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DFA Analysis Revolutionizes FSAE Steering, Enhancing Efficiency in Automotive Design

Analisis DFA Merevolusi Kemudi FSAE, Meningkatkan Efisiensi dalam Desain Otomotif

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Abstract

In the dynamic realm of automotive engineering, particularly in Formula Society of Automotive Engineers (FSAE) racing, where vehicle assessment is based on efficiency, motor power, chassis dynamics, and steering, there exists a notable focus on steering system design. This research delves into the conceptualization and component development aimed at aiding automotive mechanics in crafting steering systems for FSAE race cars. Employing Solid Edge 2021 software, the study utilizes the Design of Assembly (DFA) analysis method to streamline the mechanical process. Through DFA analysis, the study assesses various Technical Attributes (TAs) of the steering system, revealing values ranging from 0.548 to 1.765. The ideal steering system ensures that the desired steering input by the driver aligns with the output motion of the vehicle, known as the Ackerman condition. Steering gear mechanisms translate rotational motion into translation and adjust the effort applied to the steering linkage. The study's findings contribute to the advancement of steering system design in FSAE vehicles, emphasizing ergonomic considerations and the utilization of advanced software tools like Catia and Solid Edge 2021 for enhanced performance and safety.

Highlight:

1. FSAE steering: DFA analysis enhances design efficiency for racing vehicles.
2. Software aid: Solid Edge 2021 streamlines FSAE steering system development.
3. Ergonomic focus: Design prioritizes driver comfort and vehicle performance optimization.

Keyword: FSAE vehicles, Steering system design, DFA analysis, Solid Edge 2021, Ergonomics

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PENDAHULUAN

FSAE (Formula *Society of Automotive Engineers*) awal mulanya diadakan oleh *American Society of Automotive Engineers* untuk para mahasiswa dalam bidang perancangan dan pembuatan mobil balap yang penilaiannya berdasarkan pada efisiensi, tenaga motor dan lain sebagainya.[1] Adapun sistem kemudi adalah sistem yang berfungsi mengatur arah dan membelokkan kendaraan dengan cara membelokkan roda depan. Cara kerjanya bila *steering wheel* (roda kemudi) diputar.[2] Pada sistem kemudibiasanya juga terjadi suatu permasalahan yang mana salah satunya pada sistem prancangan yang buruk, yang mangakibatkan sudut belok yang tidak sesuai kondisi (dimensi) kendaraan.[3] Fungsi0sistem0kemudi0adalah0untuk0mengatur arah0kendaraan0dengan0cara0membelokan0roda0enaga0putarnya0ke0*steering0gear* (roda0gigi0kemudi). *Steering0gear* 0memperbesar0tenaga0putar0ini0sehingga0dihasilkan0momen0puntir0yang0lebih0besar0untuk0diteruskan0ke0steering0lingkage0akan0meneruskan0gerakan0steering0gear0ke0roda-roda0depan.[4] Desain dari0sistem0kemudi ini0menentukan0tingkat0keamanan dan0kenyamanan saat0berkendara.0Karena pada0saat ini0banyak0mobil-mobil0modern yang0mempunyai0ban berukuran0lebar dengan0tekanan0yang rendah, sehingga0mengakibatkan0bidang ban0dengan permukaan0jalan semakin0besar.[5] Adapun0tinjauan dari0segi kenyamanan0dalam mengemudikan0kendaraan, maka0teknologi sistem0kemudipada saat0ini0terus berkembang. Mulai0dari sistem0kemudi manual0sederhana yang0hanya menggunakan0roda gigi0yang sederhana0untuk mengubah0arah gaya0untuk membelokkan0ban, dengan0berkembang0sistem.[6] Kelebihan sistem0kemudi *power0steering* pada0saat ini0dalam keadaan0stationer dan0berjalan lambat0putaran kemudi ringan. Pengaturan0*steering effort*0berdasarkan kecepatan0kendaraan. Ketika0kendaraan melewati0jalan yang0rusak pada0kecepatan sedang0dan cepat, meskipun0ada rintangan0besar dari0permukaan jalan,0namun tidak0akan mempengaruhi0arah control0kemudi, karena0tekanan ouput0hydraulic untuk0*steering0effort* menjadi0tinggi sama0seperti *power0steering* konvensional. Kekurangan0sistem kemudi0*power steering*0pada saat0ini dalam0system ini, pengontrolan0perubahan beban0lebih sulit0dilakukan.[7]

METODE

Sistem0kemudi yang0ideal adalah0dimana input0gerakan belok0yang diinginkan0oleh pengemudi0sesuai dengan0output gerak0belok yang0dihasilkan oleh0kendaraan, kondisi0tersebut dinamakan0kondisi *Ackerman*. Pada0*steering gear0*mengubah arah0gerak rotasi0menjadi translasi0serta menyesuaikan0usaha yang0diberikan pada0roda kemudi0ke *steering0linkage*. Gerakan0*steering linkage0*yang terdiri0dari gerakan *tie0rod* kemudian0menggerakkan *steering0knuckle* sehingga0roda dapat0ikut0berbelok.

HASIL DAN PEMBAHASAN

Design Steering System Pada *Formula Society Of Automotive Engineers* (FSAE) akan dijelaskan pada diagram alir sebagai berikut:

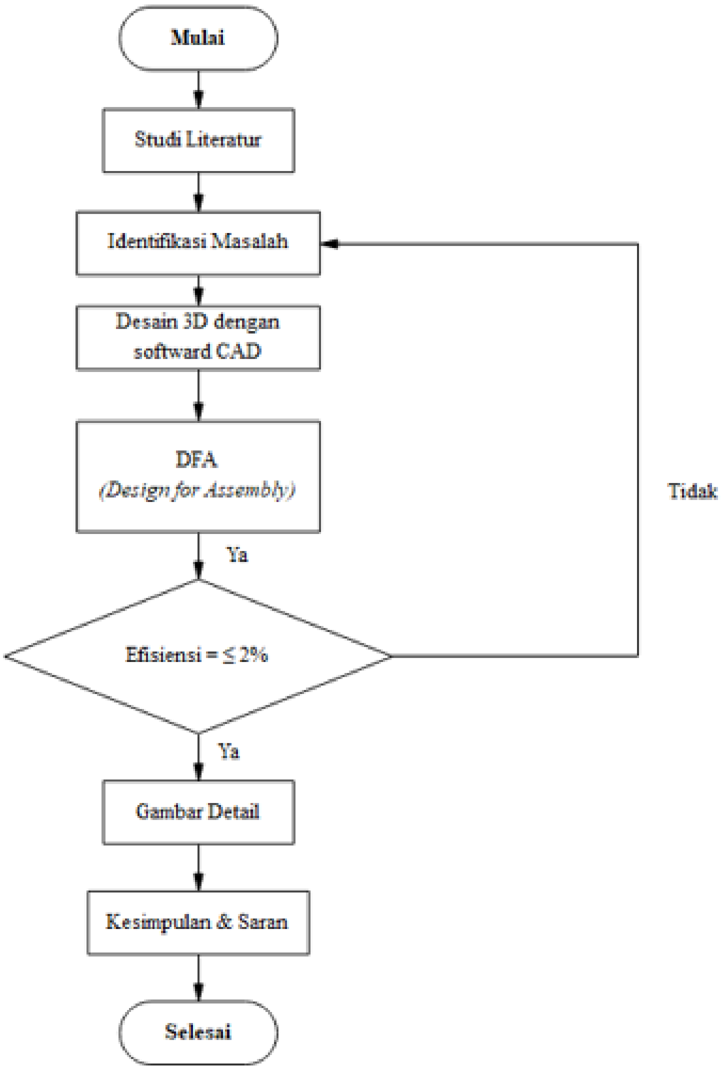

Figure 1. *Diagram Alir Penelitian*

Design for assembly DFA pada perakitan (assembly) ini memegang peranan yang sangat penting pada waktu proses *manufaktur* suatu produk. Misalnya, jika kita tidak merancang dengan baik maka dalam perakitan akan mendapatkan kesulitan. Sistem Kemudi Kendaraan yang berbelok menggunakan sistem kemudi untuk mengarahkan kendaraan menuju tempat yang akan dituju. Analisa Komponen Kemudi Mobil Analisa pembawaan (*handling*) serta penyiapan (*insertion*) akan dilakukan pada beberapa komponen sub-perakitan kemudi mobil.

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Item Number	File Name (no extension)	Quantity
1	CHASSIS NEW_Default_As Machined_	1
2	suspension arm_Default_As Machined_	4
3	suspension upper arm_Default_As Machined_	4
4	Shock connection_Default_As Machined_	4
5	suspension joint	8
6	front left wheel hub	2
7	front right wheel hub	2
8	rim	4
9	tires	4
10	Shock absorber	4
11	head rest	1
12	BASE PLATE	1
13	Seat_Predeterminado	1
14	Power Steering System	1
15	SHAFT 2	1
16	SHAFT 1	2
17	stearing wheel	1
18	01-06	2
19	01-04	2
20	01-02	2
21	01-03	2
22	01-01	2

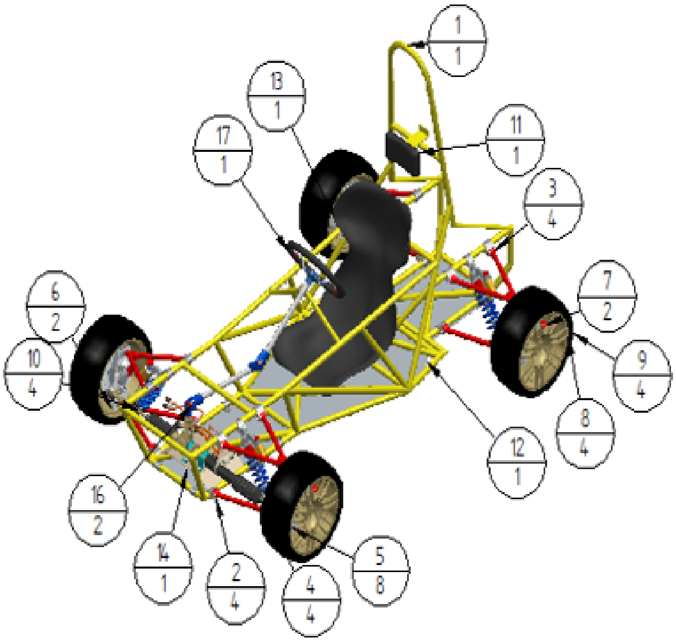

Figure 2.

Gambar 4.2 Tabel perhitungan waktu *handling*

Key: ONE HAND

Part can be grasped and manipulation by one hand without the aid of grasping tools

		Part are easy to grasp and manipulalate					Part present handling difficulties(1)				
		Thickness >2mm			Thckness < 2mm		Thickness >2mm			Thckness < 2mm	
		Size< 15 mm	6mm ≤ size ≤ 15mm	Size < 6 mm	Size > 6 mm	Size ≤ 6 mm	Size <15 mm	6mm ≤ size ≤ 15mm	Size < 6 mm	Size > 6 mm	Size ≤ 6 mm
		0	1	2	3	4	5	6	7	8	9
(α+β) < 360°	0	1.13	1.43	1.88	1.69	2.18	1.84	2.17	2.65	2.45	2.98
360° < (α+β) < 540°	1	1.5	1.8	2.25	2.06	2.55	2.25	2.57	3.06	3	3.38
540° < (α+β) < 720°	2	1.8	2.1	2.55	2.36	2.85	2.57	2.9	3.38	3.18	3.7
(α+β) = 720°	3	1.95	2.25	2.7	2.51	3	2.73	3.06	3.55	3.34	4

Figure 3.

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ONE HAND WITH GRASPING AIDS

Part can be grasped and manipulation by one hand but only with the use of grasping tools		Parts need tweezers for grasping and manipulation; can be manipulated without optical magnification; easy to grasp and manipulate; Thickness > 0,25mm	Thickness ≤ 0,25mm	Parts present handling difficulties (1); Thickness > 0,25mm	Thickness ≤ 0,25mm	Parts require optical magnification for manipulation; easy to grasp and manipulate; Thickness > 0,25mm	Thickness ≤ 0,25mm	Parts present handling difficulties (1); Thickness > 0,25mm	Thickness ≤ 0,25mm	Parts need standard tools other than tweezers	Parts need special tools for grasping and manipulation
		0	1	2	3	4	5	6	7	8	9
α ≤ 180°, 0° ≤ β ≤ 180°	4	3.6	6.85	4.35	7.6	5.6	8.35	6.35	8.6	7	7
α ≤ 180°, β = 360°	5	4	7.25	4.75	8	6	8.75	6.75	9	8	8
α = 360°, α ≤ β ≤ 180°	6	4.8	8.05	5.55	8.8	6.8	9.55	7.55	9.8	8	9
α = 360°, β = 360°	7	5.1	8.35	5.85	9.1	7.1	9.55	7.85	10.1	9	10

Figure 4.

TWO HANDS FOR MANIPULATION

		Parts present no additional handling difficulties; α ≤ 180°; Size< 15 mm	6mm ≤ size ≤ 15mm	Size < 6 mm	α = 360°; Size > 6 mm	Size ≤ 6 mm	Parts present additional handling difficulties (e.g sticky, delicate, slippery, etc.) (1); α ≤ 180°; Size< 15 mm	6mm ≤ size ≤ 15mm	Size < 6 mm	α = 360°; Size > 6 mm	Size ≤ 6 mm
		0	1	2	3	4	5	6	7	8	9
Parts severely nest or tangle or flexible but can be grasped and lifted by one hand (with the use of grasping tools if necessary((2)	8	4.1	4.5	5.1	5.6	6.75	5	5.25	5.85	6.35	7

Figure 5.

Gambar 4.3 Tabel perhitungan waktu *Insertion*

Key : PART ADDED BUT NOT SECURED

Addition of any part (1) where neither the part itself nor any other part is finally secured immediately		After assembly no holding down required to maintain orientation and location (3); Easy to align and position during assembly (4); No resistance to insertion	Resistance to Insertion (5)	Not easy to align or position during assembly; No resistance to insertion	Resistance to Insertion (5)	Holding down required during subsequent processes to maintain orientation at location (3); Easy to align and position during assembly (4); No resistance to insertion	Resistance to Insertion (5)	Not easy to align or position during assembly; No resistance to insertion	Resistance to Insertion (5)
		0	1	2	3	6	7	8	9
Part and associated tool (including hands) can easily reach the desired location	0	1.5	2.5	2.5	3.5	5.5	6.5	6.5	7.5
Part and associated tool (including hands) cannot easily reach the desired location; Due to obstructed access or restricted vision (2)	1	4	5	5	6	8	9	9	10
Part and associated tool (including hands) cannot easily reach the desired location; Due to obstructed access and restricted vision (2)	2	5.5	6.5	6.5	7.5	9.5	10.5	10.5	11.5

Figure 6.

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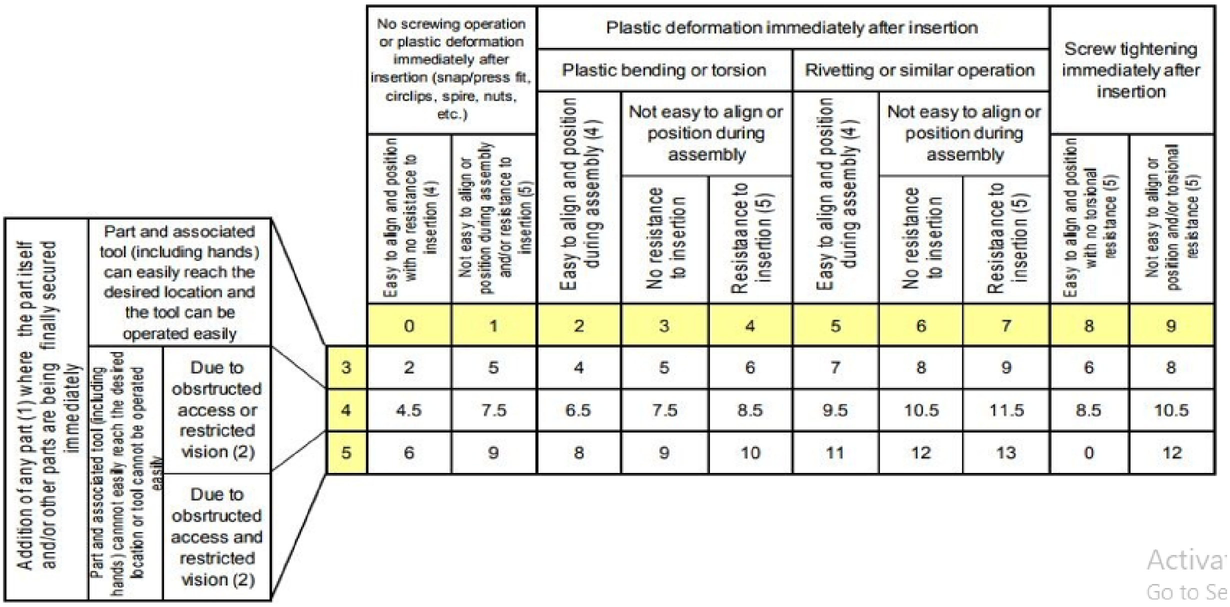

Figure 7.

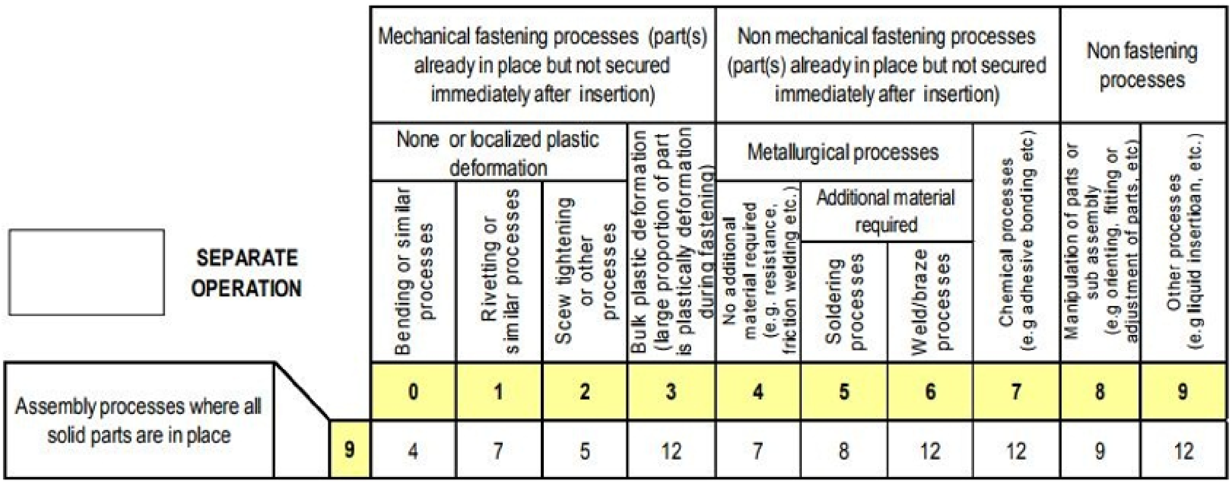

Figure 8.

Sebagai akhir dari proses penerapan DFA adalah membuat desain baru yang efektif dengan indek efisiensi yang lebih besar.

Hasil analisa dan perhitungan pada tiap komponen kemudi mobil dimasukkan pada table berikut :

Tabel 4.5 *Desain for assembly* Pada Kemudi Mobil

1	2	3	4	5	6	7	8	9	10
Part ID no	Name of assembly	Number Of Time The Operation Is Carried Out Conse cutivity	ManualHa ndling code	Manual Handling Time Per Part	Manual Insertion Code	Manual Insertion Time Per Part	Operation time,secon d = (5) +(7))	Operation cost (Rp) x (8)	Figures For Estimation Of Theoritical Minimum Part
1	Kemudi Mobil	1	1,0	1,5	0,0	1,5	3	10	
2	Poros Utama Kemudi	1	0,1	1,43	3,9	8,0	9,43		

3	Batang Kemudi	1	3,0	1,95	0,0	1,5	3,45	
4	Gear Penggerak	1	1,1	1,43	0,0	1,5	2,93	
5	Ring Garpu Penghubung (Slip Sleeve Yoke)	1	8,4	5,8	0,2	2,5	8,3	
6	Garpu Penghubung (Slip Sleeve Yoke) Pada Bagian Atas	1	1,0	1,5	0,0	1,5	3	
7	Baut Salip Penghubung (Krist Joint/Universal Joint)	1	0,1	1,43	3,9	8,0	9,43	
8	Salip Penghubung (Krist Joint/Universal joint) Antara Garpu penghubung (Sleeve Yoke)	1	3,0	1,95	0,0	1,5	3,45	
9	Baut Bagian Garpu penghubung (Sleeve Yoke)	1	1,1	1,43	0,0	1,5	2,93	
10	Garpu Penghubung (Sleeve Yoke) Pada Bagian Bawah	1	8,4	5,8	0,2	2,5	8,3	
11	Baut Garpu penghubung (Sleeve Yoke)	1	1,0	1,5	0,0	1,5	3	
12	Mur Garpu penghubung (Sleeve Yoke)	1	0,1	1,43	3,9	8,0	9,43	
13	Gear Gigi Kemudi	1	3,0	1,95	0,0	1,5	3,45	
14	Valve Body Housing	1	1,1	1,43	0,0	1,5	2,93	
15	Selang Hose Power	1	8,4	5,8	0,2	2,5	8,3	

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	Steering						
16	Baut Solar	1	1,0	1,5	0,0	1,5	3
17	Baut pada bagian valve body housing	1	0,1	1,43	3,9	8,0	9,43
18	Gear Book Steering	1	3,0	1,95	0,0	1,5	3,45
19	Rack	1	1,1	1,43	0,0	1,5	2,93
20	Karet Seal pada bagian gear book	1	8,4	5,8	0,2	2,5	8,3
21	Klem pada bagian gear book	1	1,0	1,5	0,0	1,5	3
22	Baut pada bagian klem gear book	1	0,1	1,43	3,9	8,0	9,43
23	Karet Rack Boot Pada Bagian luar Rack End	1	3,0	1,95	0,0	1,5	3,45
24	Klem pada bagian selang hose power steering	1	1,1	1,43	0,0	1,5	2,93
25	Karet Siel bagian klem selang hose power steering	1	8,4	5,8	0,2	2,5	8,3
26	Rack End/ Long Tie Rod	1	1,0	1,5	0,0	1,5	3
27	Tie Rod End	1	0,1	1,43	3,9	8,0	9,43
28	Fornt Axle	1	3,0	1,95	0,0	1,5	3,45
29	Baut pada bagian fornt axle	1	1,1	1,43	0,0	1,5	2,93
30	Mur pada bagian fornt axle	1	8,4	5,8	0,2	2,5	8,3
31	Steering Knuckle Arm	1	1,0	1,5	0,0	1,5	3
Total	31	165,66					
TM	CM	NM					

Table 1.

Desain efisiensi = 3 x NM/TM

Untuk mengetahui sejauh mana tingkat efisiensi perakitan dari suatu produk assembly dapat dihitung dengan

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rumus :

rumus dari E=NM x ta yang bagian terkecil

$$E= \frac{NM\ x\ TA}{TA} = \frac{31\ x\ 2{,}93}{165{,}66} = \frac{90{,}83}{165{,}66} = 0{,}548$$

Figure 9.

rumus dari E=NM x ta yang bagian tengah

$$E= \frac{NM\ x\ TA}{TM} = \frac{31\ x\ (2{,}93+9{,}43)}{165{,}66} = \frac{31\ x\ 6{,}18}{165{,}66} = \frac{191{,}58}{165{,}66} = 1.156$$

Rumus dari E=NM x ta yang bagian terbesar

Figure 10.

Rumus dari E=NM x ta yang bagian terbesar

$$E= \frac{NM\ x\ TA}{TM} = \frac{31\ x\ 9{,}43}{165{,}66} = \frac{292{,}33}{165{,}66} = 1{,}765$$

Figure 11.

KESIMPULAN

Berdasarkan hasil analisa dan penelitian perancangan sistem kemudi pada FSAE (*Formula Society of Automotive Engineers*) untuk proses kemajuan bagi bangsa Indonesia yang telah dilakukan, Perubahan konsep tentang bagaimana desain kemudi mobil dengan penambahan regulasi *FSAE* yang berfungsi dapat meringankan kinerja kenyamana dalam berkendara, Bagaimana cara membuat desain kemudi mobil *FSAE* dalam segi ergonomi dengan menggunakan aplikasi *catia,* Perubahan sistem kemudi pada tiap kendaraan tidak sama tergantung dari model kendaraan sistem dan masih banyak factor lainya dapat meningkatkan daya beloknya kendaraan, Analisa tentang pengujian ergonomi/geometer cara menyelesaikan permasalahan dalam menguji ergonomi/geometer diajurkan menggunakan aplikasi *catia* atau *Solid Edge 2021.*

References

1. S. Team, E. Jurnal, and K. Teknik, "No Title."
2. P. I. Purboputro, M. A. H., M. A. Saputro, and W. Setiyadi, "Uji Kemampuan Rancangan Sistem Kemudi, Transmisi, dan Pengereman pada Mobil Listrik Prototype 'Ababil'," in Proceedings of the International Conference on Mechanical Engineering, Surabaya, Indonesia, 2018, pp. 118–127.
3. D. T. Mesin, F. Teknik, U. N. Surabaya, J. T. Mesin, F. Teknik, and U. N. Surabaya, "Enggal Putra Pradana Aris Ansori," pp. 5–9.
4. P. Mobil, L. Semut, B. Setyono, and Y. Setiawan, "Rancang Bangun Sistem Transmisi, KEMUDI, DAN," in Proceedings of the International Conference on Automotive Engineering, Jakarta, Indonesia, 2015, pp. 89–96.
5. K. S. Kemudi and A. T. P. Awal, "Perancangan mekanisme uji karakteristik sistem kemudi," pp. 1–5.
6. A. Nasution, "Studi Eksperimental Karakteristik Pembebanan pada Sistem Kemudi Power Steering Mobil Daihatsu Taft Hiline," Surabaya Journal of Automotive Engineering, vol. 3, no. 2, pp. 45–52, 2017.
7. A. H. Sulistya, F. Teknik, and U. S. Dharma, "With Front Wheel Drive By: Antonius Hery Sulistya Mechanical Engineering Study Program Engineering Faculty," 2006.

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