International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

PERFORMANCE AND EVALUATION OF EMISSION CHARACTERISTICS OF BAEL SEED BIODIESEL AS AN ALTERNATIVE FUEL FOR DIESEL ENGINE

Dr. K. Kalyani Radha[1] Dr. B. Omprakash[2] ,

1.Associate Professor, *Dept. of Mech Engg, JNTUACEA, Ananthapuramu, A.P, INDIA.*

2. Associate Professor, *Dept. of Mech Engg, JNTUACEA Ananthapuramu, A.P, INDIA*

***Abstract:*In present days, the depletion of petroleum products increasing with the increasing of population growth. To meet the present requirements of the automotive industry, there is continuous search to improve the performance, exhaust emission, and life of I.C engines. The first two challenges, researchers are working both on new engine technologies and fuels. The present study focused on non-petroleum renewable and non-polluting fuels to be used for I.C engines.Hence an attempt is made to analyze the performance and emission characteristics of diesel and different blends of Bael seed oil on a four stroke single cylinder water cooled diesel engine test rig. Experiments were carried out on a diesel engine using different blends of Bael seed oil namely B10, B20, and B30 on volume basis. Performance parameters such as brake power, specific fuel consumption, and thermal efficiencies are calculated based on experimental analysis of the engine. Emissions such as carbon monoxide, carbon dioxide, NO_X and unburned hydrocarbon are measured. The test results indicate that blend B10 (10% Baelseed oil & 90% diesel) gives better performance and lower emission results compared to all fuel mixtures and diesel under this study.**

Keywords*:* Bael Seed Oil (BSO), single cylinder 4-stroke diesel engine, Specific fuel consumption,exhaust emissions

I. INTRODUCTION

With the rapid development of civilization, transport becomes essential part of life. The large increase in number of vehicles in in recent years has resulted in great demand for petroleum products. The rapid depletion of petroleum fuels and their ever-increasing cost have prompted considerable research to identify alternative fuel sources. Vegetable oils provide a viable alternative to diesel. The use of raw vegetable oil in engines is possible but not preferable. The high viscosity of raw vegetable oils and the low volatility affects the fuel atomization and spray pattern of fuel, leading to incomplete combustion and severe carbon deposits, injector choking and piston ring sticking. The trans esterification is the commonly used process to overcome all problems associated with biodiesel. The use of chemically altered or trans esterified vegetable oil called biodiesel does not require modification in engine or injection system or fuel lines and is directly possible in any diesel engine. Trans esterification is also known as alcoholysis, which uses alcohols in the presence of a catalyst (e.g., base, acid, or enzyme depending on the free fatty acid (FFA) content of the raw material) that chemically breaks the molecules of triglycerides into alkyl esters as biodiesel fuels and glycerin as a by-product.Trans esterification appears to be the most promising technique which is a chemical process of converting vegetable oil into biodiesel fuel. Biodiesel can be used as a blend in diesel engines without modification. Detailed reviews about trans esterification process are available in the literature.

II. LITERATURE REVIEW

A Dhanamurugan and R Subramanian-Explained Due to the concern on the accessibility of recoverable fossil fuel reserves and their environmental problem creates a considerable attention has been given to biodiesel production as an alternative to petro diesel. The two most common types of bio-fuels are ethanol and biodiesel. This paper presents application of bio-diesel performance and emissions characteristics with petro diesel. Performance parameters of B20 (Brake thermal efficiency and Brake specific Energy consumption) were quite close to petroleum diesel. B20 emits lesser emissions (CO, HC, NO_X and CO_2) than petro diesel except smoke level. Thus, B20 (20% bio-diesel+80% diesel by volume) can be effectively used as diesel fuel substitute in existing diesel engine without any engine modification.

Dilip Kumar Bora-Explained Due to the concern on the accessibility of recoverable fossil fuel reserves and their environmental problem creates a considerable attention has been given to biodiesel production as an alternative to petro diesel. This paper presents performance of single cylinder diesel engine using blends of karabi seed bio-diesel. Potassium hydroxide was used as catalyst to facilitate esterification process. It has been observed that karabi seed bio-diesel can effectively be used as dieselfuel substitute in existing diesel engine without any engine modification.

Yathish.K.V and Omkaresh. B.R-Explained Due to the concern on the accessibility of recoverable fossil fuel reserves and their environmental problem creates a considerable attention has been given to biodiesel production as an alternative to petro diesel.Now a day's increasing in prices and depletion of fossil fuels, creates very necessary to find out an alternative fuel (biodiesel) from non-edible oil seeds. This paper deals with the trans esterification of custard apple seed oil by means of

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

methanol in presence of Potassium hydroxide catalyst at less than 65˚C.The viscosity of biodiesel produced from custard apple seed oil is nearer to that of the commercially available diesel. The custard apple seed oil is characterized by GC (gas chromatography) analysis and the important properties of biodiesel such as density, flash point, cloud point, pour point and kinematic viscosity, ash content, carbon residue are found out and compared with that of ASTM-biodiesel standards and commercially available diesel. The study encourages the production of biodiesel from Custard Apple seed (Annona squamosa) Oil and value addition of custard apple fruit.

Mustafa Ozcanli and Hasan Serin**-** Explained Due to the concern on the accessibility of recoverable fossil fuel reserves and their environmental problem creates a considerable attention has been given to biodiesel production as an alternative to petro diesel. This study examines fuel properties and performance characteristics of diesel engine fueled with three different biodiesel mixtures (soybean, canola and palm oils) and their blends with diesel fuel according to ASTM and EN standards. Viscosity and pour point of soybean-canola-palm (S-C-P) biodiesel blends were found out of standard ranges. Blend with soybean (25%) - canola (25%) - palm (25%) - diesel (25%) reached acceptable fuel properties (kinematic viscosity4.3mm2/s, cetane number 53, pour point -4°C). It performed 3% power loss with 8% higher specific fuel consumption. While CO and CO_2 emissions were reduced, NOx emissions were increased with increasing biodieselcontents in blends. As a result, dieselusage was minimized to 25% by blending it with S-C-P biodiesels' together.

III.METHODOLOGY

A .BAEL SEEDS:

Fig.1 Bael seeds

Bael seed is also known as *aeglemarmelos*, commonly growing trees in India. The oil content from Bael seed is in range of 25-30% of seed weight which is identified as non-edible oil.Bael seeds were collected and the kernels were separatedaccording to their condition. Then the damaged seeds are removed and seeds in good conditions cleaned, de-shelled and dried at temperature 80ºc for 1-2 hours. Using expeller, oil (25%) was extracted from seeds and filtered by filter paper.

B .TRANSESTERIFICATION:

*1 .Acid treatment:*Fatty acid methyl ester (FAME) of oil was prepared by acid and alkali catalyzed pretreatment was conducted at 55^0C with methanol (CH_3OH) oil at a molar ratio of 6:1 and acid (conc.H_2SO_4) of 5 ml per liter of oil was stirred at a constant speed of 700 rpm. After 1 h, contents were poured in a separating funnel for separating lower layer (triglyceride) and remaining portion was trans esterified using base catalyst.

2 .Base treatment: In a beaker, potassium hydroxide (KOH, 13 g for 1L) and methanol (CH_3OH, 200 ml per L) were thoroughly mixed until it is properly dissolved.The solution obtained was mixed with non-edible oil was heated to 60^0C and continuously stirred at a constant speed of 700 rpm for 60 min.The solution is poured down to separating beaker and is allowed to settle for 5 hours.Glycerin settles at the bottom and methyl ester floats at the top (coarse biodiesel).Methyl ester is separated, heated above 100^0C and maintained for 10-15 min to remove untreated methanol.

*3 .Water washing***:**Washing of Biodiesel is necessary to remove the soluble components using hot water. Hot water is sprayed on top of the biodiesel. Then it is allowed to settle down and waste water is drained off. The washing is carried out 3-4 times to get pure biodiesel. The impurities are cleaned up by washing with 350 ml of water for 1000 ml of coarse biodiesel. Cleaned biodiesel is methyl ester of non-edible oil.

*4 .Dehydration process***:-** Drying can also be accomplished (more aggressively) by heating the now-washed fuel to approximately 100°C in an open container until there is no more steam rising from the fuel, which should be a clear. This heating

PROPERTY	B-10	B-20	B-30	DIESEL
Density(Kg/m^3)	869	870	871	856
Calorific value(KJ/Kg)	42565.38	41850	39722.03	43400
Kinematic viscosity $\times 10^{-6}$(m^2/s)	5.03	6.19	6.93	2.51
Flash point °C	73	76	86	72
Fire point °C	77	81	89	77

process will also drive off any traces of remaining alcohol as well. Once allowed to cool to room temperatures, it can be pumped directly into vehicles, or into storage containers.

IV. EXPERIMENTAL WORK

Experiment is carried out in diesel engine with the following engine specifications as shown in table 1

TABLE1
ENGINE SPECIFICATIONS

Model	AV1
Make	KIRLOSKAR
Type	Single cylinder, four stroke, water cooled
Bore	80mm
Stroke	110mm
Speed	1500rpm
Rated power	5hp

PROCEDURE:

Experiment is done on conventional engine fuelled with Bael seed blends of 10%, 20%, 30% and diesel from no load to full load and the following readings are noted,

a. Engine speed
b. Time taken for 5cc of fuel consumption.
c. Voltmeter and ammeter readings.
d. Temperatures at different locations.
e. exhaust emissions such as CO_2,CO,HC and NOx by using exhaust gas analyzer.

TABLE2
PROPERTIES OF BAEL SEED OIL

V. RESULTS AND DISCUSSIONS

1. Brake specific fuel consumption:

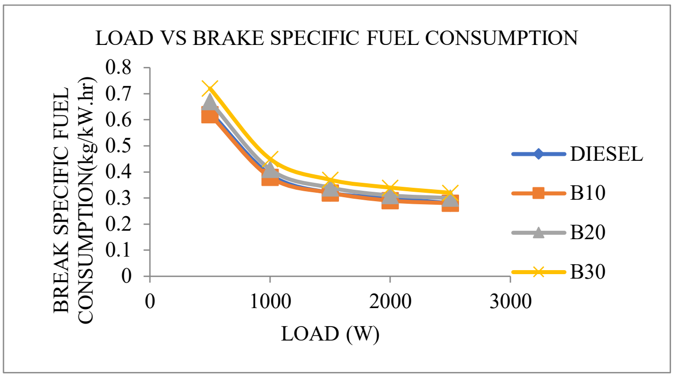

Fig: 2 Load vs Brake Specific Fuel Consumption

The result for the variations in the brake specific fuel consumption (BSFC) with load is presented in the above Fig.2. The BSFC value at full load is 0.30kg/kW-hr for diesel (standard engine). It can be observed that the engine fuelled with bael seed oil blends B10, B20 and B30 gives BSFC of 0.29 kg/kW-hr, 0.31 kg/kW-hr , 0.34 kg/kW-hr respectively at full load. The BSFC of bael seed oil blends are less compared to diesel fuel. The bael seed blend B10 has less BSFC compared to other bael seed blends as well as diesel fuel. Because of less BSFC the Brake thermal efficiency is increased.

2.Brake thermal efficiency:

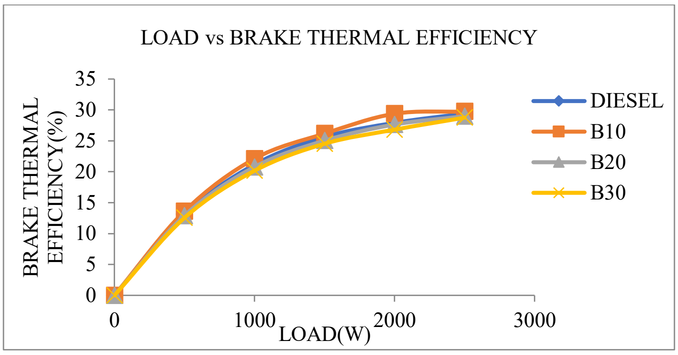

Fig: 3 Load vs. Brake Thermal Efficiency

The variation of brake thermal efficiency with respect to load for Bael seed oil blends and diesel are shown in a above Fig.3 Brake thermal efficiency of the engine by different blends B10, B20, B30and Diesel is observed as 29.38%, 27.64%, 26.81% and 27.91% at full load respectively. The values of Brake thermal efficiency of blends are higher compared to diesel fuel (standard engine). Particularly the B10 fuel gives more brake thermal efficiency than the other fuels. As the engine produces higher power output, the frictional losses are changed and hence change in the brake thermal efficiency.

3.Mechanical efficiency:

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

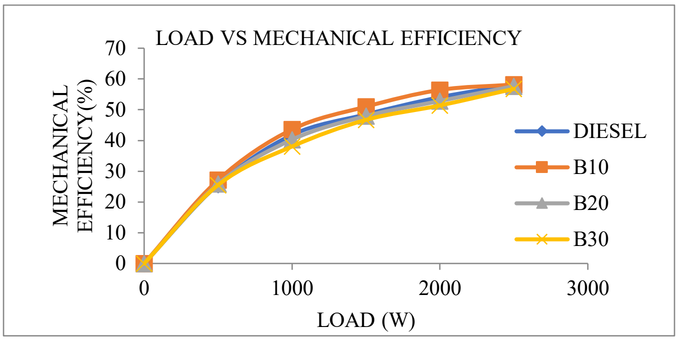

Fig: 4 Load vs Mechanical Efficiency

From the above Fig.4, the variation of mechanical efficiency with respect to load can be observed. Mechanical efficiency of the engine by different blends B10, B20 and B30 and Diesel is observed as 56.44%, 52.85%, and 51.39% and 54.07% respectively. The values of mechanical efficiency of blends are higher compared to diesel fuel (standard engine). Particularly the B10 fuel gives more mechanical efficiency than the other fuels. As the engine produces higher power output, the frictional losses are changed and hence change in the mechanical efficiency [16].

4. Exhaust emissions of nitrogen oxides:

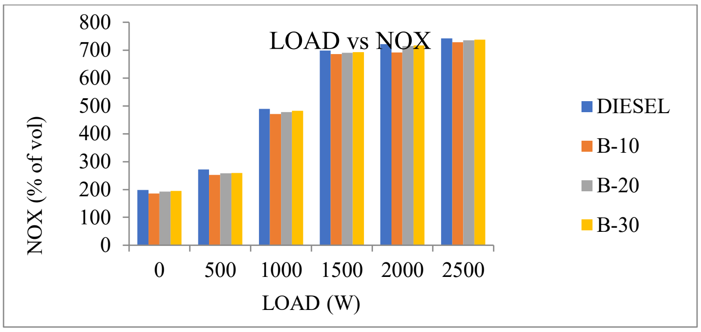

Fig: 5 Load vs NO_X

Fig.5 represents the variation of NO_x emissions with different loads of Bael seed oil. NO_xformation is mainly depends upon gas temperature inside cylinder and the availability of oxygen. NOx for all blends increases with increasing load, it may be because of increasing temperature of combustion. NO_x values at full load as follows, Diesel-721, B10-692, B20-715 and B30-717.Therefore B10 gives lower NO_x emissions compared to other blends of Bael seed oil bio-diesel [17].

5. Exhaust emissions of hydrocarbon emissions:

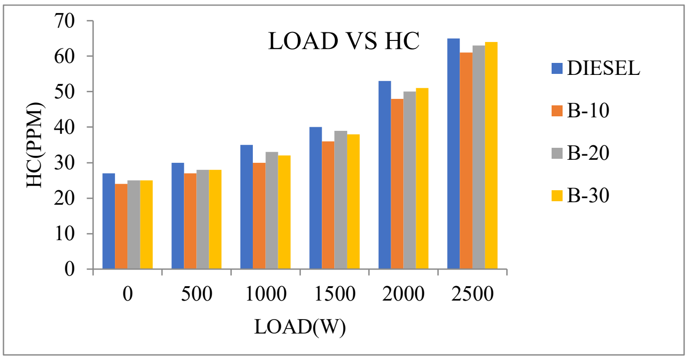

Fig: 6 Load vs HC

Fig.6 represents the variation of HC emissions with different loads of Bael seed oil. There is increase in HCemissions with the load increases. From the above graph it is cleared that B10 has the lowest HC emissions at all loads compared to other blends of Bael seed bio-diesel this may due to the availability of oxygen percentage in fuel may lead to complete combustion cause reduce HC emissions in exhaust. The HC values at full load as follows, Diesel-53, B10-48, B20-50, B30-51.Therefore B10 gives lower HC emissions compared to other blends of Bael seed oil bio-diesel [18].

6. Exhaust gas emissions of carbon monoxide:

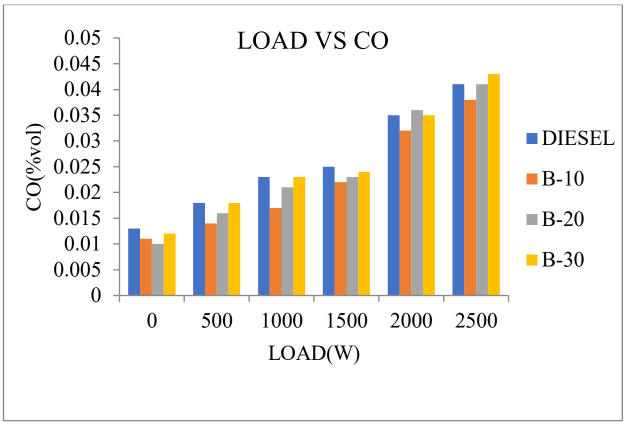

Fig: 7 Load vs CO

Fig.7 represents the variation of CO emissions with different loads of Bael seed oil.CO emissions increases with an increase in blend percentage due to presence of oxygen in bio-diesel and lower combustion temperature. It is observed from graph that B10 gives lower CO emissions compared toall the blends of Bael seed oil. The CO values at 80% of load as follows, Diesel-0.035, B10-0.032, B20-0.036 and B30-0.035. Therefore B10 gives lower CO emissions compared to other blends of Bael seed oil bio-diesel.

7. Exhaust gas emissions of carbon dioxide:

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

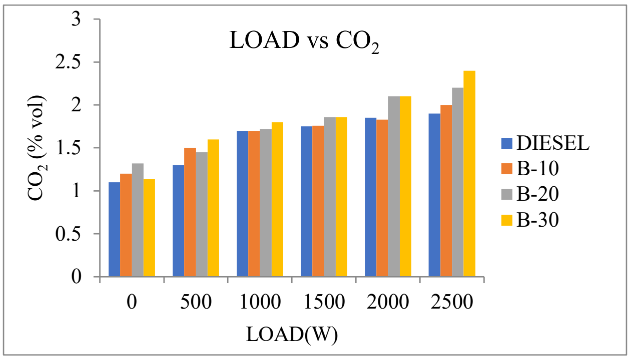

Fig: 8 Load vs CO_2

Fig.8 represents the variation of CO_2 emissions with different loads of Bael seed oil.CO_2 emissions are increased linearly with the load, may due to complete combustion at higher loads [19]. There is no significant difference for CO_2 emissions for all fuel Bael seed fuel blends. However, CO_2 emitted from bio-diesel is entirely different with CO_2 emitted from fossil fuel. Since CO_2 emitted by bio-diesel can be utilized for respiration in plants and it recycled. Also, this CO_2 is decomposed in atmosphere with in short period of time, but CO_2 emitted by fossil fuel is retained over several hundred years and can cause ozone layer depletion. The CO_2 values at 80% of load as follows, Diesel-1.85, B10-1.83, B20-2.1 and B30-2.1. Therefore B10 gives lower CO_2 emissions compared to other blends of Bael seed oil bio-diesel [20].

VI. CONCLUSION

- ❖ Brake thermal efficiency is 4.7% higher for the bael seed blend -10(B-10) at full load compared to diesel and other blends.
- ❖ Brake specific fuel consumption is reduced 6.5% for the blend -10(B-10) compared to diesel and other blends.
- ❖ The bael seed blend-10(B-10) has lower HC emissions compared to diesel and other blends.
- ❖ NO_X emissions are lower for the blend-10(B-10) compared to diesel and other blends.
- ❖ CO_2 levels are lower for the blend -10(B-10) as compared to diesel and other blends.

The performance of the engine was evaluated in terms of brake specific fuel consumption, brake thermal efficiency, indicated thermal efficiency and mechanical efficiency. The emission characteristics of the engine were studied in terms concentration ofCO, CO_2, HC and NO_X. The results obtained for Bael seed oil and their blends with diesel were compared with the results of diesel.

VII. SCOPE OF FUTURE WORK

The present work can be extended by varying the blend percentage and the engine can be tested for better performance with various alternative fuels also.

VIII. ACKNOWLEDGMENT

The author would like to thank the management and HOD of mechanical engineering department, JNTUACEA, for their support and assistance.

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

REFERENCES

[1] A Dhanamurugan and R Subramanian, "Application of bio-diesel performance and emissions characteristics with petro diesel, *JSIR 72 (11) 690-694"*.

[2] A Dhanamurugan and R Subramanian, "effect of timing on performance, combustion and emission characteristics of Bael (Aegle marmelos) bio-diesel and its blend on a single cylinder direct injection diesel engine, *JSIR 74 (4) 232-235"*.

[3] Mustafa Ozcanli and Hasan Serin, "performance characteristics of diesel engine fueled with three different biodiesel mixtures (soybean, canola and palm oils) and their blends with diesel fuel according to *ASTM and EN standards*".

[4] Dilip kumar Bora, "performance of single cylinder diesel engine with karabi seed biodiesel, *JSIR 68(11) 960-963*".

[5] Dilip kumar Bora, "Use of nahar oil methyl esters (NOME) in C.I engines, *JSIR 68(11) 960-963, 2007*".

[6] Penugonda Suresh Babu, "Significance of biodiesel use as I.C. Engines Fuels, *IJAERS E-ISSN 2249-8974*".

[7] D.F. Melvin Jose, R. Edwin Raj , B. Durga Prasad , Z. Robert Kennedy , A. Mohammed Ibrahim (2011) "*A multi-variant approach to optimize process parameters for bio diesel extraction from rubber seed oil Applied Energy", 88 (2011) 2056–2063*.

[8] Kalam MA, Husnawan M, Masjuki HH. Exhaust emission and combustion evaluation of coconut oil-powered indirect injection diesel engine. *Renew able Energy 2003; 28:2405–15*.

[9] Subramanian R, Rajendran G, Venkatachalam R, Nedunchezhian, N&Mayilsamy K, "Experimental investigation on performance, emission and combustion analysis of multi cylinder diesel engine using diesel-ethanol-vegitable oil as fuel, *SAE PapNo:2011-26-0009*".

[10] Subramanian R, Rajendran G, Venkatachalam R, Nedunchezhian, N&Mayilsamy K, "Studies on performance and emission characteristics of multi cylinder diesel engine using hydro fuel blends as fuel, *J Sci Ind Res, 70 (2011) 539-543"*.

[11] Yusuf Ali, Milford A. Hanna. In cylinder pressure characteristics of D.I. diesel engines on bio diesel. *SAE Paper 971683; 1997(9)*.

[12]Gopalakrishnan KV, Rao PS. Use of non-edible vegetable oils as alternate fuels in diesel engines. DNEs Project Report. *I.C.E. lab, IIT, Madras-36; 1996(10)*

[13]K.Srinivasa Reddy "In the present investigation tobacco-diesel blend was used as an alternate fuel for diesel engine, *JSIR 68(11) 960-963*".

[14]John B.Heywood, "Internal Combustion Engine Fundamentals", *McGraw-Hill Series in Mechanical Engineering.*

[15]V.Ganesan, "Internal Combustion Engines", *Tata McGraw-Hill Publishing Company Limited.*

[16] Kotla, P. (2024). Bridging Legacy Systems with Modern Automation: UiPath RPA in Financial Institutions. Available at SSRN 5346246.

[17] Kotla, P. (2022). Accelerating Shared Services with UiPath: Lessons from Early Automation Centres of Excellence (CoEs). Available at SSRN 5379367.

[18] Kotla, P. (2023). Combining Document Understanding and Action Center in UiPath for Human-In-The-Loop Claims Processing.

[19] Chawla, N., Kotla, P., Venna, S. R., & Patel, M. B. (2025, August). Comprehensive Analysis of Robotic Process Automation for Software Project Management. In 2025 2nd International Conference on Intelligent Algorithms for Computational Intelligence Systems (IACIS) (pp. 1-4). IEEE.

[20] Kotla, P. (2024). Task Mining as a Catalyst for Automation: Realizing Process Improvement with Uipath in Healthcare Scheduling.