

Why is aluminium utilised in the contemporary world?

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Aluminium is used extravagantly in the contemporary world, primarily due to its unique structure and desirable properties. Further, aluminium is the most abundant metal in the earth's crust; thus, scarcity is not a problem. It is a member of the Boron group of chemical elements and is 'the most widely used non-ferrous metal' (Planet Ark, 2010). It has the symbol Al, and its atomic number is 13. It is necessary to consider the fact that 'pure aluminium is not often used as it has poor mechanical properties. It is usually alloyed with other metals or silicon' (Chemical Industry Education Centre, 2011). A key area in which aluminium alloys are utilised is for the construction of aircraft and rockets.

Aircraft manufacturers use high-strength aluminium alloys for the construction of aircraft and rockets. This is because aluminium (the predominant element of the alloy) is able to be compounded with other metals and substances, is highly malleable, resistant to corrosion and consists of high strength to density ratio, in comparison to other metals. 'Aluminium is used in virtually all segments of the aircraft, missile and spacecraft industry-in airframes, engines, accessories, and tankage for liquid fuel and oxidizers' (Davis, 2000). Further, Aluminium 7075 is an aluminium alloy that is used heavily in the construction of aircraft and rockets (The Aluminum Association, 2008).

Aluminium consists of low ionisation energy, as well as a relatively high atomic radius, in comparison to other metals. The ground state valence electron configuration of Aluminium is $3s^2 3p^1$ (Web Elements Ltd, 2011). Consequently, Aluminium comprises of three valence electrons, which are able to be shared with other elements, or in this instance, metal atoms. In <https://assignbuster.com/why-is-aluminium-utilised-in-the-contemporary-world/>

addition, as aluminium has a low ionization number, 6. 0 Electron Volts (Ev), as well as moderately low ionisation energies, this implies that the valence electrons of aluminium atoms are not strongly held by the nucleus, and are thus, delocalized. Delocalized electrons are not restricted to one atom or another; they are distributed across several atoms in the solid. Thus, valence electrons can move freely out of the influence of their kernels (atomic orbit/structure minus valence electrons). Consequently, aluminium, and other metals, has free mobile electrons (Tutor Vista, 2010). In addition, the bonding in metals is often described through the " electron sea model".

Another reason as to why Aluminium is able to be compounded with other elements pertains to its electronegativity. Electronegativity is a measure of the tendency of an atom to attract a bonding pair of electrons (Clark, 2009). The Pauling scale is used to measure the electronegativity of a particular element. Metal's reactivity is dependent on their electropositivity; thus, a metal with a higher value in the Pauling Scale is less reactive than another metal with a lower value in the Pauling Scale (Tutor Vista, 2010). The electronegativity of aluminium is 1. 61 Pauling units (Pu) (refer to table 3), whereas the electronegativity of copper is 1. 65 Pu and iron, 1. 83 Pu (refer to table 3). Thus, aluminium is more reactive than copper and steel and is able to be adeptly bonded with other elements. (Other factors are involved)

Malleability is the ability of a metal to exhibit large deformation or plastic response when being subjected to a compressive force (Engineers Edge, 2012). The key reason as to why Aluminium is highly malleable pertains to its polycrystalline structure. The polycrystalline structure of aluminium

consists of various dislocations or crystallographic defects. The presence and movement of these dislocations, gives rise to characteristic and desirable metallic properties, for instance, malleability (Davison).

Aluminium is highly resistant to corrosion. This is primarily because a thin visible oxide forms instantly when the metal is exposed to the atmosphere. These substances are formed as aluminium has the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^1$, and oxygen has the electron configuration $1s^2 2s^2 2p^4$; this means that aluminium loses 1-3 valence electrons to oxygen, yielding aluminium cations with a 3+ charge, as well as oxygen atoms with a 2- charge. This is an example of an ionic bond. In addition, when Aluminium oxide is formed, it consists of a noble gas configuration, and; therefore, is balanced as well as stable.

Further, this oxide layer is one of the main reasons for aluminium's good corrosion properties; it is self-repairing if damaged, and is stable in the general pH range 4-9 (SAPA Profiles UK Ltd, 2010). When aluminium is used for the construction of aircraft and rockets, it is often anodized to improve strength, and colour (Davis, 2000).

Aluminium 7075 possesses an incredibly high strength to density ratio. The maximum/ultimate tensile strength of the alloy varies from 40000 psi to 78000 psi, depending on the grade of the temper (Alcoa, 2011). It is strong, with strength comparable to many sheets of steel (iron). The tensile strength of iron (Fe) is approximately 40, 000 psi (All Metals & Forge Group, 2011). Aluminium 7075 has a density of 2.8 g/cm^3 ; whereas the density of steel is 7.87 g/cm^3 , approximately 282.07% greater. The low atomic mass, 26.982

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AMU, and high atomic radius of aluminium, 182pm, relate to the principal reason as to why it has a low density, in comparison to iron. Iron, on the other hand, has an atomic mass of 58. 845 AMU and an atomic radius of 172pm.

Aluminium consists of a face-centred cubic (fcc) crystal structure, whereas iron has a body-centred cubic structure. The atomic packing factor (APF) of a face-centred cubic crystal structure is 0. 74, whilst the APF of a body-centred cubic crystal structure is 0. 68. Although aluminium comprises of a more compact atomic structure, the fact that Aluminium has a higher atomic radius, as well as lower atomic mass, in comparison to that of iron; thus, having less mass in a certain space than iron, allows it to have a lower density. This pertains to the fact that density is equal to mass over volume ($d= m/v$).

Aluminium is used extravagantly in the contemporary world, primarily due to its unique structure and desirable properties. A Key area in which aluminium is utilised is for the construction of aircraft and rockets. The reasons, as to why aluminium is used in this particular application, are apparent and abundant.

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