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An Unique Approach To Predict Tensile Strength For Aluminum Alloy Using Fuzzy Logic

T. Jayakumar*[1]

[1]*Research Scholar, SMBS, VIT University, Chennai-600127, Tamilnadu, India.*
jai14sep1984@gmail.com

K. Annamalai[2]

[2]*Professor, SMBS, VIT University, Chennai-600127, Tamilnadu, India.*
kannamalai@vit.ac.in

ABSTRACT
In recent years, Aluminum alloys are the most widely used material in automobile and other industries. The advantages of aluminum alloys are its less density and outstanding combination of mechanical, physical and tribological properties. In this paper a unique approach to predict tensile strength properties of aluminum alloys under room temperature to elevated condition using the fuzzy logic tool in MATLAB software is carried out. The tensile strength for various aluminum alloys available in the literatures are used as database in this research work. The developed model was validated with the previously published work.

Keywords: Aluminum alloy, high temperature condition, Tensile strength, mechanical properties, fuzzy logic.

1. INTRODUCTION

In recent legislative and environment pressure on the automobile industry to produce light weight, fuel efficient vehicle with lower emission have prompted to design for more efficient engines. Al-Si alloys are most versatile materials. Their properties include high specific strength, high wear and seizure resistance, high stiffness, better strength at high temperature, controlled thermal expansion coefficient and improved damping capacity. This leads to their excessive use in many automobile and engineering sectors where wear & tear and seizure are the major problems. Such problems are very common in some of the components like cylinder heads, pistons, connecting rods and drive shafts [1,2].Aluminum alloys are distinguished according to their major alloying elements.The4xxx group contains silicon as the main alloying element for ease of casting. Silicon performs well when used as an alloying element with metals. This is because it increases the fluidity of the melt, reduces the melting temperature, decreases the shrinkage during solidification and is in expensive as a raw material. Silicon also has a low density (2.34 g/cm^3), which may be an advantage in reducing the total weight of the cast component. Silicon has a very low solubility in aluminum; therefore it precipitates as virtually pure silicon, which is hard and hence improves the abrasion resistance [3, 4].The tensile strength as a key of all automobile alloys. In this paper, to predict the strength of alloy based on existing data of alloy using fuzzy logic tools in MATLAB.

2. PREDICTION OF TENSILE STRENGTH USING FUZZY LOGIC

The tensile strength of various aluminum alloys at different temperature were collect from literature. This data is represented in table 1.Predominately used aluminum alloying elements listed in figure1

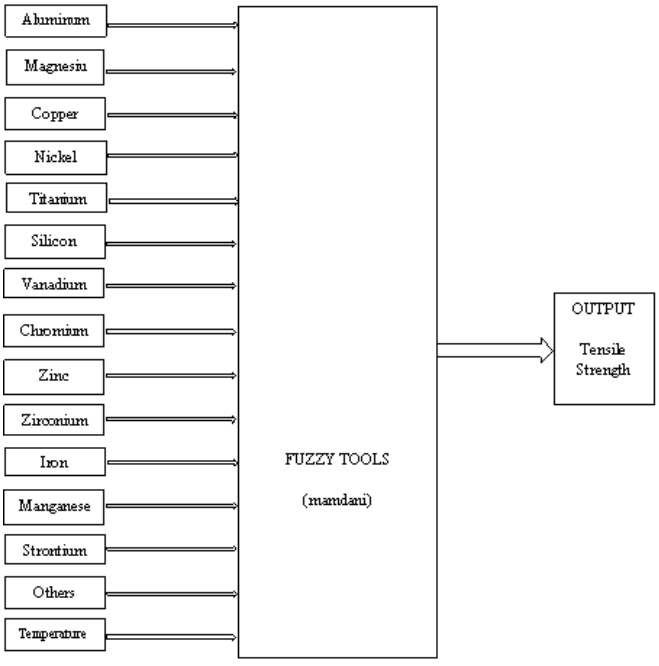


Figure 1. Input and output configuration block diagram of fuzzy logic are given as input in fuzzy logic tools of MATLAB software. The ranges of inputs like wt% of composition, temperature, and tensile strength were incorporated and a database ware created. Rules were formed to determine the tensile strength of the alloy at various temperatures. These rules were applied using fuzzy logic tool (Mamdani) as indicated figure. 2 The tensile strength of different alloy composition can be determined by running the software. The sample outputs obtained were shown in figure 3.

Table 1. Sample composition of aluminum alloy, temperature and tensile strength ranges [5-23].

SI.NO	Alloy/ composite	Tem perature	Tensile strength	Si	Fe	Cu	Mn	Ti	Mg	Ni	v	Zn	Sr	Cr	Zr	Others	Al
1	CF6	25	285	13	0.6	3	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	81.92
2		280	175	13	0.6	3	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	81.92
3		300	138	13	0.6	3	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	81.92
4		320	119	13	0.6	3	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	81.92
5		340	92	13	0.6	3	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	81.92
6	CU6	25	336	13	0.6	5	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	79.92
7		280	182	13	0.6	5	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	79.92
.		300	144	13	0.6	5	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	79.92
.		320	119	13	0.6	5	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	79.92
196	AA6061 RT	27	310	0.65	0.2	0.87	0.15	0.15	1.2	0	0	0.25	0	0.23	0	0.15	96.15

3. THE BEHAVIOR OF TENSILE STRENGTH UNDER ROOM TEMPERATURE TO ELEVATED CONDITION.

The tensile strength of various aluminum alloys are shown in table 1. It is divided in to five stage based on temperature condition are as follows.

3.1. Tensile strength under Room temperature.

The tensile strength of aluminum alloy under room temperature (20°C, 25°C, 27°C) condition are shown in figure4. The tensile strength as varies from 110 MPa to 491 MPa under room temperature. If rises wt % of Si, Cu, Fe, Ti, Ni elements of the aluminum alloy the tensile strength also rises under room temperature condition as shown in figure.4

3.2. Tensile strength under 100°C to 200°C.

To analyze the strength under 100°C to 200°C, the major composition of aluminum alloy is Si, Cu and Fe. In 17 wt% of silicon and 4.5 wt% of copper under 150°C is 355MPa as shown in figure 4. The copper has to withstand tensile strength under temperature condition of aluminum alloy.

3.3. Tensile strength under 200°C to 300°C.

In this temperature condition, tensile strength varies from 73 MPa to 250 MPa as shown figure4.The tensile strength start to decreases even though rising wt% silicon of this temperature condition [24]. For 9 wt % Si, 0.85wt% Fe, and 1.85 wt% Cu of aluminum alloy gives moderate strength 172 MPa as shown in figure 5.

3.4. Tensile strength under 300°C to 400°C.

The tensile strength varies from 35 MPa to 190 MPa at 300°C to 400°C as shown in figure 4.For this condition most of the predominantly aluminum alloy loss their strength under this temperature condition. But addition of Fe improves the strength at 300°C to 400°C as shown in figure 4.

3.5. Tensile strength under 400°C to 500°C.

The tensile strength of aluminum alloy at 400°C to 500°C is varies from 30MPa to 175 MPa shown in figure 4.The tensile strength decreases rapidly with increases the temperature condition of aluminum alloy.

Table 2. Input ranges of aluminum alloy elements data.

	Si	Fe	Cu	Mn	Ti	Mg	Ni	V	Zn	Sr	Cr	Zr	others	Al	Temp in ^{0}C	Tensile strength (MPa)
Min	.5	0	0	0	0	0	0	0	0	0	0	0	0	68	20	30
Max	24	8	5.45	10	.25	1.8	3	1.3	5.96	0.03	.5	.39	0.15	96.15	500	491

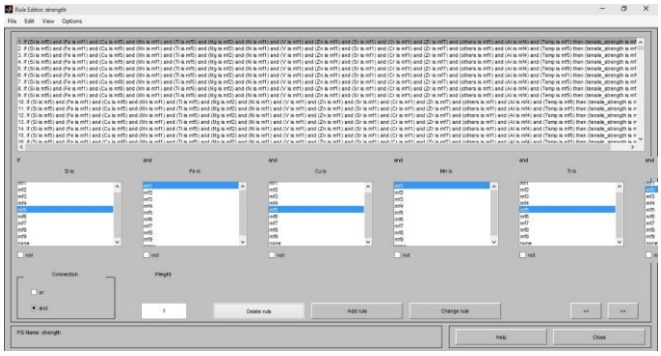


Figure 2. Adding rules of each combination of input fuzzy tools.

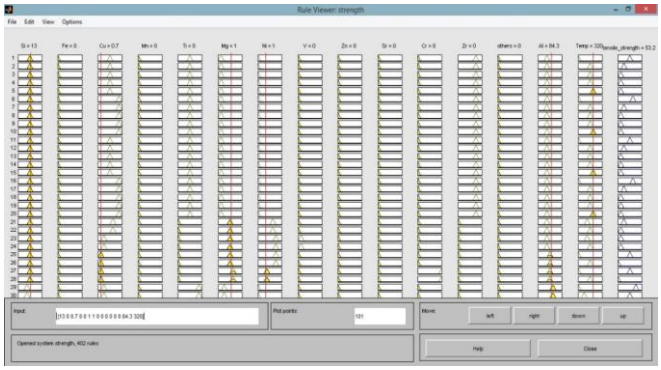
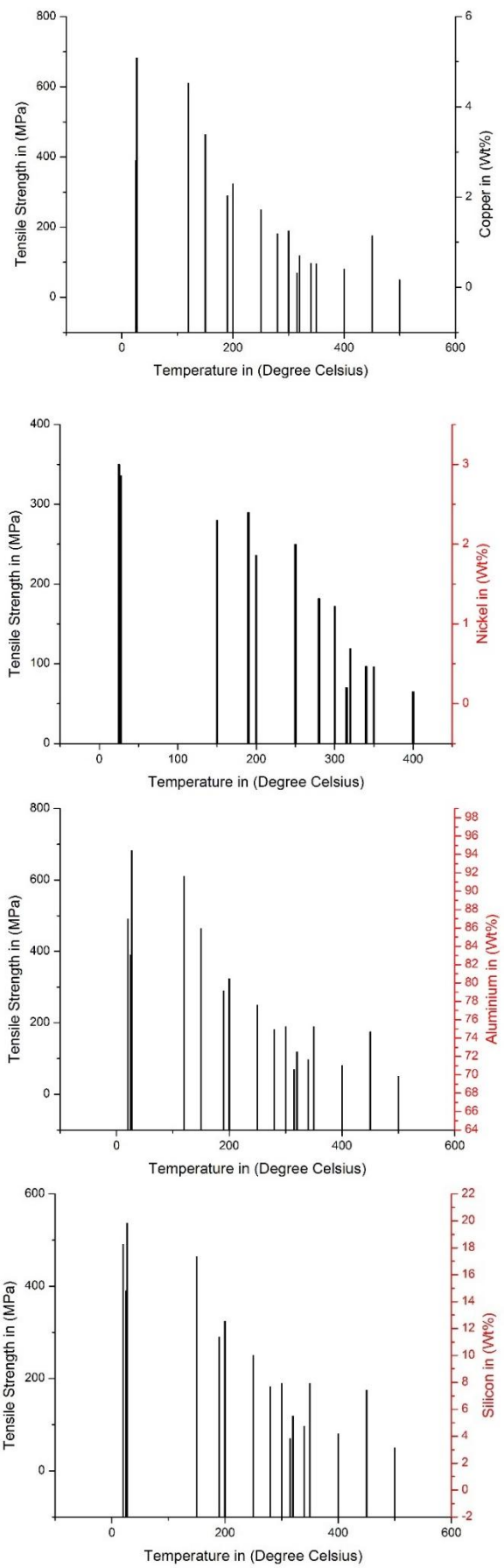


Figure 3. New combination of input alloy and temperature to get tensile strength.

4. CONCLUSIONS

From the detailed literature review carried out, the major conclusions and the future scopes are listed below

- The widely used alloying elements of aluminum are silicon, copper, nickel, magnesium, titanium and iron. Silicon plays vital role for aluminum alloys as it gives high strength.
- The Si, Fe and Cu alloying elements improves the strength, if the temperature of exposure increases then the Si wt% decreases as they cannot withstand this elevated condition. It was also observed, while temperature rises above 300°C the alloy's tensile strength decreases rapidly.



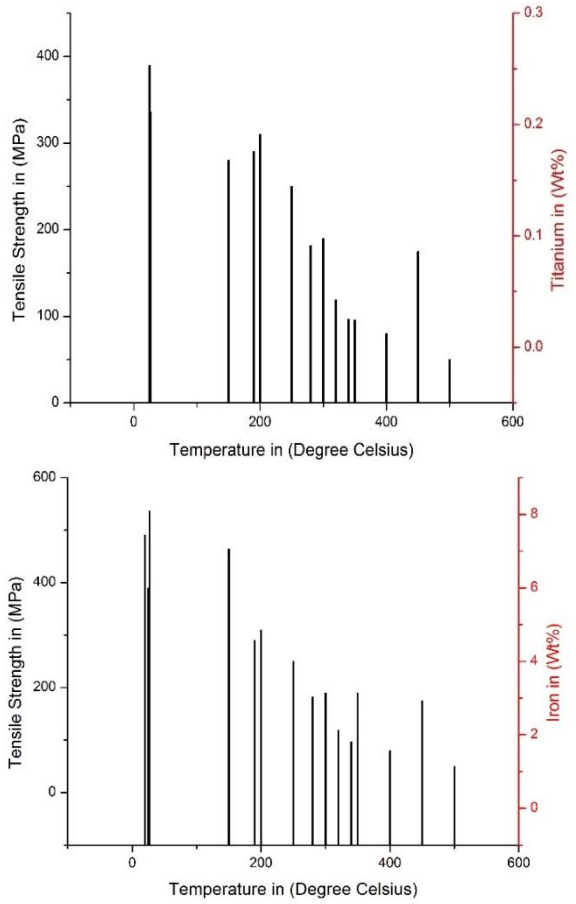


Figure 4. Tensile Strength for major alloying elements of aluminum alloy under room to elevated condition.

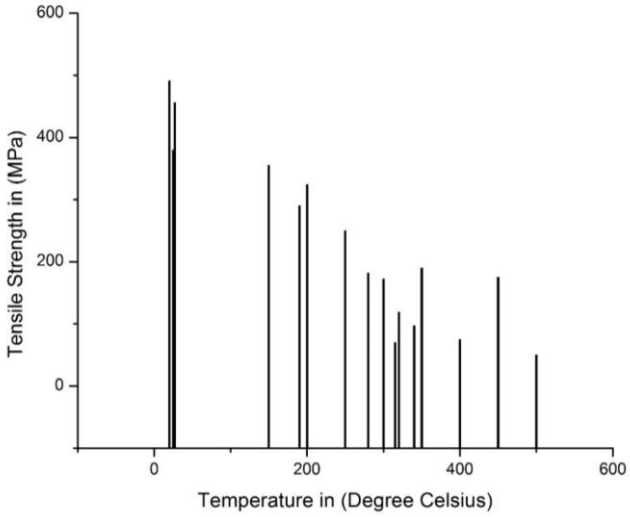


Figure 5. Tensile strength of aluminum alloy under room to elevated temperature condition

- The variation in the input of alloy wt% composition and temperature will provide the corresponding output of tensile strength from the database.

- The prediction of tensile strength of aluminum alloy can be done based on existing data and this reduces the rework of the research using fuzzy tools software.

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APPENDIX

Table 1. Composition of aluminum alloy and temperature and tensile strength ranges [5-23].

SI. NO	Alloy/ Composite	Temperature	Tensile strength	Si	Fe	Cu	Mn	Ti	Mg	Ni	v	zn	Sr	Cr	Zr	Others	Al
1	CF6	25	285	13	0.6	3	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	81.92
2		280	175	13	0.6	3	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	81.92
3		300	138	13	0.6	3	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	81.92
4		320	119	13	0.6	3	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	81.92
5		340	92	13	0.6	3	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	81.92
6	CU6	25	336	13	0.6	5	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	79.92
7		280	182	13	0.6	5	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	79.92
8		300	144	13	0.6	5	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	79.92
9		320	119	13	0.6	5	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	79.92
10		340	97	13	0.6	5	0.6	0.15	0.4	0.03	0	0	0	0	0.3	0	79.92
11	A1	250	153	13	0	4.03	0	0	0.92	1.9	0.16	0	0	0	0	0	79.99
12		300	93	13	0	4.03	0	0	0.92	1.9	0.16	0	0	0	0	0	79.99
13	A2	250	141	13.72	0	2	0	0	1.08	2.36	0.2	0	0	0	0	0	80.64
14		300	94	13.72	0	2	0	0	1.08	2.36	0.2	0	0	0	0	0	80.64
15	A0336	25	276	13	0	1	0	0	1	2.5	0	0.35	0	0	0	0	82.15
16		315	70	13	0	1	0	0	1	2.5	0	0.35	0	0	0	0	82.15
17	AC8A	25	270	13	0	1.3	0	0	1.3	1.5	0	0	0	0.5	0	0	82.4
18		300	73	13	0	1.3	0	0	1.3	1.5	0	0	0	0.5	0	0	82.4
19	A-T6	25	380	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0	0	0	0	87.92
20		190	270	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0	0	0	0	87.92
21		250	240	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0	0	0	0	87.92
22		300	130	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0	0	0	0	87.92
23	D-T6	25	340	9.16	0.08	1.84	0.01	0.22	0.49	0.46	0	0	0	0	0	0	87.74
24		190	275	9.16	0.08	1.84	0.01	0.22	0.49	0.46	0	0	0	0	0	0	87.74
25		250	230	9.16	0.08	1.84	0.01	0.22	0.49	0.46	0	0	0	0	0	0	87.74
26		300	110	9.16	0.08	1.84	0.01	0.22	0.49	0.46	0	0	0	0	0	0	87.74
27	E-T6	25	340	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0	0	0.39	0	87.95
28		190	270	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0	0	0.39	0	87.95
29		250	240	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0	0	0.39	0	87.95
30		300	140	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0	0	0.39	0	87.95
31	F-T6	25	340	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0	0	0.39	0	87.49
32		190	270	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0	0	0.39	0	87.49
33		250	245	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0	0	0.39	0	87.49
34		300	140	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0	0	0.39	0	87.49
35	G-T6	25	350	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0	0	0.19	0	88
36		190	290	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0	0	0.19	0	88
37		250	250	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0	0	0.19	0	88
38		300	140	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0	0	0.19	0	88
39	A-AC	25	230	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0	0	0	0	87.92
40		190	220	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0	0	0	0	87.92
41		300	120	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0	0	0	0	87.92
42	D-AC	25	230	9.16	0.08	1.84	0.01	0.22	0.49	0.46	0	0	0	0	0	0	87.74
43		190	220	9.16	0.08	1.84	0.01	0.22	0.49	0.46	0	0	0	0	0	0	87.74
44		300	95	9.16	0.08	1.84	0.01	0.22	0.49	0.46	0	0	0	0	0	0	87.74
45	E-AC	25	230	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0	0	0.39	0	87.95
46		190	220	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0	0	0.39	0	87.95
47		300	90	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0	0	0.39	0	87.95
48	F-AC	25	220	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0	0	0.39	0	87.49
49		190	240	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0	0	0.39	0	87.49
50		300	110	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0	0	0.39	0	87.49
51	G-AC	25	250	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0	0	0.19	0	88
52		190	230	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0	0	0.19	0	88
53		300	120	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0	0	0.19	0	88
54	Al–8Mn–2Si	20	259	2	0	0	8	0	0	0	0	0	0	0	0	0	90
55		350	84	2	0	0	8	0	0	0	0	0	0	0	0	0	90
56	Al–10Mn–3Si	20	288	3	0	0	10	0	0	0	0	0	0	0	0	0	87
57		350	101	3	0	0	10	0	0	0	0	0	0	0	0	0	87
58	Al–Fe–V–Si	20	491	1.7	8	0	0	0	0	0	1.3	0	0	0	0	0	89

59		350	190	1.7	8	0	0	0	0	0	1.3	0	0	0	0	0	89
60	ZL114A alloy	200	194	7.03	0.1	0.47	0.1	0.12	0.47	0.1	0	0	0.03	0	0	0	91.58
61		200	162	6.9	0.1	0.98	0.1	0.12	0.49	0.15	0	0	0.03	0	0	0	91.13
62		200	178	6.87	0.1	1.48	0.1	0.12	0.47	0.19	0	0	0.03	0	0	0	90.64
63		200	206	6.85	0.13	0.46	0.1	0.12	0.43	0.14	0	0	0.02	0	0	0	91.75
64		200	176	6.94	0.14	1	0.1	0.12	0.45	0.19	0	0	0.02	0	0	0	91.04
65		200	190	6.81	0.14	1.53	0.1	0.12	0.42	0.1	0	0	0.02	0	0	0	90.76
66		200	220	6.91	0.27	0.48	0.1	0.12	0.39	0.19	0	0	0.02	0	0	0	91.52
67		200	188	6.96	0.28	0.97	0.1	0.12	0.39	0.1	0	0	0.02	0	0	0	91.06
68		200	176	6.95	0.28	1.53	0.1	0.12	0.39	0.16	0	0	0.02	0	0	0	90.45
69		200	236	7.2	0.11	0	0.1	0.12	0.54	0	0	0	0.03	0	0	0	91.9
70	A1	350	42.74	13.1	0.29	0.1	0	0	1.1	0	0	0	0	0	0	0	85.41
71	A2	350	49.51	13.1	0.3	0.1	0	0	1.03	1	0	0	0	0	0	0	84.47
72	A3	350	61.63	13	0.3	1.08	0	0	1.05	1	0	0	0	0	0	0	83.57
73	A4	350	61.71	12.8	0.31	3.23	0	0	1.01	1	0	0	0	0	0	0	81.65
74	Alloy A	25	186.4	12.45	0.44	3.93	0.03	0	0.67	2.78	0	0	0	0	0	0	79.7
75	Alloy B	25	185.6	6.9	0.22	3.89	0.03	0	0.62	3	0	0	0	0	0	0	85.34
76	Alloy C	25	180.3	0.67	0.21	3.91	0.05	0	0.8	2.99	0	0	0	0	0	0	91.37
77	Alloy A	200	141.1	12.45	0.44	3.93	0.03	0	0.67	2.78	0	0	0	0	0	0	79.7
78	Alloy B	200	127.3	6.9	0.22	3.89	0.03	0	0.62	3	0	0	0	0	0	0	85.34
79	Alloy C	200	155	0.67	0.21	3.91	0.05	0	0.8	2.99	0	0	0	0	0	0	91.37
80	6061 alloy	25	170	0.65	0.2	0.87	0.15	0.15	1.2	0	0	0.25	0	0.23	0	0.15	96.15
81		200	150	0.65	0.2	0.87	0.15	0.15	1.2	0	0	0.25	0	0.23	0	0.15	96.15
82		300	90	0.65	0.2	0.87	0.15	0.15	1.2	0	0	0.25	0	0.23	0	0.15	96.15
83		400	40	0.65	0.2	0.87	0.15	0.15	1.2	0	0	0.25	0	0.23	0	0.15	96.15
84		500	30	0.65	0.2	0.87	0.15	0.15	1.2	0	0	0.25	0	0.23	0	0.15	96.15
85	7015 alloy	25	340	0.63	0.04	0.23	0.1	0.1	1.04	0	0	5.96	0	0.21	0.2	0.15	91.34
86		200	270	0.63	0.04	0.23	0.1	0.1	1.04	0	0	5.96	0	0.21	0.2	0.15	91.34
87		300	140	0.63	0.04	0.23	0.1	0.1	1.04	0	0	5.96	0	0.21	0.2	0.15	91.34
88		400	75	0.63	0.04	0.23	0.1	0.1	1.04	0	0	5.96	0	0.21	0.2	0.15	91.34
89		500	50	0.63	0.04	0.23	0.1	0.1	1.04	0	0	5.96	0	0.21	0.2	0.15	91.34
90	Ao alloy	27	382	20	0	3	0	0	1	0	0	0	0	0	0	0	76
91		200	146	20	0	3	0	0	1	0	0	0	0	0	0	0	76
92	A1 alloy	27	446	20	5	3	0	0	1	0	0	0	0	0	0	0	71
93		200	274	20	0	3	0	0	1	0	0	0	0	0	0	0	76
94	A2 alloy	27	456	20	5	3	3	0	1	0	0	0	0	0	0	0	68
95		200	324	20	0	3	3	0	1	0	0	0	0	0	0	0	73
96	A390 alloy	27	424	17	0	4.5	0	0	0.6	0	0	0.5	0	0	0	0	77.4
97		150	287	17	0	4.5	0	0	0.6	0	0	0.5	0	0	0	0	77.4
98	AS17 alloy	27	448	17	0	4.5	0	0	0.6	0	0	0.5	0	0	0	0	77.4
99		150	355	17	0	4.5	0	0	0.6	0	0	0.5	0	0	0	0	77.4
100	CF3	27	310	13	0.3	3	0.6	0.15	0.3	0.2	0	0	0	0	0	0	82.45
101	CF6	27	295	13	0.6	3	0.6	0.15	0.3	0.2	0	0	0	0	0	0	82.15
102	CF8	27	283	13	0.8	3	0.6	0.15	0.3	0.2	0	0	0	0	0	0	81.95
103	CU3	27	316	13	0.3	5	0.6	0.15	0.3	0.2	0	0	0	0	0	0	80.45
104	CU6	27	317	13	0.6	5	0.6	0.15	0.3	0.2	0	0	0	0	0	0	80.15
105	CU8	27	336	13	0.8	5	0.6	0.15	0.3	0.2	0	0	0	0	0	0	79.95
106	ZL109	27	295	13	0.6	1	0.35	0.25	1	2.5	0	0.35	0	0	0	0	80.95
107	LM13	27	291	13	0.6	1.5	0.5	0.2	1.3	1.5	0	0.5	0	0	0	0	80.9
108	A03360	27	290	13	0.4	1.5	0.2	0.2	1.2	1.5	0	0.2	0	0	0	0	81.8
109	AC8A	27	298	13	0.6	1.1	0.15	0.2	1	1.2	0	0.15	0	0.1	0	0	82.5
110	modified alloy	27	311	7.1	0.11	0.98	0	0.18	0.53	0	0.28	0	0.006	0	0.18	0	90.634
111		250	205	7.1	0.11	0.98	0	0.18	0.53	0	0.28	0	0.006	0	0.18	0	90.634
112		450	175	7.1	0.11	0.98	0	0.18	0.53	0	0.28	0	0.006	0	0.18	0	90.634
113	Alloy A	27	262	12.14	0.61	1	0.012	0.02	0.78	1.2	0	0.049	0	0	0	0	84.189
114		200	225	12.14	0.61	1	0.012	0.02	0.78	1.2	0	0.049	0	0	0	0	84.189
115		250	175	12.14	0.61	1	0.012	0.02	0.78	1.2	0	0.049	0	0	0	0	84.189
116		400	50	12.14	0.61	1	0.012	0.02	0.78	1.2	0	0.049	0	0	0	0	84.189
117	Alloy B	27	262	11.75	0.34	2.85	0.018	0.12	1.01	2.63	0	0.047	0	0	0	0	81.235
118		200	225	11.75	0.34	2.85	0.018	0.12	1.01	2.63	0	0.047	0	0	0	0	81.235
119		250	200	11.75	0.34	2.85	0.018	0.12	1.01	2.63	0	0.047	0	0	0	0	81.235
120		400	60	11.75	0.34	2.85	0.018	0.12	1.01	2.63	0	0.047	0	0	0	0	81.235
121	Alloy C	27	272	12.21	0.2	4.89	0.11	0.13	0.76	2.83	0	0.033	0	0	0	0	78.837
122		200	235	12.21	0.2	4.89	0.11	0.13	0.76	2.83	0	0.033	0	0	0	0	78.837

123		250	205	12.21	0.2	4.89	0.11	0.13	0.76	2.83	0	0.033	0	0	0	0	78.837
124		400	65	12.21	0.2	4.89	0.11	0.13	0.76	2.83	0	0.033	0	0	0	0	78.837
125	Al-Si alloy	27	185	10.9	0.43	0.18	0.14	0	0.26	0	0	0	0	0	0	0	88.09
126		250	151.7	10.9	0.43	0.18	0.14	0	0.26	0	0	0	0	0	0	0	88.09
127	Al-Si alloy	27	161	10.9	0.43	0.18	0.14	0	0.26	0	0	0	0	0	0	0	88.09
128	LM13 -CAST	27	180	11.95	0.8	1	0.6	0	1	1.5	0	0	0	0	0	0	83.15
129	LM13 -HT	27	210	11.95	0.8	1	0.6	0	1	1.5	0	0	0	0	0	0	83.15
130	Al-319 alloy(T7)	150	280	8.6	0.5	3.8	0.3	0.0127	0.36	0.023	0	0	0.012	0	0	0.0142	86.3781
131	Al-319 alloy(T4)	150	260	8.6	0.5	3.8	0.3	0.0127	0.36	0.023	0	0	0.012	0	0	0.0142	86.3781
132	Al-319 alloy(CAST)	150	225	8.6	0.5	3.8	0.3	0.0127	0.36	0.023	0	0	0.012	0	0	0.0142	86.3781
133	Al-319 alloy(T7)	250	175	8.6	0.5	3.8	0.3	0.0127	0.36	0.023	0	0	0.012	0	0	0.0142	86.3781
134	Al-319 alloy(T4)	250	175	8.6	0.5	3.8	0.3	0.0127	0.36	0.023	0	0	0.012	0	0	0.0142	86.3781
135	Al-319 alloy(CAST)	250	155	8.6	0.5	3.8	0.3	0.0127	0.36	0.023	0	0	0.012	0	0	0.0142	86.3781
136	Al-319 alloy(T7)	400	37	8.6	0.5	3.8	0.3	0.0127	0.36	0.023	0	0	0.012	0	0	0.0142	86.3781
137	Al-319 alloy(T4)	400	37	8.6	0.5	3.8	0.3	0.0127	0.36	0.023	0	0	0.012	0	0	0.0142	86.3781
138	Al-319 alloy(CAST)	400	35	8.6	0.5	3.8	0.3	0.0127	0.36	0.023	0	0	0.012	0	0	0.0142	86.3781
139	Alloy A	25	263.8	12.75	0.03	2.63	0.21	0.081	1.01	1.93	0	0	0	0	0	0.0058	81.3532
140	Alloy B	25	229	12.82	0.04	3.64	0.21	0.07	1.01	1.93	0	0	0	0	0	0.0074	80.2726
141	Alloy C	25	254.8	12.72	0.12	4.48	0.24	0.128	1.07	1.94	0	0	0	0	0	0.0054	79.2966
142	Alloy D	25	278.9	12.87	0.19	5.45	0.2	0.114	1.04	1.83	0	0	0	0	0	0.0052	78.3008
143	Alloy A	350	78.1	12.75	0.03	2.63	0.21	0.081	1.01	1.93	0	0	0	0	0	0.0058	81.3532
144	Alloy B	350	85.5	12.82	0.04	3.64	0.21	0.07	1.01	1.93	0	0	0	0	0	0.0074	80.2726
145	Alloy C	350	86.6	12.72	0.12	4.48	0.24	0.128	1.07	1.94	0	0	0	0	0	0.0054	79.2966
146	Alloy D	350	93.5	12.87	0.19	5.45	0.2	0.114	1.04	1.83	0	0	0	0	0	0.0052	78.3008
147	A/AC	25	233.236	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0.015	0	0	0	87.905
148	A/AC	190	213.17	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0.015	0	0	0	87.905
149	A/AC	300	101.204	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0.015	0	0	0	87.905
150	B/AC	25	230.914	9.16	0.08	1.84	0.01	0.22	0.49	0.46	0	0	0.0149	0	0	0	87.7251
151	B/AC	190	208.492	9.16	0.08	1.84	0.01	0.22	0.49	0.46	0	0	0.0149	0	0	0	87.7251
152	B/AC	300	98.466	9.16	0.08	1.84	0	0.22	0.49	0.46	0	0	0.0149	0	0	0	87.7351
153	C/AC	25	233.108	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0.0145	0	0.39	0	87.9355
154	C/AC	190	206.794	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0.0145	0	0.39	0	87.9355
155	C/AC	300	93.91	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0.0145	0	0.39	0	87.9355
156	D/AC	25	228.71	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0.0122	0	0.39	0	87.4778
157	D/AC	190	210.676	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0.0122	0	0.39	0	87.4778
158	D/AC	300	105.288	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0.0122	0	0.39	0	87.4778
159	E/AC	25	250.13	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0.0127	0	0.19	0	87.9873
160	E/AC	190	215.704	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0.0127	0	0.19	0	87.9873
161	E/AC	300	172.228	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0.0127	0	0.19	0	87.9873
162	A/T6	25	338.648	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0.015	0	0	0	87.905
163	A/T6	190	274.818	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0.015	0	0	0	87.905
164	A/T6	250	214.422	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0.015	0	0	0	87.905
165	A/T6	300	101.174	9.43	0.08	1.85	0.01	0.22	0.49	0	0	0	0.015	0	0	0	87.905
166	B/T6	25	337.652	9.16	0.08	1.84	0.01	0.22	0.49	0.46	0	0	0.0149	0	0	0	87.7251
167	B/T6	190	276.098	9.16	0.08	1.84	0.01	0.22	0.49	0.46	0	0	0.0149	0	0	0	87.7251
168	B/T6	250	217.082	9.16	0.08	1.84	0.01	0.22	0.49	0.46	0	0	0.0149	0	0	0	87.7251
169	B/T6	300	103.688	9.16	0.08	1.84	0.01	0.22	0.49	0.46	0	0	0.0149	0	0	0	87.7251
170	C/T6	25	340.212	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0.0145	0	0.39	0	87.9355
171	C/T6	190	273.466	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0.0145	0	0.39	0	87.9355
172	C/T6	250	214.442	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0.0145	0	0.39	0	87.9355
173	C/T6	300	104.688	9.1	0.07	1.83	0	0.21	0.45	0	0	0	0.0145	0	0.39	0	87.9355
174	D/T6	25	339.866	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0.0122	0	0.39	0	87.4778
175	D/T6	190	269.866	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0.0122	0	0.39	0	87.4778
176	D/T6	250	208.888	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0.0122	0	0.39	0	87.4778
177	D/T6	300	133.982	9.1	0.08	1.86	0	0.22	0.46	0.4	0	0	0.0122	0	0.39	0	87.4778
178	E/T6	25	346.212	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0.0127	0	0.19	0	87.9873
179	E/T6	190	286.266	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0.0127	0	0.19	0	87.9873
180	E/T6	250	229.932	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0.0127	0	0.19	0	87.9873
181	E/T6	300	143.184	9.01	0.08	1.85	0	0.21	0.45	0.21	0	0	0.0127	0	0.19	0	87.9873
182	Al-12Si	25	287	12.37	0.42	4.13	0.2	0.106	0.82	2.67	0	0.006	0	0	0	0	79.278
183		200	225	12.37	0.42	4.13	0.2	0.106	0.82	2.67	0	0.006	0	0	0	0	79.278
184		350	88	12.37	0.42	4.13	0.2	0.106	0.82	2.67	0	0.006	0	0	0	0	79.278
185	alloy-1	27	280	0.6	0.6	4	0	0	1.5	1.8	0	0	0	0	0	0	91.5
186	alloy-2	27	175	10.5	0.6	0.9	0	0	1	0.9	0	0	0	0	0	0	86.1

187	alloy-3	27	180	12	0.5	1	0	0	0.8	1	0	0	0	0	0	0	84.7
188	alloy-4	27	120	18.1	0.5	0.9	0	0	0.9	0.9	0	0	0	0	0	0	78.7
189	alloy-5	27	110	24	0.6	1.1	0	0	0.8	1.2	0	0	0	0	0	0	72.3
190	alloy-1	27	310	0.6	0.6	4	0	0	1.5	1.8	0	0	0	0	0	0	91.5
191	alloy-2	27	275	10.5	0.6	0.9	0	0	1	0.9	0	0	0	0	0	0	86.1
192	alloy-3	27	280	12	0.5	1	0	0	0.8	1	0	0	0	0	0	0	84.7
193	alloy-4	27	190	18.1	0.5	0.9	0	0	0.9	0.9	0	0	0	0	0	0	78.7
194	alloy-5	27	165	24	0.6	1.1	0	0	0.8	1.2	0	0	0	0	0	0	72.3
195	AA7005 – RT	27	350	0.35	0.4	0.1	0.5	0.06	1.8	0	0	4	0	0.2	0.15	0.14	92.3
196	AA6061 RT	27	310	0.65	0.2	0.87	0.15	0.15	1.2	0	0	0.25	0	0.23	0	0.15	96.15