Journal of Farayandno – Vol.19 – No.86 (2024): pp. 27-38

National Iranian Oil Refining and Distribution Company (NIORDC)

Journal of Farayandno

Research Paper

DOI: 10.22034/farayandno.2024.2034309.1965

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Study of the Polypropylene Production via the Hierarchical Analysis Process: Simulation and Optimization of the Process

Asadollah Karimi [*1], Alireza Kaviani [2]

[1] Associate Professor, University of Maragheh
[2] B. Sc student of Chemical Engineering, University of Maragheh

Received: 31 May 2024 **Accepted:** 13 Aug 2024

1. ABSTRACT

This work employed the Analytical Hierarchy Process (AHP) to investigate the advantages and disadvantages of polypropylene production reactors. Five criteria were considered for this process, and three alternatives were evaluated based on the AHP method. Then, the polypropylene production process was simulated and, ultimately, the operational conditions were optimized. The tubular reactor was identified as the highest priority alternative, and cost was the highest priority criterion in the process, with 38% and 25%, respectively. The percentage of polymer yield from the reactor and the reduction of operational costs were chosen as the objective functions of this process. The optimization results showed that the best feed gas temperature and mass flow rates were 78 degrees Celsius and 5000 Kilograms per hour, respectively. Additionally, by reducing operational costs as an objective function at the optimal point, energy savings of up to 78102 dollars per year can be achieved.

Keywords: Tubular Reactor; Expert Choice Software; Aspen Plus Software; Analytical Hierarchy process.

2. INTRODUCTION

Polypropylene is known as one of the most important synthetic polymers by humans, so that it is known as the most widely used polymer after polyethylene. Due to its excellent plasticity and chemical resistance, this polymer is widely used in various fields such as automotive, cosmetic, textile and packaging. It should be noted that more than a quarter of the global demand for polymer is propylene; therefore, proper quality control on polypropylene production processes will definitely affect the quality and cost of the product. In this work, the Analytical Hierarchy Process (AHP) was employed to systematically and logically select the best propylene reactor. After this stage, the proposed reactor will be simulated by the hierarchical analysis process in Aspen Plus Polymer software, and the operational parameters of the polypropylene production reactor will be optimized [1-2].

3. MATERIALS AND METHODS

The AHP method employed to choose the appropriate reactor in the propylene production process. One of the significant comprehensive systems designed for judging by numerous criteria is the hierarchical analysis process. This technique provides the equation hierarchically and applies the consideration of different criteria in decision making. [3-5]. Cost (operational and material), catalyst, environmental regulationsefficiency and operating conditions are selected as criteria, and CSTR reactor, Tubular reactor and FBR reactor are chosen as alternatives. The flowchart of the analytical hierarchy process is demonstrated in figure 1.

a.karimi@maragheh.ac.ir

Please Cite This Article Using:
Karimi, A., Kaviani, A., "Study of the Polypropylene Production via the Hierarchical Analysis Process: Simulation and Optimization of the Process", Journal of Farayandno – Vol. 19 – No. 86, pp. 27-38, In Persian, (2024).

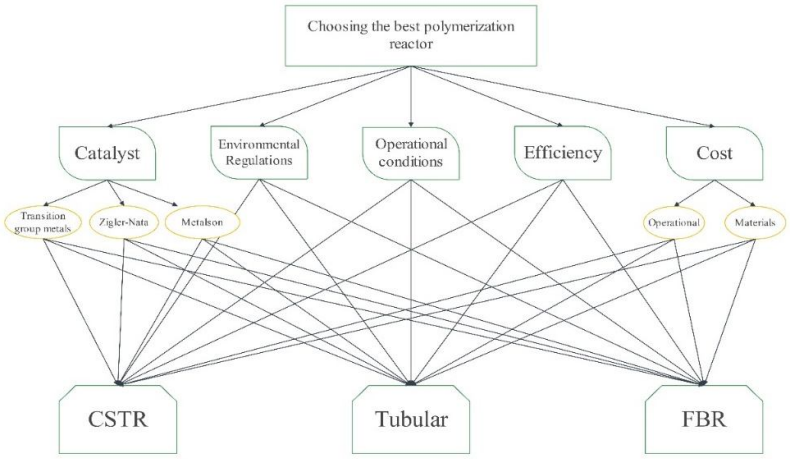


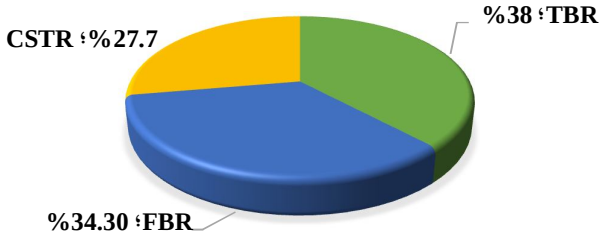
Fig.1 Process view of the criteria and alternatives of the hierarchical analysis process

Then, the propylene production process is simulated in ASPEN PLUS POLYMER.

4. RESULTS AND DISCUSSION

4.1. AHP Results

A pairwise comparison between the criteria was organized based on the previous studies, and the software was employed for pairwise comparison. The preference of each of criteria (parameter) and alternatives have been analyzed and compared



based on the existing situation in the process. Each of the three alternatives has benefits and disadvantages that for paired comparison should be studied carefully. According to Figure 2 and 3, the tubular reactor and cost has the highest priority among other alternatives and criteria, respectively.

Fig. 3 Pairwise comparison of alternatives in Expert Choice software

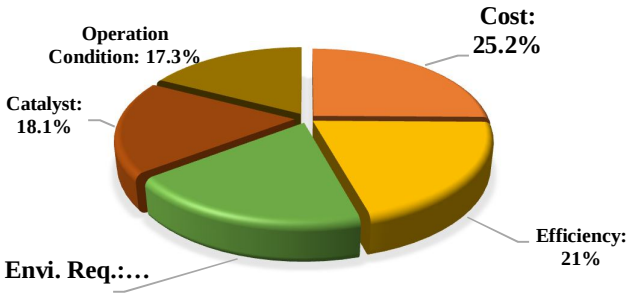


Fig. 4 Pairwise comparison of criteria in Expert Choice software

4.2. Simulation Results

The validation of data is the first step in each software simulation, which error in the software data has by 15% considering the case study information. Table 1 is shown simulation results and objective function errors.

Table 1: Validation of the simulation results with the actual value

Item	Simulation Value	Actual Value	Percentage Error
Feed Temp. (°C)	40	44	10
Flow rate (kg/h)	6300	6300	0
Yield of polymer (%)	55	50	9

5. CONCLUSION

In this research, the optimal selection of propylene reactors was investigated. Considering the multitude of available methods, the AHP was applied to select the logical method for optimal selection. The achieved results from AHP indicated that cost criteria have the highest priority. Also, the tubular reactor was selected as the premium alternative. The process was simulated in Aspen plus Polymer and then the operation conditions were optimized. Although the optimization results showed that the best mass flow rate of feed and the feed gas temperature was 5000 kg.h-1 and 78 °C, respectively.

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