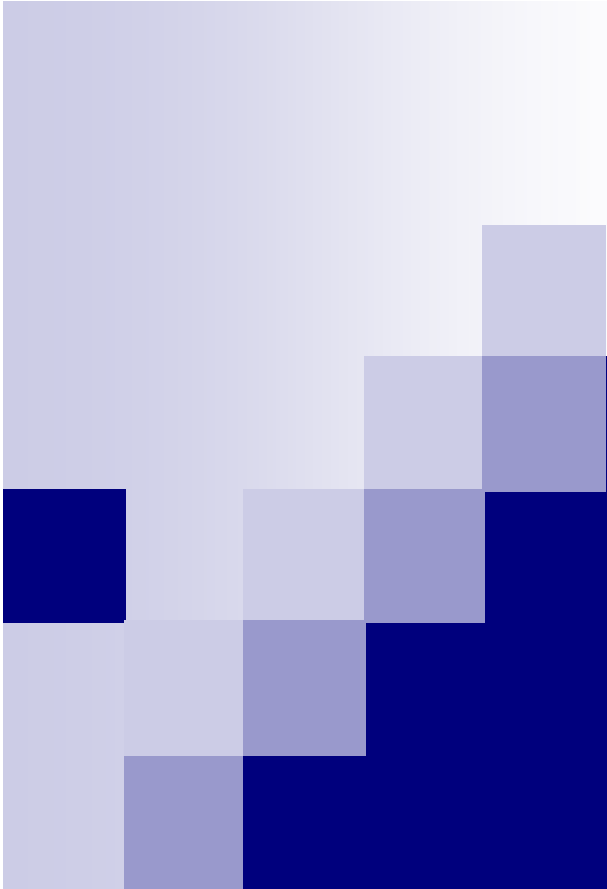




Optimization of Fuel Consumption by Adjusting Gear Ratio

3H (Humanity, Heritage, Hi-tech)

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조원 : 김효식, 임현덕



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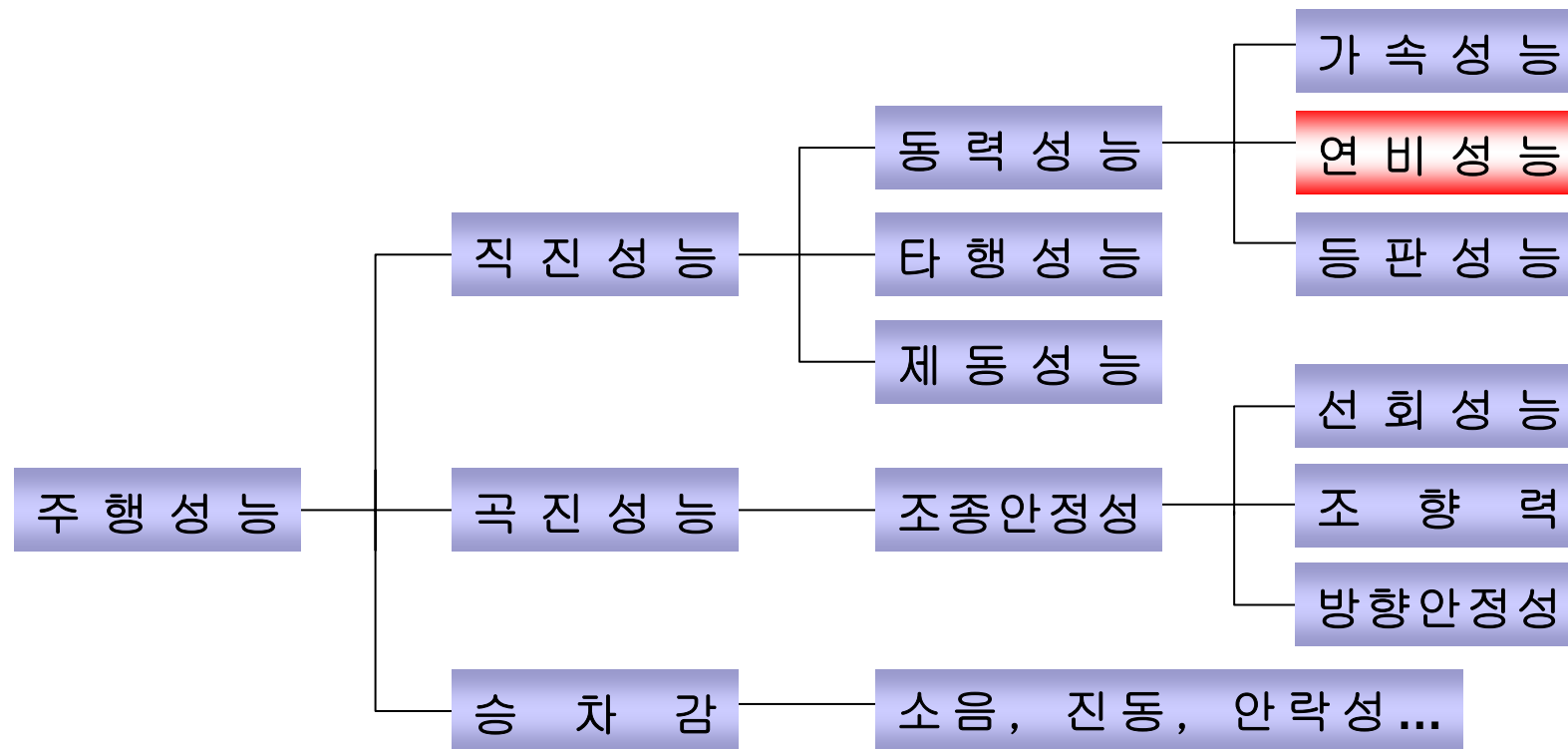
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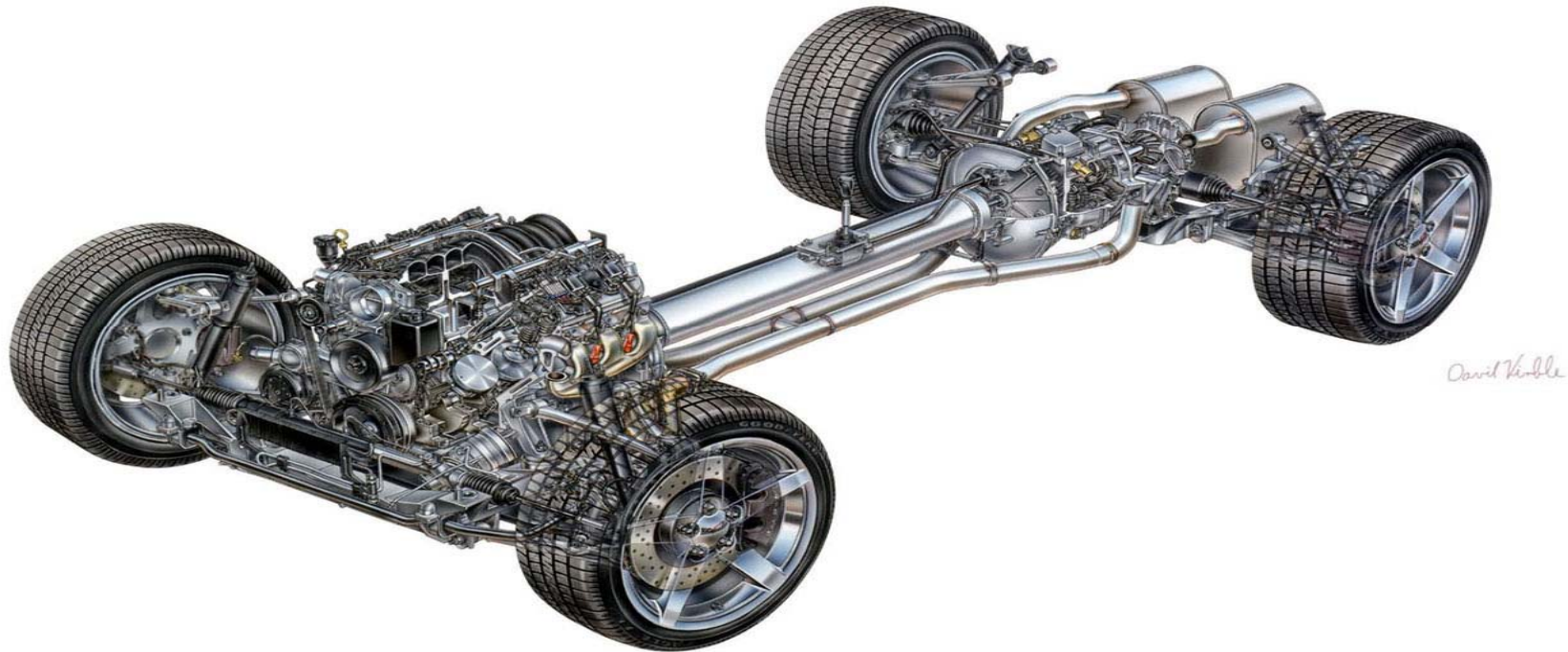
Project/problem Statement

Performance of a vehicle



Project/problem Statement

Redesign of gearbox



Data and Information

Terminology

$B(\text{km/l})$: 단위거리당 연료소비량

$$B = \frac{1000\gamma V}{bNe} \left(\begin{array}{l} \gamma: \text{연료소비중량 (g/cc, b)} \\ b: \text{연료소비율 (g/PS}\cdot\text{h)} \\ Ne: \text{엔진출력(PS)} \end{array} \right)$$

$Ne(\text{PS})$: 주행중 필요한 기관마력

$$Ne = \frac{RV}{270\eta} \left(\begin{array}{l} R: \text{주행저항 (kg)} \\ V: \text{자동차의속도 (km/h)} \\ \eta: \text{기계효율} \end{array} \right)$$

Constraint



Definition of Design Variables

i_m : 각 단에서 기어비 $\Rightarrow x_1$

i_f : 종감속비 $\Rightarrow x_2$

Identification of Criterion

$B(\text{km/l})$: 단위거리당 연료소비량

$$B = \frac{1000\gamma V}{bNe} \left(\begin{array}{l} \gamma: \text{연료소비중량 (g/cc, b)} \\ b: \text{연료소비율 (g/PS}\cdot\text{h)} \\ Ne: \text{엔진출력(PS)} \end{array} \right)$$

$Ne(\text{PS})$: 주행중 필요한 기관마력

$$Ne = \frac{RV}{270\eta} \left(\begin{array}{l} R(\text{kg}): \text{주행저항} \\ V(\text{km/h}): \text{자동차의속도} \\ \eta: \text{기계효율} \end{array} \right)$$

$$B = \frac{270000\gamma\eta}{b \left\{ \mu W + \frac{\rho}{2} \cdot Cd \cdot A \left(\frac{2\pi r 60 n}{1000 x_1 x_2} \right)^2 \right\}}$$

$B(\text{km/l})$: 단위거리당 연료소비량

$b(\text{g/PS}\cdot\text{h})$: 연료소비율

$\rho(\text{kg/m}^3)$: 공기밀도

Cd : 공기저항계수

$A(\text{m}^2)$: 차량 전면 투영면적

n : rpm

$$R = \mu W + \frac{\rho}{2} \cdot Cd \cdot A \left(\frac{2\pi r 60 n}{1000 x_1 x_2} \right)^2$$

(주행저항) = (마찰저항) + (공기저항)

Identification of Constraints

$F(N)$: 구동력

$$g_1: F_{\min} - \frac{R}{x_1 x_2 \eta} \leq 0, \quad g_2: \frac{R}{x_1 x_2 \eta} - F_{\max} \leq 0$$

$V(km/h)$: 속력

$$g_3: V_{\min} - \frac{2\pi 60n}{x_1 x_2 100} \leq 0, \quad g_4: \frac{2\pi 60n}{x_1 x_2 100} - V_{\max} \leq 0$$

부피 제약조건

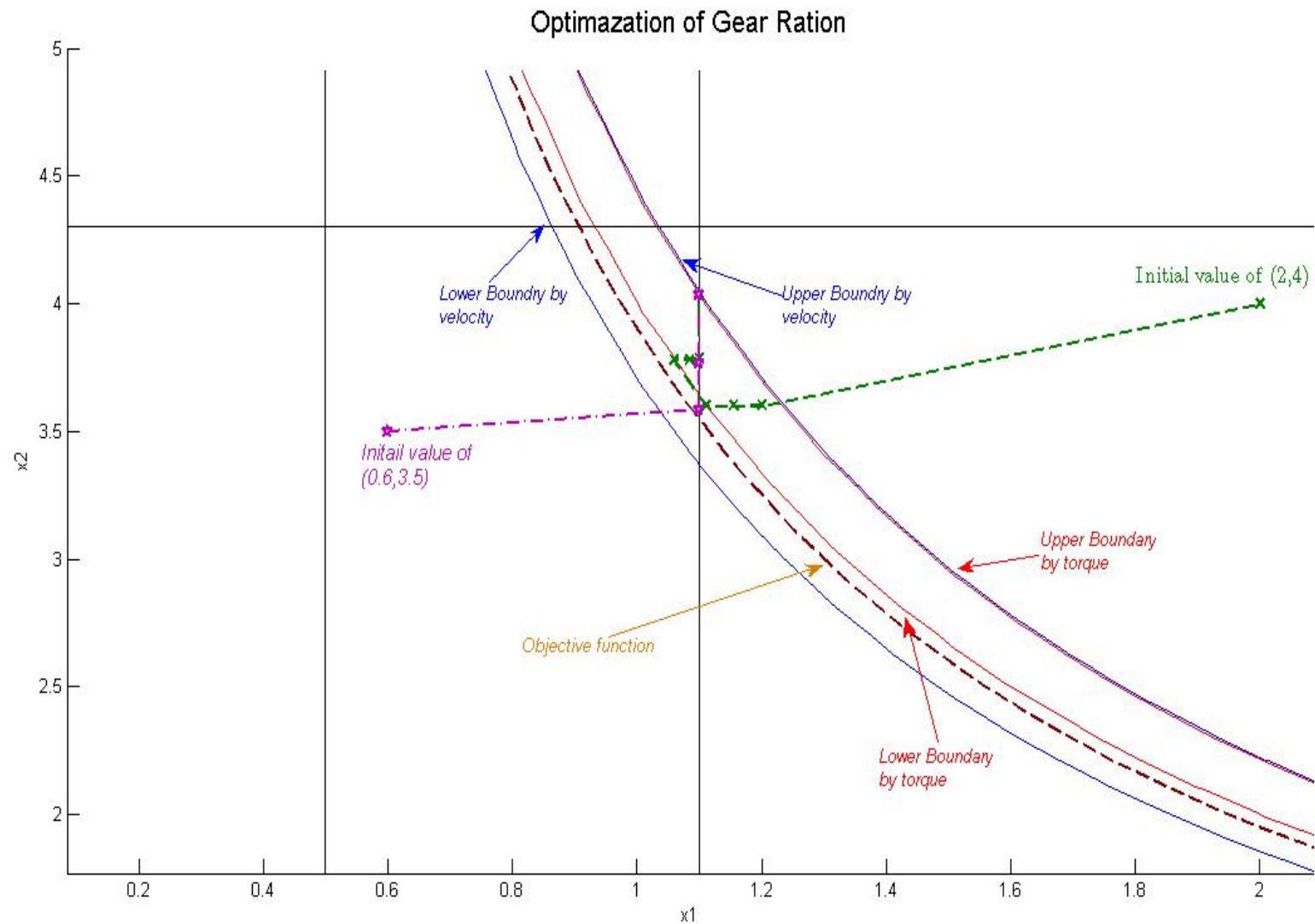
$$g_5: i_{n,\min} - x_1 \leq 0, \quad g_6: x_1 - i_{n,\max} \leq 0$$

$$g_7: i_{F,\min} - x_2 \leq 0, \quad g_8: x_2 - i_{F,\max} \leq 0$$

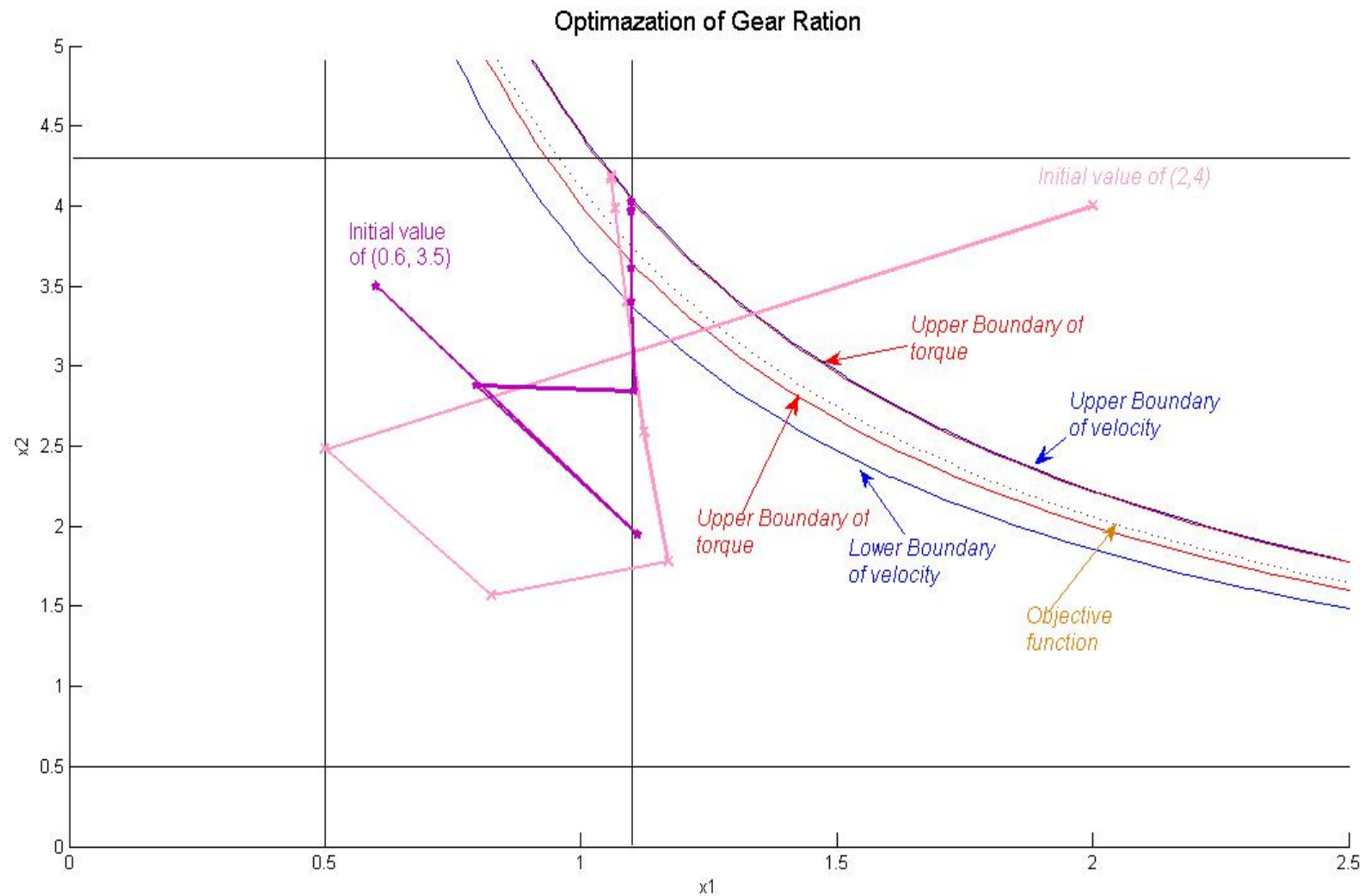
Excel Solver

	A	B	C	D	E	F
1						
2	parameter	symbol	value	unit		
3	Weight of car	w	1140	kg		
4	Friction coefficient of Road	rf	0,02			
5	Density of air	smair	1,293	kg/m ³		
6	specific weight of fuel	swfuel	0,7	g/cc		
7	Dragforce coefficient	airf	0,3			
8	Projected Area of front side of car	area	2	m ²		
9	Revolution of number	N	2000	rpm		
10	Fuel consumption rate	fuelc	250	g/PSh		
11	Radius of Tire	tirerad	0,295	m		
12						
13	design variables					
14	ratio of Transmission gear	x_a	1,1			
15	ratio of Final drive	x_b	4,033874			
16						
17	Objective function					
18	fuel consumption rate	f	12,45589	km/l		
19						
20	constraints			type	value	
21	Max driving Force		-0,12659	<=	0	
22	Min driving Force		-9,87341	<=	0	
23	Max velocity		6,28E-08	<=	0	
24	Min velocity		-200	<=	0	
25	Volume limits of gear		-0,6	<=	0	
26	Volume limits of gear		0	<=	0	
27	Volume limits of Final drive		-3,53387	<=	0	
28	Volume limits of Final drive		-0,26613	<=	0	
29						

Graph by Excel solver



Graph by Matlab fmincon



Current VS Optimum Design

	기존 설계	Excel solver	Fmincon
4단 기어비	1.00	1.10	1.10
종감속기어비	4.12	4.034	4.029
연비 (km/l)	10.002	12.456	12.408



참고자료(*Reference*)

자동차 설계학(이형복 외)

자동차 공학(박재림 외)

Introduction to optimum design