Energy-efficient production process trough "Green" Management

ANITA KOVAC KRALJ[1] , JUI-MIN HSIAO[2] , DAVORIN KRALJ[3]

Faculty of Chemistry and Chemical Engineering, University of Maribor,
Smetanova 17, Maribor, Slovenia[1]
Department of Applied Economics and management, National Ilan university, Taiwan[2],
Faculty of Organizational Studies, novi trg 5, 6000 Novo mesto, Slovenia[3]

anita.kovac@uni-mb.si, jmhsiao@niu.edu.tw, davorin.kralj@amis.net

Abstract: - Leading global corporation are embracing sustainable business development as a strategic framework for integrating their business enterprises, creating innovative solutions to the complex needs and requirements of the business environment, and thinking strategically about leading change. "Green" management and leadership integrates the full spectrum of social, economic, quality, environmental, market, technological, business excellent, and management responsibilities and realities into a global corporate management system, organizational development, organizational structure, organizational and process production. Process production of the different products should be more economical. The fact is we target that more products are being produced more energy-efficient. Hexamethylenetetramine or hexamine is a white chemical compound known for over 100 years, which is formed as a product of the reaction between formaldehyde and ammonia. Hexamine use is widespread but it is only universally used in small quantities. Most of it is used for the production of explosives, and various resins. Hexamine is produced as a powder or a 42 % solution. It is produced as a powder or a 42 % solution. Our aim is to simulate a more efficient continuous 42 % hexamine solution production process in order to operate with minimal cost, and to use exothermic heat flow rate and waste materials.

Key-Words: - green management**,** hexamine, energy-efficient process, waste material, aqueous solution, utilities

1 Introduction

In early 1980s the United Nations Environment Programme (UNEP) saw environmental management as the control of all human activities that could potentially have significant impact on the environment (Toolba, 1982). The two current published environmental management system standards are the ISO 14000: 1996 (revised 2004) family of standards, and the Eco-Management and Audit Scheme (EMAS), Council Regulation 761/2001 EC. Both of these are voluntary standards to which an organisation may choose to become accredited, both being validated by means of third party confirmation audit. There is a marked difference in the reporting philosophy of these two standards, which results in organisations having to internally identify their own organisational reasons for wishing to achieve either standard (Harmer, 1997; Barker, 2000) [1]. "Green" innovation, management and leadership integrates the full spectrum of social, economic, quality, environmental, market, technological, business excellent, and management responsibilities and realities into a global corporate management system, organizational development, organizational structure, organizational and innovation processes and whole responsibilities from top to down. With these aspects we could talk about "greenovate" organizational development. Integrated system approach integrates the requirements of sustainable green development and environmental excellence with other business requirements. Consequently, following a holistic approach to competitiveness, it is of utmost importance to consider all the relevant factors of competitiveness. These factors could be subdivided into systemic and enterprise thinking, visionary green management and leadership, green production processes management, product and technological innovation, sustainable management and business/environmental excellence. Moreover, competitiveness is the basis for successful company performance as well as for a future better quality of life. Inventing the future through green management and innovation requiring systems thinking and integrated system approach to sustainable management.

2 "Green" Excellence

Recent public policy trends and new consumer demands are redirecting the attention of management outside the traditional focus of customers, suppliers and internal operations [2].

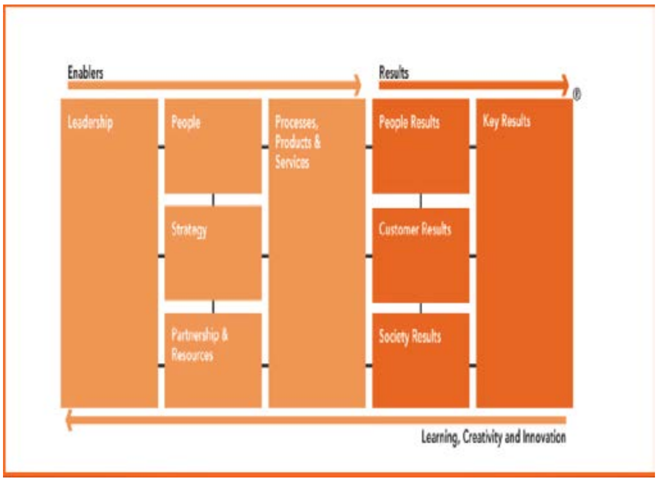
Environmental management has become strategic and the integration of the design, production, delivery, circulation, use and disposal of products is necessary to achieve improved environmental performance. Second, by including environmental factors in the integrated training of the workforce and the reward structure of the firm, long-term continuous improvement is possible. Like quality goals, environmental improvement goals must become part of the annual business plan, with performance reviews to track progress and to encourage environmental excellence [2].

The recent changes have occurred within the EFQM Business Excellence model as the most used European management framework for self-assessment. An important reason for the revision of the model is the recognition of strong trends of innovation, risk management and sustainability. Quite significant were the recommendations of the European Union aimed at improving the relevance of the model and its visual identity. The task of this part of paper is to describe and explain the causes that have led to changes in fundamental concepts of the model, but also to specify the changes that occurred within the results criteria and the enablers criteria. Changes that have occurred in the 2010 model are reflecting ones in the global business environment [6].

The research study involving small organizations [3] investigated how organisations can progress from total quality (TQ) to business innovation. The main findings were that, in general, innovation models were based more on organisational learning and appreciation of human capital than on TQ models, which were based more on mechanistic process based continuous improvement. The study found that organisations, which have a history of continuous improvement, are more likely to go on and build a successful innovative culture. That represents an additional agrument for EFQM and RADAR principle of achieving and sustaining superior levels of performance that meet or exceed the expectations of all their stakeholders. On the other hand *Part of the* OECD Innovation Strategy is *SMEs, Entrepreneurship and Innovation* [4] which is a comprehensive policy strategy to harness innovation for stronger and more sustainable growth and development, and to address the key global challenges of the 21st century. Environment innovation is the most important part of innovation because it can help living longer in a better world.

Excellent organizations can operate in different environments, with different stakeholder constituencies, and come in all shapes and sizes but what they do have in common is a mindset based on eight Fundamental Concepts of Excellence according to EFQM. Each concept is a part of sustainable business. Regardless of sector, size, structure or maturity, organisations need to establish an appropriate management framework to be successful. The EFQM Excellence Model is a practical, non-prescriptive framework that enables organisations to: assess where they are on the path to excellence; helping them to understand their key strengths and potential gaps in relation to their stated Vision and Mission as well as to integrate existing and planned initiatives, removing duplication and identifying gaps. Model provides an holistic view of the organisation and it can be used to determine how these different methods fit together and complement each other. The Model can therefore be used in conjunction with any number of these tools, based on the needs and function of the organisation, as an overarching framework for developing sustainable excellence because *excellent Organisations achieve and sustain superior levels of performance that meet or exceed the expectations of all their stakeholders.* [5]

Figure 1. EFQM Excellence Model 2010

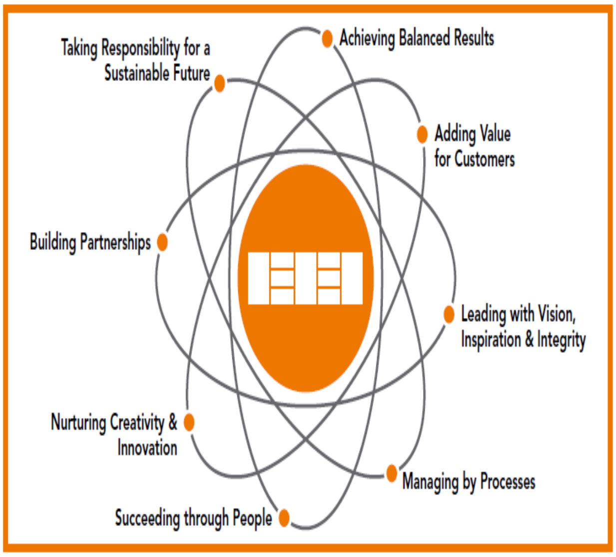


Source: EFQM Excellence Model EFQM 2010, EFQM 2009, Avenue des Olympiades 2, B-1140 Brussels, Belgium, p. 26.

The EFQM Excellence Model represented in the diagram above is a non-prescriptive framework based on nine criteria. Five of these are 'Enablers' and four are 'Results'. The 'Enabler' criteria cover what an organisation does and how it does it. The 'Results' criteria cover what an organisation achieves. 'Results' are caused by 'Enablers' and 'Enablers' are improved using feedback from 'Results'[6].

The arrows emphasise the dynamic nature of the Model, showing learning, creativity and innovation helping to improve the Enablers that in turn lead to improved Results and there has been the feed back arrow changed its name from innovation and learning to learning, creativity and innovation. That emphasises creative learning as a prerequisite for success. The underlying fundamental principles are the essential foundation of achieving sustainable excellence for any organisation.

Figure 2. EFQM Excellence Model 2010



Source: EFQM Excellence Model EFQM 2010, EFQM 2009, Avenue des Olympiades 2, B-1140 Brussels, Belgium, p. 2

The Fundamental Concepts of Excellence are:
1. Achieving Balanced Results
2. Adding Value for Customers
3. Leading with Vision, Inspiration and Integrity
4. Managing by Processes
5. Succeeding through People
6. Nurturing Creativity and Innovation
7. Building partnerships
8. Taking Responsibility for a Sustainable Future [6].

3 Green Innovation

The performances of the green product innovation and green process innovation were positively correlated to the corporate competitive advantage. Therefore, the result meant that the investment in the green product innovation and green process innovation was helpful to the businesses [7].

Joseph Chou expresses that a sustainable environment will be a global trend in the future. The governments of every nation, international investment associations and investors are also gradually asking companies to provide related details. Especially when enterprises in every country are choosing their supply chain companies, they will now pay more attention to green management then in the past. Therefore, Taiwanese enterprises in the process of becoming international must increasingly emphasize environment sustainability issues, such as carbon disclosure and carbon rights management, to perfect company control and enhance competitiveness [8].

A significant shift in production technologies has been taking place in the manufacturing industries worldwide. High production efficiency and low cost are no longer the only criteria in manufacturing modern electronic products. In the 21st century, green manufacturing is not just a business or marketing consideration but a company's strategic decision since green products and green production technologies will eventually become a competitive edge. These developments have more impact on export-oriented Taiwanese companies than those in other developed and developing countries. [9].

Focal areas in green manufacturing include energy consumption, water consumption, hazardous substances management, waste reduction, emission reduction, and others. Because of the broad scope of green manufacturing and the rapid development of Taiwan's LED and PV industries, SEMI Taiwan's EHS activities have been expanded to green manufacturing in order to cover all arising issues facing Taiwan's high-tech industries [9].

Most definitions of innovation follow the Schumpeterian tradition, defining innovation as new processes i.e.technologies and organisations and new products i.e. goods and services (Edquist 2001:23). This Schumpeterian tradition includes also institutional innovations such as new markets and social innovations such as new forms of consumer organisation[11]. These innovations are normally are left out in the discussion within innovation studies (Klemmer/Lehr/Löbbe 1999, Meyer-Kramer 2001). It is not always possible to distinguish clearly between different forms of innovation: a product innovation of one firm is a process innovation in another firm; a new organisational solution implemented in one firm might be sold as a new product for another company by a consulting company [18].

Incremental innovations improve the efficiency and / or change some aspect of products and processes. Some very critical observers might even not regard them as innovations because they do not correspond with the widespread idea of "innovation" which has to to be brandnew or even groundbreaking [19].

Radical innovations are characterised by discontinuities and are unexpected or not foreseeable outcomes of the innovation process. They partly or totally make previous investments of an enterprise or an innovation system in knowledge obsolete. Therefore, radical innovationsconstruct or lay the base for new paradigms. Most incremental and radical innovations occur in firms and are not restricted to R&D intensive sectors (Lundvall 1992, Edquist 2001) [18]. Innovation is a complex process due to the division of labour in the generation and application of knowledge. The idea of a distributed innovation process (Andersen/ Metcalfe/ Tether 2000) is one of the main outcomes of the innovation studies literature.The division of labour is related to the specialisation in the generation of complementary forms of knowledge by different processes in different organisational contexts. Specialisation entails the co-ordination of different knowledge generating activities which are valued for their different contributions to the innovation process and leads to outcomes which depend upon the interrelatedness of the different kinds of knowledge [18].
Leaders of successful, high-growth companies understand that innovation is what drives growth, and innovation is achieved by awesome people with a shared relentless growth attitude and shared passion for problem solving and for turning ideas into realities. Companies that continuously innovate will create and re-invent new markets, products, services, and business models – which leads to more growth. Innovation is founded on your enterprise's ability to recognize market opportunities, your internal capabilities to respond innovatively, and your knowledge base. So, the best thing to do to guarantee growth is to build a sustainable innovation organization.

Empowered employees driving innovation [20]. Integrated production processes innovation model which promotes production processes innovation was derived from the model of managing company policy following the interest theory and business excellence. The successful development and implementation of processes innovation in an organizational system can produce a significant saving in the amount of business and environment resources and therefore a smaller environmental impact [19]. The heightened awareness of the importance of environmental protection, and the possible impacts associated with products manufactured and consumed, has increased the interest in the development of methods to better comprehend and reduce these impacts [21].
Organizational innovation reflects the recognition that new ways of organizing work in areas such as work-force management (such as employee empowerment, new people partnership, or positive action to involve all employees in order to make work organization a collective resource for innovation), knowledge management, value chain management, customer partnership, distribution, finance, manufacturing, etc. can improve your competitiveness [22].

Process innovation can and should happen at various levels within the organization as no organization can depend solely upon innovation occurring at one level only. Successful organizations have an innovation process working its way through all levels of the organization. Hamel (Harvard Business Review) states, "*Innovation has become a mantra: Innovate or Die. Acompany can't outgrow its competitors unless it can out-innovate them. Surely everyone knows that corporate growth – true growth, not just agglomeration – springs from innovation.*" This article will provide various examples of process innovation, using the various innovation drivers, which include technology [23].

Boeing's new 787 Dreamliner is made of composite materials and is 20% more fuel-efficient over today's airplanes. The ceiling resembles a skylight, complete with blue LED lighting that mimics the sky. The LEDs allow the crew to adjust the lighting to match different phases of the flight. The thought is mimicking the light schedule of your destination, some of the dreaded jet lag can be alleviated. The new serrated engine nacelles on the 787 make the plane quieter — both for passengers and those who live in the plane's flight path (the fan blades inside the engine are designed to be quieter). Although the airplane weighs more than initially anticipated, the 787 engine makers, Rolls-Royce and General Electric are working on improving fuel consumption along with Boeing's weight and drag reduction. In an interview, 787 chief project engineer Mike Delaney insisted that the Dreamliner would meet its targets for range and payload and still deliver on the original promise of being 20% more fuel-efficient [24].

4 Environmental Organizational Scanning

Global Compact's environment principles are derived from the Rio Declaration on Environment and Development. The three principles are:

- Principle Seven: business should support a precautionary approach to environmental challenges;
- Principle Eight: undertake initiatives to promote greater environmental responsibility; and;
- Principle Nine: encourage the development and diffusion of environmentally friendly technologies.

The key element of a precautionary approach, from a business perspective, is the idea of prevention rather than cure. In other words, it is more cost-effective to take early action to ensure that irreversible environmental damage does not occur. Companies should consider the following:

- While it is true that preventing environmental damage entails both opportunity - and implementation - costs, remediation environmental harm after it has occurred can cost much more, e.g. for treatment costs, or in terms of company image.
- Investing in production methods that are not sustainable, i.e. that deplete resources and degrade the environment, has a lower, long-term return than investing in sustainable operations. In turn, improving environmental performance means less financial risk, an important consideration for insurers.
- Research and development related to more environmentally friendly products can have significant long-term benefits[28].

PESTLE analysis is a useful tool for understanding the industry situation as a whole, and is often used in conjunction with a SWOT analysis to assess the situation of an individual business. PESTLE stands for "Political, Economic, Sociological, Technological, Legal and Environmental" factors. The questions to ask yourself are :

- What are the key political factors likely to affect the industry?
- What are the important economic factors?
- What cultural aspects are most important?
- What technological innovations are likely to occur?
- What current and impending legislation may affect the industry?
- What are the environmental considerations [25]?

Originally designed as a business environmental scan, the PEST or PESTLE analysis is an analysis of the external macro environment in which a business operates. These are often factors which are beyond the control or influence of a business, however are important to be aware of when doing product development, business or strategy planning [25].

Factor	**Often Comprised Of**
Political	- Current taxation policy - Future taxation policy - The current and future political support - Grants, funding and initiatives - Trade bodies - Effect of wars or worsening relations with particular countries
Economic	- Overall economic situation - Strength of consumer spending - Current and future levels of government spending - Ease of access to loans - Current and future level of interest rates, inflation and unemployment - Specific taxation policies and trends - Exchange rates
Sociological	- Demographics - Lifestyle patterns and changes - Attitudes towards issues such as education, corporate responsibility and the environment - Social mobility - Media views and perceptions - Ethnic and religious differences

Technological	- Relevant current and future technology innovations - The level of research funding - The ways in which consumers make purchases - Intellectual property rights and copyright infringements - Global communication technological advances
Legal	- Legislation in areas such as employment, competition and health & safety - Future legislation changes - Changes in European law -Trading policies - Regulatory bodies
Environmental	- The level of pollution created by the product or service - Recycling considerations - Attitudes to the environment from the government, media and consumers - Current and future environmental legislative changes

Table 1: PESTLE analysis [25]

It is important to take into account PESTLE factors for the following main reasons:

- Firstly, by making effective use of PESTLE analysis, you ensure that what you are doing is aligned positively with the powerful forces of change that are affecting our working environment. By taking advantage of change, you are much more likely to be successful than if your activities oppose it
- Secondly, good use of PESTLE analysis helps you avoid taking action that is likely to lead to failure for reasons beyond your control
- Thirdly, PESTLE is useful when you start a new product or service. Use of PESTLE helps you break free of assumptions, and helps you quickly adapt to the realities of the new environment [18].

The PESTLE subject should be a clear definition of the market being addressed, which might be from any of the following standpoints:

- A company looking at its market
- A product looking at its market
- A brand in relation to its market
- A local business unit or function in a business
- A strategic option, such as entering a new market or launching a new product
- A potential acquisition
- A potential partnership [26].

5 Energy –efficient processes

Energy-efficient processes are very important in the real chemical industry, because it can reduce energy losses and costs, and can improve the operation of energy and process systems.

Hexamine or hexamethylenetetramine is used in pharmaceutical industries as a primary feed material, and in chemical industries as an intermediate material. It is highly soluble in water and, as with some other tertiary amines, has an inverse solubility at low temperatures [10].

The Meissner process is an optimum method for producing hexamine from formaldehyde and gaseous ammonia in which the reaction and crystallization stages take place simultaneously in order to produce crystalline hexamine. The crystallization stage controls the Meissner process due to a high dissolution rate of ammonia and formaldehyde in the aqueous solution and a high reaction rate during hexamine production [11].

The values for those kinetic parameters regarding hexamine crystallization from aqueous solution that are necessary for controlling industrial crystallizers, have been calculated by Alamdari and Tabkhi [12].

6 Hexamine production

Hexamethylenetetramine or hexamine is a heterocyclic organic compound with the formula $(CH_2)_6N_4$. It was first prepared in 1859 by Butlerov of Russia [13, 15]. This white crystalline compound is highly soluble in water and polar organic solvents. It is useful in the synthesis of other chemical compounds, e.g. plastics, pharmaceuticals, rubber additives. It sublimes in a vacuum at 280 °C.
Hexamine is produced from ammonia and formaldehyde:

$$4\ NH_3 + 6\ CH_2O = (CH_2)_6N_4 + 6\ H_2O \qquad \Delta H_r = -230\ \text{kJ / mol} \qquad \text{(R1)}$$

The are mainly two methods of obtaining hexamine in the world. In the first ammonia and formaldehyde are added into the reactor as an aqueous solution, and the second is the use of anhydrous ammonia, if we want to reduce the amount of water entering the

reactor.
If you add ammonia to a gaseous reactant within a plural relationship of formaldehyde and ammonia between 3:2 and 3:3 when allowing the reactor to be an aqueous solution of formaldehyde, the composition is between w = 30-50 % formaldehyde. This reaction is exothermic, so the temperature in the reactor is between 50 and 90 °C [16] or 102 °C [14]. The ammonia-formaldehyde reaction is highly exothermic. Conversion in the reactor is 97 % [16]. Passes expire at a pH of between 7 and 8. The reaction mixture is collected in a vacuum evaporator. Within it, the solution is concentrated until most of the water evaporates, therefore the hexamine is crystallized better. If solid hexamine is required, concentrated aqueous solution is pumped into a crystallizer. The wet crystals are then separated by centrifugation or filtration. After centrifugation or filtration, those crystals are washed with water to produce pure hexamine. The crystals and then collected in a spray dryer, as the crystals contain less than 1 % water. After drying, the final product is ready for sale [15].

This paper presents a more efficient production producing continuous 42 % hexamine solution [b].

6.1 Continuous 42 % hexamine solution production

Hexamine is produced as a granular and free-flowing powder, as well as an approx. 42 % solution. Solution is cheaper because is not needed crystallizer.

Continuous hexamine water solution production is simulated using an Aspen Plus simulator [8]. Firstly, the outlet temperature of the reactor is simulated at 80 °C (chapter 2.1.1), and then for a second time at 102 °C (chapter 2.1.2). Continuous hexamine production is produced under a constant pressure of 1 bar. Both simulations are compared.

The purpose of this study was to simulate the production of hexamine solution using an Aspen Plus simulator [8]. This simulator is very common for any engineer assisting in the planning process. The Aspen Plus simulator calculates the mass flows and energy balances during hexamine production, and analyzes the process at different temperatures by using an ideal thermodynamic model that includes Raoult's and Henry equations of state.

Aspen Plus is used for the simulation of arbitrary processes, which are comprised of a processing unit associated with continuous mass and energy flows. As a proven software package, it has a wide range of applications for simulating processes within the chemical and petrochemical industries, petroleum refining, the production of fuels and fuel products, industrial metals and minerals, the paper and food industries, pharmaceuticals and biotechnology, etc. The programs in the software package are written in Fortran, so it is also useful for advanced users who want Aspen Plus to complement their knowledge [17].

6.1.1 Reactor outlet temperature of 80 °C

The reactor releases 321 kW of heat flow rate (Table 1; Fig. 1). The evaporator was assumed to have a temperature of 101 °C, and needed 163 kW of heat flow rate. A temperature of 101 °C is best for the evaporator, when producing hexamine, which contains 42 % aqueous solution. A temperature of 100 °C gives 35.0 % aqueous hexamine solution, but at 102 °C, this is 50.3 %. Table 2 shows the mass flows of the entire process and the composition of the flow simulations at an evaporator temperature of 101 °C. The final product (stream 4; 711.1 kg/h), when cooled with water, releases 47 kW of heat flow rate in the cooler.

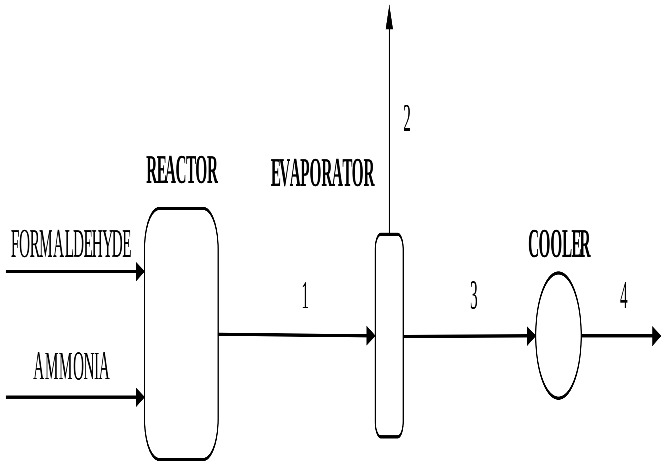


Figure 3. Basic simulation process of 42 % hexamine solution production.

q_m (kg/h)	AM MO	FOR MA	1	2	3	4
formaldehyde	0.0	400.0	10.6	10.0	0.5	0.5
water	0.0	400.0	633.6	224.7	408.9	408.9
ammonia	151.0	0.0	3.8	3.6	0.1	0.1
hexamine	0.0	0.0	302.9	0.8	302.2	302.2

Temperature, °C	20	20	80	101	101	25
Pressure, bar	1	1	1	1	1	1

Table 2: The composition of mass flows simulated production hexamine with a discharge temperature of 80 °C in the reactor and 101 °C in the evaporator.

6.1.2 Reactor outlet temperature of 102 °C

The reaction takes place at an outlet temperature of 102 °C from the reactor, as in the literature [13]. The reactor releases a 99 kW heat flow rate. A partial condenser was analyzed by running at 101 °C, with an entrained heat flow rate of 57 kW, thus producing a 42 % aqueous hexamine solution (Fig. 2). Table 3 shows the mass flows of the entire process, and the compositions of the flow simulations at a flash temperature of 101 °C. The final product (stream 4; 711.1 kg/h) was cooled in a cooler with a released heat flow rate of 47 kW.

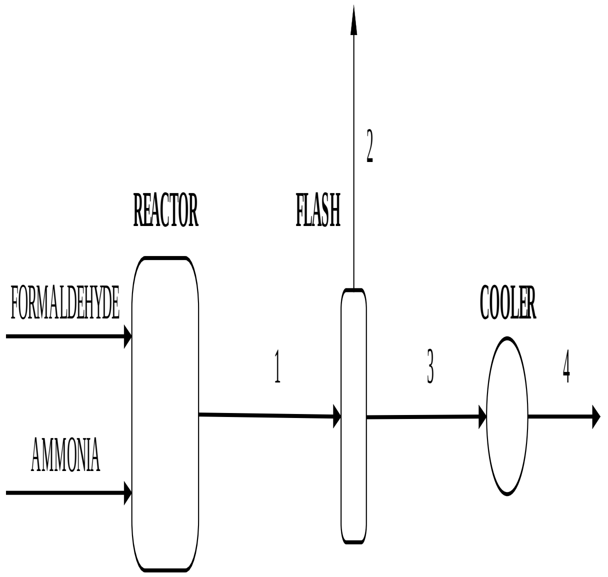


Figure 4: Basic simulation process of 42 % hexamine solution production.

q_m (kg/h)	AMMO	FORMA	1	2	3	4
Formald.	0.0	400.0	10.6	10.0	0.5	0.5
Water	0.0	400.0	633.6	224.7	408.9	408.9
Ammonia	151.0	0.0	3.8	3.6	0.1	0.1
Hexamine	0.0	0.0	302.9	0.7	302.2	302.2
Temp., °C	20	20	102	101	101	25
Pressure, bar	1	1	1	1	1	1

Table 3: The composition of a mass flow's simulated production of hexamine, with a discharge temperature of 102 ° C from the reactor, and 101 ° C from the flash.

5.1.3 Energy-efficient continuous 42 % hexamine solution production

The most favourable is the one that operates at a maximum temperature (102 °C; Fig. 3), because of its totally available heat flow rate, and it can be added into the process.

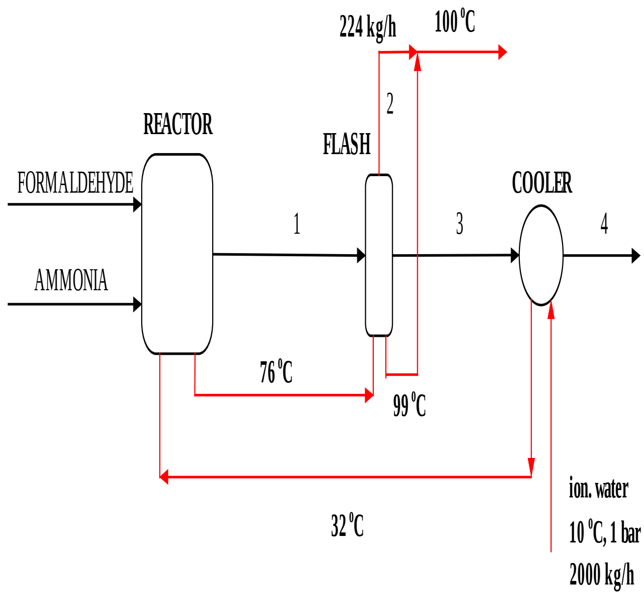


Figure 5: Energy-efficient simulation process of 42 % hexamine solution production.

Any available heat may be used for the heating of ionized water: first into the cooler, followed by into the reactor, and then into the flash. The water separated in the flash can be combined with ionized water, because it contains minimal impurities (Fig. 3).

7 Conclusion

"Green" innovation, management and leadership integrates the full spectrum of social, economic, quality, environmental, market, technological, business excellent, and management responsibilities and realities into a global corporate management system, organizational development, organizational structure, organizational and innovation processes and whole responsibilities from top to down.

The successful green development and implementation of green innovation in an organizational system can produce a significant saving in the amount of business and environment resources and therefore a smaller environmental impact [27]. The successful development and implementation of processes innovation in an organizational system can produce a significant saving in the amount of business and environment resources and therefore a smaller environmental impact.

Hexamine has a wide use in the military, the pharmaceutical industries, and in the production of resins. The economic and operational hexamine solution production was more favourable than the powder production. The most favourable is the process that operates at a maximum temperature of 102 °C, because of the total available heat flow rate, and without the need for heat flow rate. Energy-efficient continuous 42 % hexamine solution production is very simple, and uses only a small number of processing units. The process itself can heat the hot utilities within all process units, separately. No materials are discarded during the process. The water, after separation, could be use as utility or material.

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