EFFECT OF COMPOSITE MATERIALS USED IN THE MANUFACTURE OF AIRCRAFT PARTS ON ENVIRONMENTAL POLLUTION AND THE ECONOMY

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We have investigated and compared energy use and production of emissions when various aerospace materials are used in aircraft. Computer-based models were prepared to compare lightweight composites with the traditional heavier aluminum over their whole lifetime which is termed a "lifecycle assessment". This included raw materials, production, useful life in the aircraft and disposal at the end of the material's useful life. The information provided by this work is independent of industrial influence and so provides an objective view of potential savings in energy and emissions [1].

Lightweight composite materials such as carbon fiber-reinforced epoxy resins and glass-fiber reinforced laminates are increasingly finding application in aircraft to replace traditional heavier metal structures. In commercial aircraft, this is driven largely by the high cost of aviation fuel and the introduction of legislation setting limits on the emission of greenhouse gases. Already the Airbus A380 is constructed of around 25% composites while the Boeing 787 "Dream liner" uses about twice this amount [1]. Composites are especially adept at achieving overall weight reduction but also facilitate the construction of novel aerodynamic aircraft shapes such as the blended wing-body thus providing additional routes to improved fuel efficiency [2].

However, the production, manufacture and final disposal of high performance composites and similar materials for use in aircraft requires considerably more energy than metal components such as aluminum alloys. For example, aluminum can be recycled at about one 20th the energy that it takes to refine it from ores. This energy saving, when aluminum is recycled, provides a significant reduction in the energy use of aluminum over its whole lifetime. This illustrates that it is vital to consider the energy and raw materials used and waste products produced at all stages of the lifetime of the material. A more accurate view of the total savings in aviation fuel use and emissions achieved by using the lighter materials can be obtained. Lifecycle assessment (LCA) has been employed to ascertain the effect on the environment in terms of fossil fuel use and emissions of potentially hazardous products when different aerospace materials are used. Aluminum alloy (AlCuZnMg, aerospace grade 7075), the laminate GLARE (which is used by Airbus and consists of layers of glass fiber-reinforced epoxy resin sandwiched between aluminum foil), and carbon fiber reinforced epoxy resin composites were chosen for comparison. The choice of these materials had the additional advantage of facilitating the evaluation of the software and currently available data bases for the LCA. The LCA takes into account all the stages of the material lifetime: raw materials, production and manufacturing, useful life in the aircraft and waste management at the end of the component life [3, 4].

The results of our LCA modeling contain data concerning the use and production of literally hundreds of chemicals and raw materials. The exact number of items depends on the particular material and the nature of the processes involved in its overall lifetime. The huge amount of data that is concealed within the LCA model provides a challenge to present it in a meaningful way. For the purposes of this short study, items of current interest have been extracted from the LCA model for further analysis, airborne emissions of substances which influence climate change (known as radioactively active substances6) such as carbon dioxide, sulphur and nitrogen oxides and particulates have been initially selected.

From time to time it is discovered that a chemical, previously considered to present no risks to human health or to adversely affect the environment, is actually hazardous. This could be that it adversely affects the climate or causes global warming or perhaps that it is toxic to global environment in other ways. As another example, chemicals that were previously thought to be harmless are often found to be carcinogenic or otherwise damaging to human health. Emissions of particulate materials, for example, can affect both the environment, contributing to climate change and are hazardous to human health. Particulate materials can be particularly damaging to human health if they are produced in the lower part of the atmosphere, around airports for example. When such particulate matter is produced in the atmosphere during flight of aircraft, they become radioactively active and affect global warming. Similarly, aircraft contrails (consisting of mainly water) are thought to be radioactively active and thus influence climate change.

At the present time there is a lot of uncertainty about the effect on climate change caused by water emitted by aircraft. This illustrates the potential of our LCA model as it contains information on many materials and emissions that are likely to be of great importance in the future.

References

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