Profit Optimization VIA Process Enhancement through A.I. Controllers

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Abstract In today's market businesses are always trying to find ways to keep up with the escalating economic model of supply and demand. To do this, they either need to improve on their product to make sales higher or find ways to cut down on the money and material used to make that product. This could be accomplished by savings millions, if not billions, using total quality management and artificially intelligent controllers. Even with the ever-growing popularity of total quality management, and the introduction of it in to some of the bigger corporations, not all businesses have adopted its methods. In 2005 it was said that only around 5% - 25% of all petroleum companies worldwide implemented some form of quality management. However, today it is recorded that around 40% of all oil and gas companies do implement some sort of quality management. For years companies have been investing money into the research and development of Artificial Intelligence (A.I.) and attempting to implement this technology into their processes and distribution methods. A few companies who have been successful with this undertaking are companies like Spotify, Facebook and Netflix. These companies use a series of complex algorithms and artificial intelligence to learn your preferences, so whatever your preferences are, those can be the first things seen on your newsfeed when you log in. Hypothetically, it is possible that the petroleum companies could also use this sort of technology to regulate and maintain their processes during the refinement stages, making the overall efficiency of the process/production increase. If an A.I. could manage production processors that could automatically time and adjust parameters for flow, pressure, liquid levels, temperature, and chemical compositions; then, time, man-power, and materials used could be cut down, and production increased.

Keywords *Artificial Intelligence, Oil & Gas, Quality Management, Control Modes, Control Loops, PID Loops*

I. Introduction

In the last fifty years the way business has been conducted and the technology that used to do that business have both been growing exponentially with an ever-growing market demand. Due to this ever-growing demand, a large majority of big businesses have adapted some sort of total quality management application within their company. There have been many articles warning companies of the dangers of not having some type of quality management in place. One such article written by CEBOS [5] states that, "Businesses that want to grow in size and market share need a quality management system to remain economically relevant in the future." They also stated that, "Without such a program, progress will be hit-and-miss, and the entire potential of the organization will never be attained." So, it is to no surprise that the petroleum companies, like many of the other larger businesses, are starting to hop on board with the idea of quality management. It has already been proved that quality management can improve a business in many ways, especially companies that rely heavily on processes and production distribution, like petroleum companies. This is where new types of technology and equipment can come in to play. Applying modern and innovative technology to already put in place processes can not only improve the time of the process, but also cut down on the manpower and resources used, saving the company money in the long run. In petroleum refining process variables such as flow, pressure, level, temperature, and chemical compositions are always changing due to environmental, weather, and many other possible scenarios. Whenever there is a change in any of these variables or chemical compositions, the tuning parameters of that process must be changed in the proportional, integral, and derivative modes, known as the PID loops, to adjust the process to these changes. When making these adjustments to the operating parameters it is not an exact science, it is more of a trial and error situation that comes from having working knowledge and previous experience of the process in question. Since changing the parameters is not an exact science this is where human error can come into

play. Which can end up either costing the company more money by using more supplies than needed, or by having a longer process time. Introducing an A.I. into this scenario could reduce human error and improve the process simultaneously by correcting the operating parameters in real time as variables and chemical compositions change.

II. Controls and A.I.

According to the Gas Processors Suppliers Association (GPSA) Engineering Data Book Volume 1 [1], "Controller tuning has been referred to as the most important, least understood, and most poorly practiced aspect of process control." Control tuning occurs whenever a process variable is different from the setpoint variable. When this occurs, as seen in figure 1, the measure variable is manipulated by the controller to bring the measured variable back to the setpoint variable.

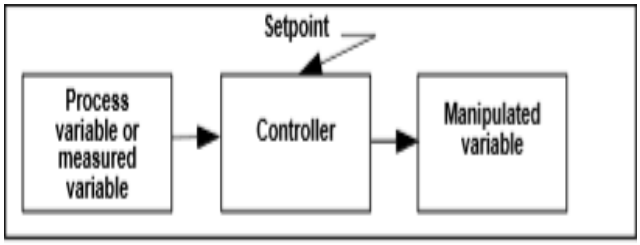

Figure 1: Manipulation of Setpoint Variables

The four basic forms of control modes used in most processes today consist of two-position, proportional, integral, and derivative controllers. The proportional, integral, and derivative controllers can be used in various combinations with each other when the cycling nature of the two-position control cannot be tolerated. However, there are advantages as well as disadvantages when using the latter three control modes.

2.1 Proportional Mode (P)

This type of control mode is considered the simplest of the three control modes we will be discussing. Its advantages are that it is simple and inexpensive, plus it does not introduce any extra time lags into the system. The proportional mode is expressed as:

$$CO = K_P(PV - SP) + MO \qquad (1)$$

Where MO represents the controller output while set on manual, (PV – SP) the error signal, and K_P the gain constant. The major downfall is that this type of controller mode does not cope well with load changes in the process. Whenever there is a process load change, and the original manual output cannot maintain the controlled process variable at the setpoint, offset will occur in the system. Offset is the deviation from the controlled variable from the setpoint. To battle these offsets in the system, you can add an integral to the proportional mode.

2.2 Proportional Plus Integral Plus Derivative Mode (PID)

The PI controllers, proportional modes plus integral modes, make up about 70% - 90% of controllers used in a typical plant. The bonus of combining the integral mode with the proportional mode is that when offset occurs the integral will cause the control element to move with speed proportional to the offset until the offset is cancelled out. The PI mode is expressed as:

$$CO = K_P\left[(PV - SP) + \frac{1}{T_i}\int (PV - SP)dt\right] + MO \qquad (2)$$

The main problem with PI mode controllers is that if the integral is to large then the reset rate will be longer due to the offset going past the setpoint value, adding time lag to the system. This will make the variability larger, thus taking it longer for the process to zero-out and stabilize as seen in figure 2 in the next column. Engineers and technicians soon learned that to speed up and counter these long-time delays in the responses a derivative

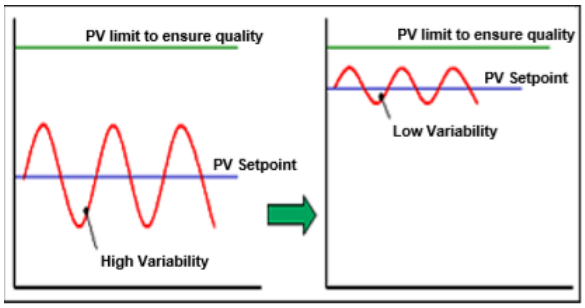

Figure 2. Variability Curve

needed to be added to act as a brake, so the output didn't overshoot the setpoint value. This is how the derivative mode came into play. The downside to using a derivative mode is that by nature derivatives are sensitive to signal noise, which can cause excessive wear and tear on the control valve, and thus need enough signal filtering to be used and maintained. By combining all three modes you get a PID controller mode expressed as:

$$CO = K_n\left\{K_p(PV - SP) - \frac{1}{T_i}\int (PV - SP) + T_d\left[\frac{d(PV - SP)}{dt}\right]\right\} + MO \qquad (3)$$

PID mode controllers are easy to implement and can balance all three modes giving your process time a better overall cycle. The downfall is that if

the system parameters cannot be precisely estimated or achieved, then the desired process outcome might not be achieved. Another downfall is that the integral and derivative must be readjusted whenever there are disruptions from the operating environment such as temperature changes, flow changes, weather, power surges, and so on. There are two major causes of deficient performance when it comes to controller loops. The first is due to excessive time delay between the actuation of the element and the resulting change in the controlled variable, and second, is some variation in loop gain due to changes in the process conditions. All in all, the process will be efficient and work perfectly if there are no upsets are changes to the working system. Once a change is detected time lag will occur and process time will be lost until the parameters are adjusted and the system is corrected. The problem is no one knows there is a change in the system until the alarm notifies the controller of the situation. This is where the help of Artificial Intelligence technology could come into play. If the A.I. can sense the change in the system in real time, then the A.I. could adjust the integral and the derivative to compensate for the best approach needed.

2.3 Artificial Intelligence (A.I.)

The field of artificial intelligence research has been heavily invested into on and off ever since the early days of its founding at Dartmouth college in the summer of 1956. It wouldn't be until the beginning of the 21'st century that machine learning would be successfully applied to problems within industry. Deep learning, big data, and artificial general intelligence are the three core zones being developed for business practices. According to the Harvard Business Review, there are many advantages as well as disadvantages when dealing with artificial intelligence. Some of the advantages include the ability to automate job functions to improve efficiency for manufacturing, improve business processes in transportation and logistical supply chains, predict performance and behavior, increased revenue, pattern recognition mentioned before as in the case of Netflix and Spotify, and interpretation of big data for business insight. The disadvantages that make big business have second thoughts on using A.I. technology is that the technology itself is expensive. It costs a lot to purchase, install, and maintain the hardware. Financial analysis on the company needs to be done to see if the cost of the technology is worth it in the long run of the business. Another downfall is that A.I. takes a long time to set up. A high-performance infrastructure and massive storage resources need to be built around the technology for the A.I. to perform correctly. A.I. also needs to be integrated, so the engineers would have to know how to identify and mitigate interoperability or usability issues. The use of artificial intelligence in business also comes with the risk of security and privacy concerns and can possibly disrupt employees due to the possibly of some employees losing their jobs. According to an article written by Matt Slowikowski [4], "Whether its neural networks, machine learning, fuzzy logic, case-based reasoning or expert systems, AI has the potential to transform the industry." Today, CEO's and executives are starting to see the financial advantages of adopting artificial technology. McKinsey, a consulting firm, reported that there is $50 billion worth of savings and increased profit in the oil and gas supply chain alone by adopting A.I. There is not a lot of data or articles regarding the amount of money companies have specifically saved after implementing artificial intelligence to their infrastructure, but the top five oil and gas companies ExxonMobil, Royal Dutch Shell, China Petroleum, Total, and Gazprom have all invested millions into artificial intelligence, and are combining it within their infrastructure today. In an article written by Accenture, a leading global professional services company, it is pointed out how the use of artificial intelligence could reinvent our industry and lead to a huge economic boost by the year 2035. As seen in figure 3 on the following page, Accenture believes that their research into the profitability of artificial intelligence shows, "AI has the potential to boost rates of profitability by an average of 38 percentage points."

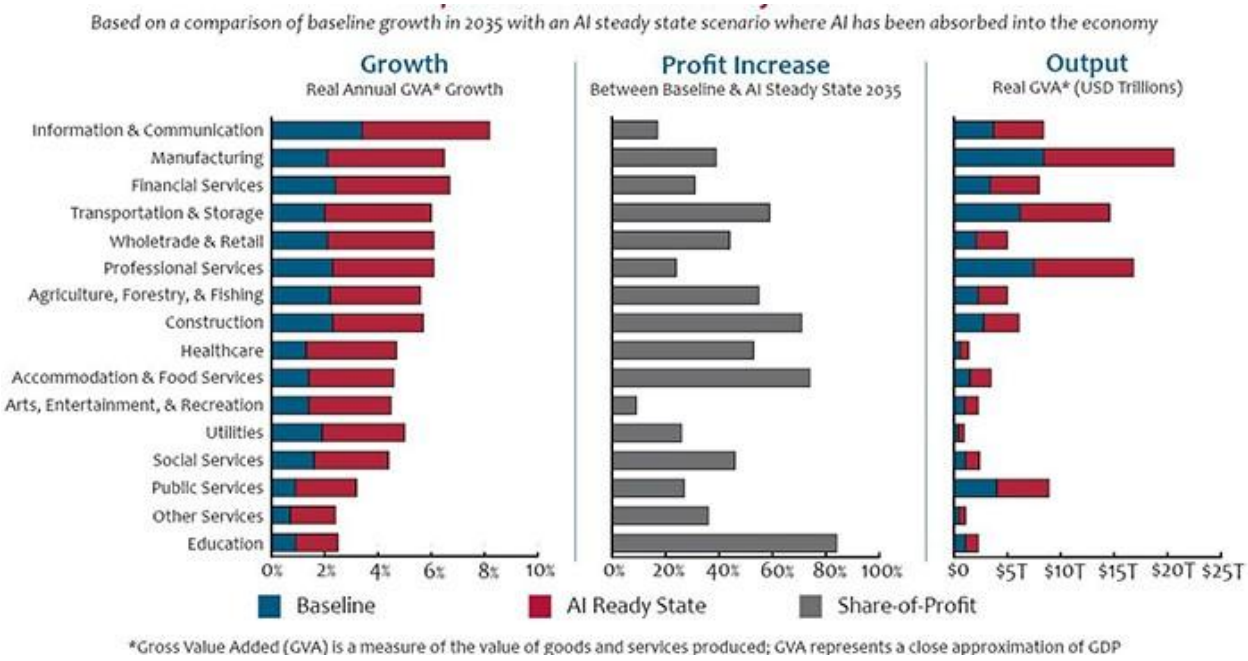

Figure 3: Financial Impact of A.I. on Businesses

III. Cost Analysis

With the latest downturn in the petroleum industry, and their hand being forced by low prices for end products, the companies who have invested in innovative technologies to improve efficiency, reduce costs, and minimize any unplanned downtime shall be the ones who emerge stronger than ever afterwards.

3.1 Financial Savings

The potential financial return a company can save by integrating an A.I. controller should be enough for any company to give it a second thought. Carlos Uribe-Gomez, Netflix's VP of Product Innovation, and its Chief Product Officer Neil Hunt, published a paper saying that Netflix's A.I. algorithms save them $1 billion every year by impacting their churn rate. They also go on to say that, "Retention rates are already high enough that it takes a very meaningful improvement to make a retention difference of even 0.1%".

Netflix's technology and development budget has increased slightly faster than its overall revenue. Last year it was reported that the company's budget increased 38% to $651 million, roughly about 10% of their revenue; however, only a small part of their development budget goes to their A.I. recommendation engine, so if the claim of $1 billion in savings is accurate then Netflix is seeing a significant return from its A.I. research.

What does this mean for the petroleum companies though? By 2020 it is estimated that the A.I. market will be worth over $5 billion. It is also believed that, even though its adoption is slow compared to other sectors, the oil and gas division will be one of its major benefactors. Drilling is not only highly expensive, but it is also an extremely risky investment. For these reasons companies are always trying to find ways to improve on their product and process time. By implementing an A.I. controller you can ensure a process in a refinery will be repeatable in a consistent fashion and improve the success rate across various stages of production. This could save oil companies millions of dollars per day by eliminating non-productive times and reducing risks.

3.2 Social Obligations

Ever since the Industrial Revolution companies have slowly evolved into protecting their workers, work place, and surrounding communities. By implementing an A.I. controller catastrophes such as blowouts, and refinery explosions could be non-existent. If an A.I. controller was in place to perform an emergency shutdown in real time as the setpoint variable change, explosions such as the Pemex oil rig, which left 4 workers dead, the Union Carbide pesticide plant that claimed the life of 15,000 people when toxic gas was released on the city of Bhopal, and the explosion at the Husky Energy Superior Refinery where multiple causalities have been reported, would not have happened. With the help of artificial intelligence communities, the environment, and the workers

who work in or around the refineries and rigs would have extra security and peace of mind knowing that the company they work for is looking out not only for the environment and surrounding communities, but also for their wellbeing.

IV. Discussion

What does all this really mean though? It means that by integrating an A.I. into a controller it has the potential to enhance human worker capabilities by freeing them up for greater strategic thinking and enabling smarter decision-making. It also means that by enabling an A.I. integrated controller you can save your company money by cutting costs due to non-productive process time and potential liabilities due to loss of human life, product, and environmental disasters.

V. Conclusion

Artificial intelligence has already found many applications in the business and manufacturing areas, but its potential for growth is still vast and numerous. In processes, deadtime results in a loss of operating time, which in return leads to a loss of profit. By implementing some form of artificial intelligence in the controller to read, analyze, and adjust to real-time changes in the process system, this deadtime can be cut down, and system efficiency can be increased, leading to increased production, profit, and company prestige. The recent research and documentation from companies that have implemented A.I. into its business practices proves that artificial intelligence technology has provided growth and financial gain for those companies. Further research and improvement in an A.I. controller could excel the technology towards the benefit of engineering and scientific sectors, while potentially savings a company billions of dollars.

References

[1] Gas Processors Suppliers Association. Engineering Data Book Volume 1 Sections 1-16, Gas Processors Association, USA, 1987

[2] John M. Campbell, Robert A. Hubbard, Robert N. Maddox. Gas Conditioning and Processing: Volume 1 The Basic Principles, sixth edition, Campbell Petroleum Series, USA, 1988

[3] Paul Mampilly. Paul Mampilly's Profits Unlimited, www.banyanhill.com, USA, 2018

[4] Matt Slowikowski. How Artificial Intelligence Could Help Transform the Oil Industry, available online at: https://oilprice.com/Energy/Energy-General/How-Artificial-Intelligence-Could-Help-Transform-The-Oil-Industry.html

[5] CEBOS blog. CEBOS a division of QAD, online at https://www.cebos.com/blog/the-top-risks-of-not-having-a-quality-management-system/

[6] PAControl. Instrumentation and Control: Process Control Fundamentals, available online at: https://oilprice.com/Energy/Energy-General/How-Artificial-Intelligence-Could-Help-Transform-The-Oil-Industry.html

[7] Bright Hub Project Management. Companies That Benefited From TQM, available online at: https://www.brighthubpm.com/methods-strategies/99895-companies-that-benefited-from-tqm/

[8] IQS. Quality Management for Oil & Gas, available online at: https://www.iqs.com/oil-gas/

[9] International Organization for Standardization. Quality management system for the oil and natural gas industry, available online at: https://www.iso.org/news/2003/11/Ref879.html

[10] North Bridge Consultants. Impact of Artificial Intelligence, available online at: http://www.northbridgeconsultants.com/newsletters/summer2017/impact_of_artificial_intelligence.php

[11] Accenture. How A.I. Boosts Industry Profits and Innovation, available online at: https://www.accenture.com/us-en/insight-ai-industry-growth

[12] OGM. Artificial Intelligence in Upstream Oil and Gas, available online at: http://www.oilgasmonitor.com/artificial-intelligence-upstream-oil-gas/

[13] Tech Emergence. Artificial Intelligence in Oil and Gas – Comparing the Applications of 5 Oil Giants, available online at: https://www.techemergence.com/artificial-

intelligence-in-oil-and-gas/

[14] Wikipedia. History of Artificial Intelligence, available online at:https://en.wikipedia.org/wiki/History_of_artificial_intelligence

[15] Datamation.Artificial Intelligence Impacts Business: the AI-Business Revolution, available online at: https://www.datamation.com/big-data/artificial-intelligence-impacts-business-the-ai-business-revolution.html

[16] Gillian Mohney. ABC News. Oil Rig Explosion Kills 4 in Gulf of Mexico, No Spill Reported, available online at:https://abcnews.go.com/International/oil-rig-explosion-kills-gulf-mexico-spill-reported/story?id=30052063

[17] Fox News 9. Explosion at Superior, Wisconsin oil refinery: Multiple injuries, evacuations ordered, available online at: http://www.fox9.com/news/explosion-at-superior-wisconsin-oil-refinery-multiple-injuries

[18] Elizabeth Dunbar. MPR News. Five lessons of loss and resilience after Superior refinery fire, available online at: https://www.mprnews.org/story/2018/06/04/five-lessons-of-loss-resilience-after-superior-refinery-fire-explosion

[19] Alan Taylor. The Atlantic. Bhopal: The World's Worst Industrial Disaster, 30 Years Later, available online at: https://www.theatlantic.com/photo/2014/12/bhopal-the-worlds-worst-industrial-disaster-30-years-later/100864/

[20] Dan Hebert, PE, and Alex Misiti. Engineering 360.The Growing Role of Artificial Intelligence in Oil and Gas, available online at: https://insights.globalspec.com/article/2772/the-growing-role-of-artificial-intelligence-in-oil-and-gas

[21] Value Global.How AI Is Transforming the Oil & Gas Industry, available online at: http://www.valueglobal.net/how-ai-is-transforming-the-oil-gas-industry

[22] Dr. Arun Kumar Ranganathan. Infosys. Artificial Intelligence in Upstream Oil and Gas, June 24, 2016

[23] Adam Levy. The Motley Fool. How Netflix's AI Saves It $1 Billion Every Year, June 19, 2016

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