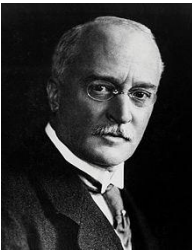


Diesel Cycle model

Dr A. French. September 2017



Rudolf Diesel
(1858-1913)

Input parameters

Temperature T1 of air draw into piston /Celsius	25
Low pressure state p1 /atm	1.00
Volume V1 of uncompressed gas /litres	1820
Volume V2 of compressed gas /litres	79
Volume V3 of compressed gas after isobaric heating /litres	170
Degrees of freedom of molecular motion	3
Molar mass of gas /gmol^-1	28.966

Outputs

Heat input during isobaric heating /kJ	4267
Heat output during isochoric cooling /kJ	710
Total work done by gas on surroundings /kJ	3557
Efficiency (work done / heat input)	0.834

Theoretical efficiency

0.834

$$\eta = 1 - \frac{1}{r^{\gamma-1}} \left(\frac{s' - 1}{\gamma(s-1)} \right)$$

$$r = \frac{V_1}{V_2} \quad s = \frac{V_3}{V_2} \quad \gamma = \frac{c_p}{c_v}$$

Note all temperatures incorporated into calculations
will be converted to Kelvin first
- i.e. add 273 to Celsius number.

Pressure, volume, temperature coordinates of heat cycle

p1	1.0
V1	1820
T1	298
p2	186.0
V2	79.1
T2	2410
p3	186.0
V3	169.7
T3	5168
p4	3.6
V4	1820.0
T4	1063

Single cylinder power output

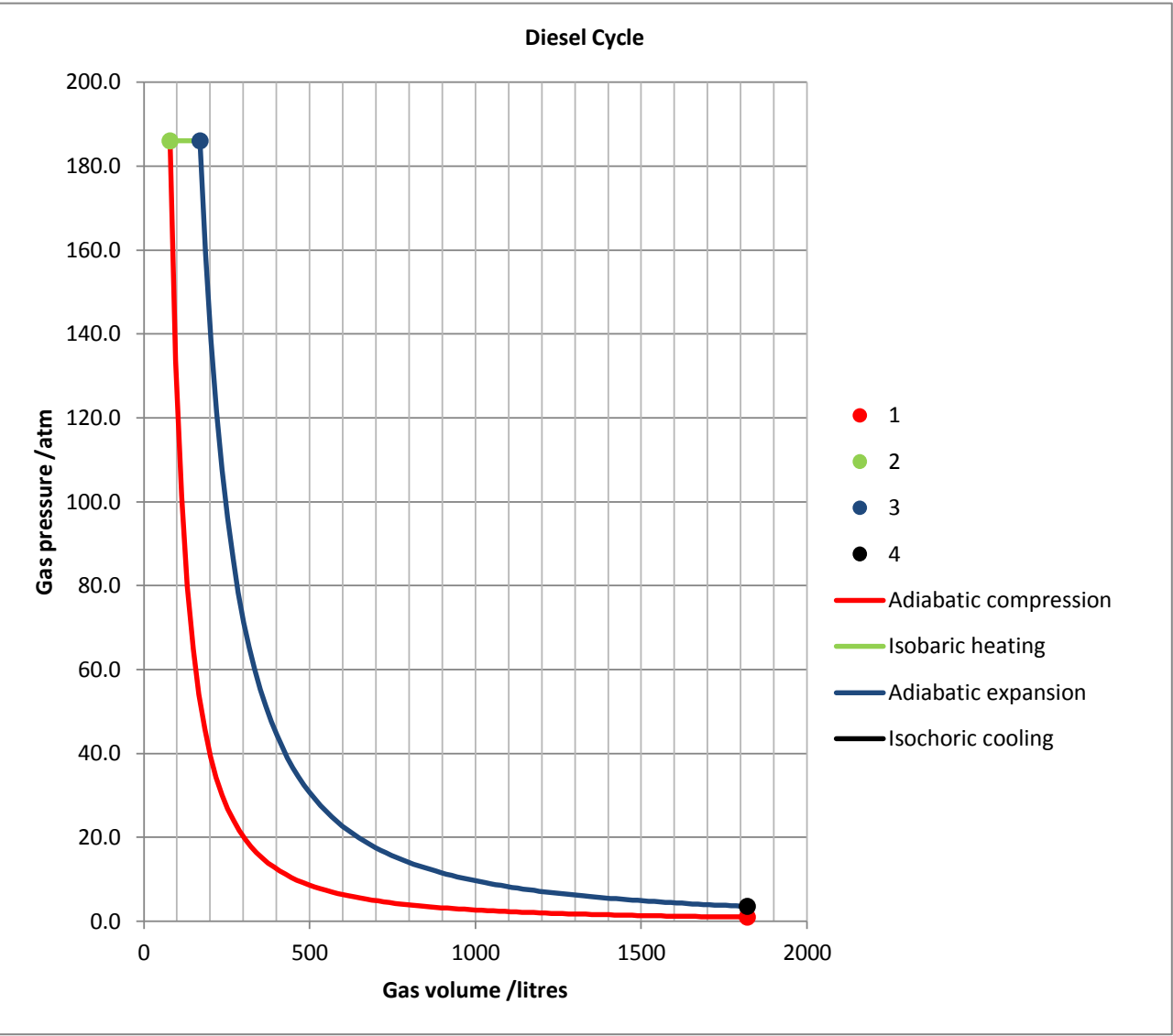
Engine RPM	84
Power output /kW	4,980

Number of cylinders	14
Total power output /kW	69,717

Note all pressures are quoted in atmospheres. 1atm = 101,325 Pa. Volumes in litres, T in K

Number of moles of gas in engine	74
Ratio of specific heats gamma	1.667
Constant volume specific heat capacity /Jkg^-1K^-1	431
Constant pressure specific heat capacity /Jkg^-1K^-1	718

Note real petrol engines have an efficiency of more like 20%, whereas diesels can be
up to 40%. In other words, significant losses!



World's largest container ship in 2014

MV CSCL Globe



MAN B&W 12S90ME-C Mark 9.2 diesel engine. 69,720kW at 84RPM

Assume about 1820 litre
cylinder volume V1

Max compression ratio:
V1/V2 = 23

V3 guessed at:
V1/10.726

V or p diff fraction	1 to 2		2 to 3		3 to 4		4 to 1	
	Adiabatic compression		Isobaric heating		Adiabatic expansion		Isochoric cooling	
	p	V	p	V	p	V	p	V
0	1.000	1820.000	186.014	79.130	186.014	169.681	3.566	1820.000
0.01	1.016	1802.591	186.014	80.036	159.354	186.184	3.540	1820.000
0.02	1.033	1785.183	186.014	80.941	138.322	202.688	3.514	1820.000
0.03	1.050	1767.774	186.014	81.847	121.404	219.191	3.489	1820.000
0.04	1.067	1750.365	186.014	82.752	107.569	235.694	3.463	1820.000
0.05	1.085	1732.957	186.014	83.658	96.095	252.197	3.437	1820.000
0.06	1.104	1715.548	186.014	84.563	86.461	268.700	3.412	1820.000
0.07	1.122	1698.139	186.014	85.469	78.285	285.203	3.386	1820.000
0.08	1.142	1680.730	186.014	86.374	71.279	301.707	3.360	1820.000
0.09	1.162	1663.322	186.014	87.280	65.225	318.210	3.335	1820.000
0.1	1.182	1645.913	186.014	88.186	59.954	334.713	3.309	1820.000
0.11	1.204	1628.504	186.014	89.091	55.332	351.216	3.284	1820.000
0.12	1.225	1611.096	186.014	89.997	51.256	367.719	3.258	1820.000
0.13	1.248	1593.687	186.014	90.902	47.639	384.223	3.232	1820.000
0.14	1.271	1576.278	186.014	91.808	44.414	400.726	3.207	1820.000
0.15	1.295	1558.870	186.014	92.713	41.525	417.229	3.181	1820.000
0.16	1.319	1541.461	186.014	93.619	38.925	433.732	3.155	1820.000
0.17	1.344	1524.052	186.014	94.524	36.577	450.235	3.130	1820.000
0.18	1.370	1506.643	186.014	95.430	34.447	466.739	3.104	1820.000
0.19	1.397	1489.235	186.014	96.335	32.508	483.242	3.078	1820.000
0.2	1.425	1471.826	186.014	97.241	30.739	499.745	3.053	1820.000
0.21	1.453	1454.417	186.014	98.146	29.119	516.248	3.027	1820.000
0.22	1.483	1437.009	186.014	99.052	27.631	532.751	3.001	1820.000
0.23	1.513	1419.600	186.014	99.957	26.264	549.254	2.976	1820.000
0.24	1.543	1402.191	186.014	100.862	25.014	565.757	2.951	1820.000
0.25	1.573	1384.782	186.014	101.767	23.876	582.260	2.926	1820.000
0.26	1.603	1367.373	186.014	102.672	22.845	598.763	2.901	1820.000
0.27	1.633	1349.964	186.014	103.577	21.918	615.266	2.876	1820.000
0.28	1.663	1332.555	186.014	104.482	21.091	631.769	2.851	1820.000
0.29	1.693	1315.146	186.014	105.387	20.361	648.272	2.826	1820.000
0.3	1.723	1297.737	186.014	106.292	19.724	664.775	2.801	1820.000
0.31	1.753	1280.328	186.014	107.197	19.178	681.278	2.776	1820.000
0.32	1.783	1262.919	186.014	108.102	18.721	697.781	2.751	1820.000
0.33	1.813	1245.510	186.014	109.007	18.351	714.284	2.726	1820.000
0.34	1.843	1228.101	186.014	109.912	18.066	730.787	2.701	1820.000
0.35	1.873	1210.692	186.014	110.817	17.855	747.290	2.676	1820.000
0.36	1.903	1193.283	186.014	111.722	17.716	763.793	2.651	1820.000
0.37	1.933	1175.874	186.014	112.627	17.648	780.296	2.626	1820.000
0.38	1.963	1158.465	186.014	113.532	17.648	796.799	2.601	1820.000
0.39	1.993	1141.056	186.014	114.437	17.714	813.302	2.576	1820.000
0.4	2.023	1123.647	186.014	115.342	17.844	829.805	2.551	1820.000
0.41	2.053	1106.238	186.014	116.247	18.037	846.308	2.526	1820.000
0.42	2.083	1088.829	186.014	117.152	18.292	862.811	2.501	1820.000
0.43	2.113	1071.420	186.014	118.057	18.608	879.314	2.476	1820.000
0.44	2.143	1054.011	186.014	118.962	18.984	895.817	2.451	1820.000
0.45	2.173	1036.602	186.014	119.867	19.420	912.320	2.426	1820.000
0.46	2.203	1019.193	186.014	120.772	19.916	928.823	2.401	1820.000
0.47	2.233	1001.784	186.014	121.677	20.472	945.326	2.376	1820.000
0.48	2.263	984.375	186.014	122.582	21.088	961.829	2.351	1820.000
0.49	2.293	966.966	186.014	123.487	21.764	978.332	2.326	1820.000
0.5	2.323	949.557	186.014	124.406	22.500	994.835	2.301	1820.000
0.51	2.353	932.148	186.014	125.311	23.296	1011.338	2.276	1820.000
0.52	2.383	914.739	186.014	126.217	24.152	1027.841	2.251	1820.000
0.53	2.413	897.330	186.014	127.122	25.068	1044.344	2.226	1820.000
0.54	2.443	879.921	186.014	128.028	26.044	1060.847	2.201	1820.000

Note the Wärtsilä-Sulzer RTA96-C engine is perhaps more powerful, producing 80,080kW from it's 14 cylinders, at 120RPM

0.55	3.471	862.522	186.014	128.933	8.544	1077.357	2.155	1820.000
0.56	3.591	845.113	186.014	129.839	8.330	1093.860	2.129	1820.000
0.57	3.718	827.704	186.014	130.744	8.125	1110.363	2.103	1820.000
0.58	3.852	810.296	186.014	131.650	7.928	1126.866	2.078	1820.000
0.59	3.994	792.887	186.014	132.555	7.738	1143.369	2.052	1820.000
0.6	4.145	775.478	186.014	133.461	7.555	1159.872	2.026	1820.000
0.61	4.305	758.070	186.014	134.366	7.379	1176.376	2.001	1820.000
0.62	4.475	740.661	186.014	135.272	7.210	1192.879	1.975	1820.000
0.63	4.656	723.252	186.014	136.177	7.047	1209.382	1.949	1820.000
0.64	4.848	705.843	186.014	137.083	6.889	1225.885	1.924	1820.000
0.65	5.055	688.435	186.014	137.988	6.738	1242.388	1.898	1820.000
0.66	5.275	671.026	186.014	138.894	6.591	1258.892	1.872	1820.000
0.67	5.511	653.617	186.014	139.799	6.450	1275.395	1.847	1820.000
0.68	5.765	636.209	186.014	140.705	6.313	1291.898	1.821	1820.000
0.69	6.038	618.800	186.014	141.610	6.181	1308.401	1.795	1820.000
0.7	6.332	601.391	186.014	142.516	6.053	1324.904	1.770	1820.000
0.71	6.649	583.983	186.014	143.421	5.929	1341.408	1.744	1820.000
0.72	6.993	566.574	186.014	144.327	5.810	1357.911	1.718	1820.000
0.73	7.367	549.165	186.014	145.232	5.694	1374.414	1.693	1820.000
0.74	7.773	531.757	186.014	146.138	5.582	1390.917	1.667	1820.000
0.75	8.217	514.348	186.014	147.043	5.473	1407.420	1.641	1820.000
0.76	8.702	496.939	186.014	147.949	5.368	1423.923	1.616	1820.000
0.77	9.235	479.530	186.014	148.854	5.266	1440.427	1.590	1820.000
0.78	9.822	462.122	186.014	149.760	5.167	1456.930	1.564	1820.000
0.79	10.471	444.713	186.014	150.665	5.071	1473.433	1.539	1820.000
0.8	11.192	427.304	186.014	151.571	4.977	1489.936	1.513	1820.000
0.81	11.995	409.896	186.014	152.477	4.887	1506.439	1.487	1820.000
0.82	12.895	392.487	186.014	153.382	4.799	1522.943	1.462	1820.000
0.83	13.908	375.078	186.014	154.288	4.713	1539.446	1.436	1820.000
0.84	15.054	357.670	186.014	155.193	4.630	1555.949	1.411	1820.000
0.85	16.359	340.261	186.014	156.099	4.550	1572.452	1.385	1820.000
0.86	17.856	322.852	186.014	157.004	4.471	1588.955	1.359	1820.000
0.87	19.584	305.443	186.014	157.910	4.395	1605.459	1.334	1820.000
0.88	21.596	288.035	186.014	158.815	4.321	1621.962	1.308	1820.000
0.89	23.961	270.626	186.014	159.721	4.248	1638.465	1.282	1820.000
0.9	26.769	253.217	186.014	160.626	4.178	1654.968	1.257	1820.000
0.91	30.143	235.809	186.014	161.532	4.109	1671.471	1.231	1820.000
0.92	34.253	218.400	186.014	162.437	4.043	1687.974	1.205	1820.000
0.93	39.339	200.991	186.014	163.343	3.978	1704.478	1.180	1820.000
0.94	45.751	183.583	186.014	164.248	3.914	1720.981	1.154	1820.000
0.95	54.015	166.174	186.014	165.154	3.852	1737.484	1.128	1820.000
0.96	64.956	148.765	186.014	166.059	3.792	1753.987	1.103	1820.000
0.97	79.928	131.357	186.014	166.965	3.733	1770.490	1.077	1820.000
0.98	#####	113.948	186.014	167.870	3.676	1786.994	1.051	1820.000
0.99	#####	96.539	186.014	168.776	3.620	1803.497	1.026	1820.000
1	#####	79.130	186.014	169.681	3.566	1820.000	1.000	1820.000