Optimal Control Strategy for the Production of Biodiesel by using Dynamic Programming Problem

R.Prabakaran, D. Anandakumar

ABSTRACT--- In this paper, we consider an arrangement of biodiesel creation with no underlying mass exchange resistance. Here we locate an efficient control procedure to produce biodiesel smoothly utilizing AVK Method. Additionally we proved optimal control strategies by powerful dynamic programming and explore temperature profile.

Keywords: Biodiesel, AVK, Dynamic programming

I. INTRODUCTION

Biodiesel is a spotless consuming inexhaustible fuel made utilizing natural fats and oils from vegetable. The use of fluid powers, for example, it is created from Jatropha oil by transesterification procedure stand amongst the best encouraging choices for the utilization of customary petroleum usages. Creation of biodiesel from transesterification through Jatropha oil altogether relies upon following attributes, for example, period of reaction, oil to liquor molar proportion, speed of stirrer and temperature.

Biodiesel is also called as (FAME)Fatty acid methyl esters. It is gotten from sustainable oils from vegetable, for example, Jatropha curcas oil and can be utilized as an elective fuel for diesel [1]. It highlights for locally accessible, environment benefit, open, reasonable and dependable fuel got from sustainable sources, for example, fats from animals and oils from vegetable by transesterification [2]. The best elective methods for preparations is from nature Jatropha Curcas plant. It's a kind of such anti eatable oils, having a expected yearly generation capability of 200000000 kilogram fromIndia and it tends to be developed in waste land [3].

Liquors or transesterification was generally utilized to change over oils from vegetable into biodiesel within the sight of catalyst. Various procedures have been created to generate biodiesel including substance such as semi fluid, bases, catalyst of heterogeneous else biological, acids else free catalyst [4]. In existing many authors have analyszed in the production of biodiesel has explored, such a resource consists of high FFA (free fatty acid) and huge water quantity involves preprocessing to attain defined FFF utilizing catalyst from acidic.

Attributes like temperature, triglycerides, liquor, response period and proportion of catalyst will make change in progress of transesterify. For example, an abundance of liquor can ensure the total change of oils or fats to esters in a brief timeframe. More often than not, the molar proportion utilized is 6:1 in a nearness of soluble base impetus. Then again, the transformation rate of unsaturated fats esters increments periodically which discovered that the yield achieves a most extreme at the response period of under 90 min. Impacts of molar proportion of liquor and fixation of catalyst assume a fundamental job in production of biodiesel. An overabundance of response period decrease the outcome because of the regressive responses and it will make progressively unsaturated fats to structure soap. One of the significant job taken by the catalyst by its fixation builds the change of triglyceride, where it cultivates biodiesel production. Through jatropha curcas oil the parameters such as response period and temperature are monitored during diesel generation. Production improves as well as above parameter value also incremented as well as more than fifty degree Celsius the production get dropped down. Hence, crucial parameter in this process is temperature. Along these lines, an ideal heat should be maintained for ideal creation. Stirring can be involved in this production process due to the lack that occurs during manufacture of huge quantity. Roy et al. [5], effectively demonstrates the impact of blending on transesterification by figuring a numerical calculation. The blending speed of 600 rpm will be the solution for above conflicts. Hence in proposed work we had form a structure to demonstrate the impact of temperature. Likewise, we had decided a proportion to make reasonable in generation. By utilizing optimal control theory proper heat is maintained to achieve a goal of most extreme measure of biodiesel can be acquired from transesterification of Jatropha Curcas oil in a stable period of response. Optimal control problem during production of biodiesel has taken as a challenge in this research article. To achieve this we utilizing dynamic optimization concept to control the policy of temperature.

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II. TRANSLATING CHEMICAL KNOWLEDGE TO ORDINARY DIFFERENTIAL EQUATIONS (ODE)

By defining the upcoming solution for analytical by correlating differential conventional condition, organized as issue proclamation of advancement optimization, that are feasible to utilize strategy from common mathematical techniques. Through substance information we create the ODE's. taking a structure of 6 differential conditions.

Through research we analyzed the proportion of triglycerides with methanol forms biodiesel. In 3 inverse procedure the substance change occurs. Over the span of response of methanol and triglycerides, a few intermediates monoglyceride and diglyceride had noted. The response had clarified in following steps

$$TG+AL \leftrightarrow DG+BD \quad (2.1)$$
$$DG+AL \leftrightarrow MG+BD$$
$$MG+AL \leftrightarrow GL+BD$$

Total response: $TG+3AL \leftrightarrow 3BD+GL.$

Understanding of numerical model of transesterification response framework, the upcoming scenario was are embraced [5]

i) We can conclude that 3 subsequent reactions only occurs by the quantity of water is minimum (0.2% w/w) which was present as well as unimportant free unsaturated fats are identified in the framework,
ii) Catalyst utilized in this investigation contains neither specificity in fixed manner so on whatever acyl-gathering it works simultaneously,
iii) As blending force in the response framework coordinates the huge exchange impediments in different stages, so mechanical mixing is a standout amongst the best factors in transesterification response.

Mass Transfer rate - k_s
Unit - min^{-1}
Miaxture speed - N
Constants - a,b and c

$$k_s = \frac{a}{1+e^{-bN+c}} \quad (2.2)$$

The constraints utilized in this framework was

$$k_s x_B \left[1 - \frac{x_B}{B_{max}}\right] \quad (2.3)$$

Biodiesel concentration - x_B
Bulk production - B_{max}
Unit - moles/L

Principle of this has been utilized strategically in light of the fact that with the expansion of speed of stirrer, huge exchange obstruction diminishes and past a specific speed of stirrer during that time resistance is unimportant. It has been clear from existing perceptions of different specialists [6].

Glycerol - x_G
Diglycerides - x_D
Triglycerides - x_T
Methanol and - x_A
Monoglycerides - x_M

By using action of mass rules with above material composition we derive upcoming solutions:

$$\frac{dx_B}{dt} = k_1 x_T x_A - k_2 x_D x_B + k_3 x_D x_A - k_4 x_M x_A + k_5 x_G x_B + k_s x_B \left[1 - \frac{x_B}{B_{max}}\right]$$
$$\frac{dx_T}{dt} = -k_1 x_T x_A + k_2 x_D x_B$$
$$\frac{dx_D}{dt} = k_1 x_T x_A - k_2 x_D x_B - k_3 x_D x_A + k_4 x_M x_A$$
$$\frac{dx_M}{dt} = k_3 x_D x_A + k_4 x_M x_A - k_5 x_G x_B + k_6 x_G x_B$$
$$\frac{dx_A}{dt} = -k_1 x_T x_A + k_2 x_D x_B - k_3 x_D x_A + k_4 x_M x_A - k_5 x_G x_B + k_6 x_G x_B$$
$$\frac{dx_G}{dt} = k_3 x_D x_A + k_6 x_G x_B \quad (2.4)$$

+ ve attributes - B_{max}, k_s, k_1, k_2, k_3, k_4, k_5 and k_6
Response in forward - k_1, k_3, and k_5
Response in reverse - k_2, k_4 and k_6

The expression of Arrhenius solution for temperature in response constant is

$$k_i = \alpha_i e^{-\frac{\beta_i}{T}} \quad (2.5)$$

Temperature in response -T
Factor of frequency - α_i

$$\beta_i = -\frac{E\alpha_i}{R} \quad (2.6)$$

Energy of activation/component - $E\alpha_i$
Constant of gas R

Dynamic programming approach:

It's a valuable apparatus in taking care of streamlining and ideal control issues. Basically depends on the guideline of accurateness. An ideal approach contains attribute in any underlying stage and beginning choices the rest of the choices should comprise an ideal arrangement as per stage coming about because of the primary choice.

III. PROCEDURE AND STRUCTURE:

Efficient type of the framework is depicted by:

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$$\frac{dx_i}{dt} = f_i(t, x, T) \quad i = 1,2,3,4,5,6 \tag{3.1}$$

the starting values of attributes was:

$$x_T(0) = x_{T_0}, x_B(0) = x_D(0) = x_m(0) = x_G(0) = 0, x_A(0) = x_{A_0} \tag{3.2}$$

where T is a control attribute which was bounded by $\alpha \leq T \leq \beta$

At the time of fininshing t_f is evaluated as $J = x_B(t_f)$ to increment in a scalar function of performance index. By given interval of time $0 \leq t \leq t_f$ want to identify the control T(t) thus performance will get boosted.

By utilizing this approach a ideal management strategy is roundup by subset level handling approach in time of P segments, every one of length L, thus $L = t_f / P$, according to period interim $t_{k-1} \leq t < t_k$ is viewed as the steady flow T(t) = T (k-1). A issue at this point is to discover T(0), T(1),… T(P-1) that augmented the exhibition list.

The first calculation of iterative dynamic programming developed [1], take care of this issue comprise in the accompanying procedures:

1. Partition the periodic interim t_f into P sets, every one of length L.
2. Pick the quantity of x-network focuses N and the quantity of reasonable qualities M for the control u.
3. Pick the locale r for the control esteems.
4. By picking N estimations of control inside reasonable district incorporate Eq.(1) N periods to create the x-framework in every period set.
5. Beginning on final period set P, comparing on period t_f – L, for every x-framework point incorporate Eq.(1) from t_f – L to tf in each M reasonable estimations of control. Pick the point that expands the efficiency and records through the estimation of control for use in the following stage of the calculation.
6. Going to set P-1, comparing by period t_f – 2L, to coordinate Eq.(1) at t_f – 2 L in between t_f – L for every x-network coordinates by M reasonable control estimations. By proceeding with reconciliation from t_f – L to t_f pick the control from stage 5 that compares to the lattice direct nearest toward the subsequent x at t_f – L. Look at the M estimations of the exhibition record and store the estimations of control that gives the most extreme number.
7. Proceed with the strategy until stage 1, comparing to the underlying period t = 0 is come to. Record the strategy that boosts the presentation file and store the comparing x-direction.
8. Lessen the x-lattice position and the locale for passable control esteems by a factor ε :

$$r^{(j+1)} = (1\text{-}\varepsilon)\, r^{(j)} \tag{3.3}$$

9. Boosting the cycle file j by 1 and go to stage 4. Proceed with the cycle for a predefined value of cycle.

The adjustment of calculation for different aspects principle where T issues is direct, yet the relating expanding of processing speed is impressive.

IV. AUGMENTATIONS AND CHANGES IN ABOVE CONCEPT:

The past calculation can be stretched out [3] to issues including obliges on particular factors, for example,

$$G[\mathbf{x}(t_f)] = 0$$
$$x_{min,i} \leq x_i \leq x_{max,i} \qquad i=1,2,\ldots n \tag{4.1}$$

To fulfill these limitations a different steps should be utilized. At the point when the quantity of control factors is huge, so as to diminish the length, rather than consistently picked acceptable qualities for control, In [4] introduced the utilization of arbitrarily created control esteems. In this way, for parallel circulation, the base quantiy of number shall be utilized is 3^m thus m stands for quantity of manageable factors. Using six manageable factors, the base 729 even now reasonable, however handling ten manageable factors the quantity of qualities to be inspected

The issue of achieving an ideal set in starting period in least time is an significant issue in designing. For instance, while a plant in initial stage, it is attractive to achieve the grown result at the earliest opportunity. Likewise, while jumping from particular to some where, the progress ought to be cultivated as quick as would be prudent.

In 2-D frameworks the ideal in periodic management issues is possible to unraveled with the help of Pontryagin's greatest guideline. The utilization of this rule in large-dimensional issues, while conditions are nonlinear the deal in periodic management issue is extremely hard to understand. By implementing IDP on that issue is viewed as a fitting finishing period scalar execution record to be limited:

$$J = \phi(x_B(t_f), t_f) \tag{4.2}$$

constraint of the finishing stage is: $x_{min,i} \leq x_i \leq x_{max,i}$ was fulfilled in particular estimation of conclusive time period t_f. The persistent management strategy will adopt to subset fixed control issue by isolating the periodic interim $0 \leq t \leq t_f$ into P period phases of diffenent size:

$$v(k) = t_k - t_{k-1} \quad k = 1,2,\ldots P \tag{4.3}$$

At the point maintaining the contol consistent in every one of periodic interims. Through phases of different size, exchanging period are resolved precisely. Likewise, it is presented a standardized period attribute τ to such an extent that $\tau = t/t_f$ with the discrete reesults $\tau k = k/P$, k = 0,1,… P. In this way, in the changed periodic area, every set is of equivalent length L = 1/P and the changed framework conditions, in the periodic interim $\tau k \leq \tau < \tau k+1$, become:

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$$\frac{dx_i}{dt} = \mathrm{v(k)}\, f_i\,(t, x, T) \quad i = 1,2,3,4,5,6 (4.4)$$

For every periodic interim the control maintained it's consistent at u(τk). The periodic-ideal management issue is to decide u(τk) and the time span sets v(k), for k = 1,2,… P, to such an extent that the limitations are fulfilled thus that t_f is limited.

Thus the issue is currently preferably appropriate for implementing IDP calculation.

V. CONCLUSIONS:

Hence the extension of iterative dynamic programming delivers an exceptionally appealing path for assurance of proper chemical processes through optimal control strategies. This technique will be useful for software efficiency. The analyzed solution leaves many ways for future scientists.

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