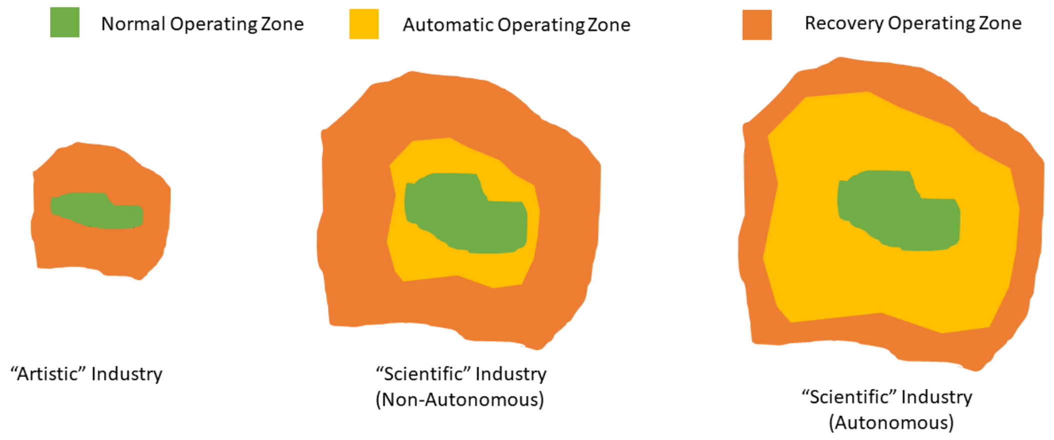

Figure 1. Diagrammatic Representation of industries at various developmental stages.

In Figure 1, the green area represents the operating conditions of a stable system operating normally; yellow represents conditions in which automatic controls can be trusted to return the system to its normal state, and dark-orange represents an area in which complex decision making is required urgently to prevent loss of system control, here referred to as the "recovery" zone.

also be a target of vandalism and theft – which is far harder to prevent with no personnel on site. A carefully managed public relations strategy is essential for a driverless alumina refinery to become reality.

Capital Intensity – The autonomous alumina refinery will have higher capital costs than their non-autonomous counterparts. This will partially originate from a need to automate various components of the process, which naturally has associated capital costs. It may also require more substantial sparing or surge tankage in order to allow for maintenance to be conducted on an intense, sporadic basis rather than consistently by a relatively small team. In return for expending greater capital, the refinery reduces its operating costs.

Alumina has always been a capital-intensive industry, and this change will make it more so. The capital pressure poses a risk to overall plant performance, as attempts to reduce upfront costs may lead to shortcuts which ultimately cost the quality of installed refinery or equipment. These refineries are therefore more likely to be viable in jurisdictions with low interest rates that justify a capital-intensive industry.

Although these risks are significant, and cannot be underestimated, they are also not unique. They are common to all industries that are making the transition to autonomy. The alumina industry will not need to pioneer solutions to these challenges; they are already being pioneered by industries across the world, from whom alumina can borrow and adapt the right answers.

5. Conclusions

There are significant opportunities to be realized in refinery performance by going autonomous. At the same time, there are many technical barriers to overcome before a such a refinery and its benefits can be realized.

Overcoming those barriers may well be a necessity for the alumina and aluminium industry. The trend towards autonomous operation is not unique to this industry; it is common across the global economy. Aluminium's competitors – other light metals, steel, and light composite materials like carbon fibre – will begin the move to autonomy with or without the alumina industry. Some of them, like carbon fibre, are more suited to autonomy than alumina – increasingly, the processes to produce them are mature, without the technical complexity and measurability challenges faced in the alumina industry. To stay relevant in comparison to those industries, autonomy may be essential.

Greenfield alumina refineries built today will need to be able to operate competitively in the autonomous future. Retrofitting those refineries to make them autonomous would be an enormous task. However futuristic a driverless alumina refinery may sound, it is a future the industry needs to pursue today.

6. References

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