Novel robot aircraft coating removal technology has a low carbon footprint

Dr. Stijn Mattheij., Jos Gunsing MSc. [1], Peter Boeijink MSc. [2]

Avans University, Breda, The Netherlands, apm.mattheij@vans.nl, [1]) Avans University, Breda, The Netherlands, jtg gunsing@avans.nl, [2]) LR Systems, Amsterdam Schiphol-Rijk, The Netherlands peter.boeijink@lrsystems.com

Both civil and military aircraft need a new paint job about every 6-7 years. The first step in the process involved is the removal of the existing paint. Today, there are many choices in conventional depainting systems, including mechanical abrasive as well as chemical removal techniques. Abrasive removal of paint is labor intensive, depainting utilizing chemicals results in lots of waste. Robot technology offers many advantages over conventional methods. A high power laser beam removes the paint layer by layer, and can be programmed to leave the primer intact. The software controlling the robot knows the three dimensional shape of the aircraft, and optical sensors allow for fine tuning the position of the laser beam. The laser technique requires no chemicals, less materials and less labor.

Climate change is one of the biggest challenges of this time. The temperature increase of the earth's atmosphere, also known as the greenhouse effect, is stimulated by natural and anthropogenic sources of CO_2 and other greenhouse gases. The key phenomenon of the greenhouse effect is the ability of these gases to absorb radiant energy. These gases trap infrared radiation in the form of heat which is emitted via the sun by the earth's surface, causing an increase in temperature of the atmosphere. A carbon footprint is an index that represents the impact of an activity or product on the environment. For example, the carbon footprint for the production of electricity using average technology used in the Netherlands is 560 grams/kWh. There are several different definitions of carbon footprint in use from different types of sources. However, for this study the definition of the carbon footprint is "the total sets of greenhouse gas emissions caused by a product or event".

Carbon footprint: Amsterdam case

We have investigated the carbon footprint for a typical depainting job for a Boeing 777-300ER aircraft at Amsterdam airport. Currently, a combination of abrasive (for the wings and the tail) and chemical de-painting (for the body) is used. A typical de-painting job takes about 36 hours. In the past, the most popular method of chemically stripping aluminum skinned aircraft was methylene chloride. It is an effective stripping method that quickly removes old paint and primer. However, methylene chloride is a suspected carcinogen, causing the industry to switch over to lower toxicity chemicals such as benzyl alcohol. The relevant processes that contribute to the carbon footprint are the

production of chemicals, abrasive paper, gloves, plastic foil and tape to prevent migration of dust to vulnerable components, and to a lesser extent the use of electricity for the machinery. The chemicals are only effective at elevated temperatures, for this reason the hangar (with a volume of 300,000 m^3) has to be heated up to a temperature of 25 degrees Celsius.

The LCR process (see figure 1) utilizing a laser robot requires a high electric power of roughly 200 kW. Typically two robots working in parallel are used. The laser beam removes the paint (layer thickness 300 microns) layer by layer (thickness: 10 microns) in successive passes. This has the advantage that the primer layer (thickness 50 microns) can be left intact. This is an important advantage over the conventional method, which can only remove the painting as a whole. The application of a fresh primer layer containing Chromium VI has important health issues, and the production of the primer results in CO2 emissions. The process of removing the paint is exothermal, and a substantial part of the heat of burning the paint and the electrical heat generated by the robot itself can be recovered.

The results of the carbon footprint analysis are shown in figure 2. For the conventional method by far the most important contribution results from the heating of the hangar. The removal of the primer and the use of materials contribute to a lesser extent. The contribution from the use of electricity is almost insignificant. For the LCR process the major contribution to the carbon footprint results from the use of electricity, but the recovery of heat gives a substantial negative contribution to the footprint. The contribution from the use of materials is negligible. The results show a clear advantage in carbon footprint for the LCR method: for a de-painting job we find a carbon footprint of 44000 kg of CO_2 equivalents for the conventional method and 14400 kg for the LCR method.

Carbon footprint: Singapore case

Singapore has a warm climate with monthly average temperatures of more than 25 degrees Celsius. Therefore, heating the hangar to facilitate the chemical removal of paint is unnecessary. Electricity production in Singapore is mainly produced from natural gas, comparable to the Dutch situation. This leads to a much lower footprint for the conventional method of 15700 kg and 18700 for the LCR method, so there is no advantage for the LCR system in terms of carbon emissions, see figure 2. However, the situation for low carbon intensive electricity production using solar photovoltaic systems is very beneficial in Singapore. The annual solar irradiation has a value of 1600 kWh/m^2 (to be compared with 1000 kWh/m^2 in the Netherlands) with little variation over the season (in the Netherlands there is a strong seasonal variation, making a PV system much less attractive). The carbon footprint of the production of electricity in Singapore using PV systems includes only the production of the PV systems themselves and has a value of 30 grams/kWh. The carbon footprint for a de-painting job in Singapore utilizing the LCR method in combination with PV electricity has a value of 1760 kg, much better than all other de-painting alternatives.

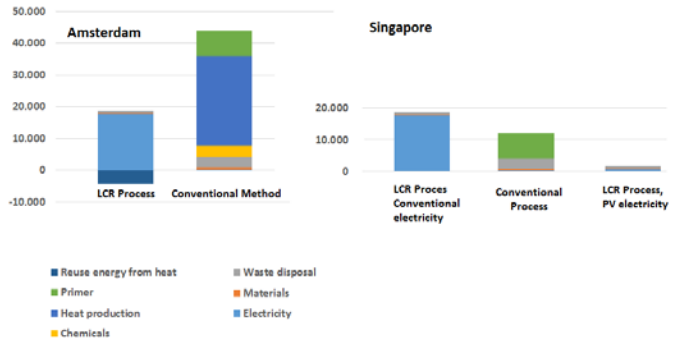

Figure 2 Carbon footprints (in kg CO_2 equivalents) for conventional paint stripping and the LCR process in Amsterdam and Singapore.

Conclusion

De-painting an aircraft utilizing the LCR method has a lower carbon footprint than a conventional technique at Amsterdam, mainly due to the need to maintain the hangar at a temperature of 25 degrees during the de-painting job. In a warmer climate such as in Singapore there is no need to heat the hangar, and with conventional electricity the conventional method has a lower carbon footprint. If electricity from a PV system is used, then the LCR method has by far the lowest footprint. The LCR technique has an additional advantage as it can remove the paint in layers of 10 microns thickness: thus the primer layer can be left intact, which saves on the costs of a primer layer and reduces the health related problems due to working with Chromium VI based paint.