

①

a)

• Surface preparation

Advantage

Limitations

The two surfaces must match very closely due to the narrow weld seam otherwise the materials won't join.

• Weld integrity.

Advantages.

Due to the low heat that laser welding is capable of, it ~~also~~ is less ~~the~~ likely to have an adverse or negative effect on the strength of the substrate.

Limitations.

• The weld seam is very precise but narrow laser welding doesn't have very good penetration either especially on copper together this can cause a weak joint.

• exclusion of atmosphere

Advantage.

Laser welding unlike other electron beam operation does not need to be done under vacuum and can be performed at atmospheric pressure.

Limitation

Shielding gasses are still needed to reduce oxidation and impurities. Also different shielding gasses have ~~the~~ effects on the process such as penetration, weld profile, plasma reduction and embrittlement of some materials.

• Potential defects

Advantages.

By using nitrogen as a shielding gas ~~there~~ on Inconel 625 ~~porosity~~ there is no porosity.

Limitations.

Solidification cracking is a likelihood due to the weld profile having a high width to depth ratio.

• distortion

Advantages

laser welding uses low heat and very precise beam this allows very little distortion.

Limitation

Due to the laser ^{shooting electrons and} contacting the surface instead of a current moving electrons within the material causing the heat the material heats from the outside in ~~this~~ this could cause the top and bottom layers of the substrate to behave differently.

① b)

i). Argon gas is denser than air therefore requiring less flow rate than other gasses.

• Helium requires high flow rates due to ~~its~~ its low density. it also requires high voltage to allow the arc due to its resistance to ionisation.

• hydrogen is used for Aluminium, titanium, nickel and some stainless steels. it improves molten metal fluidity and enhances cleanliness of the surface. it can cause hydrogen embrittlement though.

②
a)

i) Thermal Spraying is a kinetic based application process that relies on the speed of the heated accelerated particles to mechanically bind with the substrate.

Due to this it is prone to delamination and once the coating thickness increases, different operations have different thicknesses that they are able to reach before this occurs. Wire spray being better than HVOF for example. ~~Surface preparation~~

grit blasting must be done before hand in order to create a key for the ~~part~~ coating to bind to.

~~This~~ This coating doesn't deal with impact well.

Compare this to weld cladding which is a fused coating ~~the~~ where the substrate and coating are fused together with heat this is a much stronger coating that is less likely to laminate but will deform sheet or long material.

ii)

~~that the different types HVOF is better~~

HVOF has a better oxide content than wire spraying due to the increased velocity that the particles are sprayed, this reduces the time that they are in the air and limits how much the ^{particles} oxidises before impacting the substrate.

Compare that to weld ~~cl~~ cladding that can use a shielding gas to prevent the heated coating from coming into contact with ~~the~~ oxygen.

iii) Thermal spraying can be done by hand but a lot of safety equipment is required to safeguard the operator. Overspray and bounce back can occur ~~the~~ where the particles ricochet and could hit the operator. Robots are usually used to apply the coatings also as they can do this more evenly but then this has to be isolated so that operators do not get struck by the equipment. This is the same for weld cladding as this can also be done by robot. Weld cladding can produce carcinogenic and toxic fumes, therefore must be done with adequate ~~vent~~ ventilation. The arc in weld cladding is also a hazard so eye protection must be worn.

② b)

Alloys

Nickel $\wedge$ resists creep at high temperatures do to the high concentration of interstitial elements increases the lattice strain in the crystallisation sites thereby resisting dislocations that cause creep.

③ a)

i) Sorting procedures for metals are ~~enter~~ based upon their properties such as density, conductivity, magnetic permeability and melting point.

The main method for sorting ferrous and non ferrous materials is whether they are magnetic or not. This can be done quickly and at scale whereas finer categorisation can be done with a spectrometer but this would be slow as each individual piece would have to be tested.

An eddy current separator is used to separate small non-ferrous contaminants ~~from~~ from ~~the~~ ferrous metals and non metallic

so that contamination doesn't occur, by using magnetic properties to propel the material into separate bins off of a conveyor.

Spectroscopic plastic identifier relies on air to blow material into bins ~~pre~~ after they have been identified the limitation of this is if material is covered by another layer of material whilst on the conveyor being scanned.

ii) Non metallic impurities such as Sulphur, Silicon and phosphorous tend to form inclusions in the steel. Whereas metallic impurities such as copper, tin, lead and Zinc tend to segregate at the grain boundaries of steels, and therefore effect their processing and mechanical properties. ~~Due~~ due to Chromium, nickel and molybdenum are common alloy additions to steels. They are not normally a problem at low levels.

Polymer contamination of each other is a major issue due to the effect it has on the hydrocarbon strain structures.

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b)

i) Austenitic SS

- ↳ melting temp $1370-1450^{\circ}\text{C}$
- ↳ ~~high~~ very high toughness and ductility
- ↳ has a high thermal expansion.
- ↳ is non-magnetic.
- ↳ good weldability.
- ↳ has a carbon content of above ~~0.25~~ 0.25%.
- ↳ Chromium between 16-26%.
- ↳ 7-22% Nickel.

ii) Ferritic SS

- ↳ melting temp $1400-1530^{\circ}\text{C}$
- ↳ moderate toughness ~~and~~, Ductility and Thermal expansion.
- ↳ is ferro magnetic.
- ↳ Limited weldability.
- ↳ Carbon content of 0.2% maximum.
- ↳ Chromium 11.5-27%.
- ↳ ~~Nickel 0-2.5%~~ No nickel.
- ↳ can't be heat treated due to low carbon content.

iii) Martensitic SS

- ↳ $1400-1530^{\circ}\text{C}$ melting point.
- ↳ 0.15-1.2% Carbon
- ↳ 11.5-27% Chromium
- ↳ 0-2.5% Nickel.
- ↳ is magnetic
- ↳ can be tempered by heat treatment.
- ↳ poor weldability.

④

- a) Life cycle based carbon accounting takes into account the carbon produced in the manufacture running and disposal of the product (car). Although the ~~fuel~~ fuel savings from the reduced weight would decrease the carbon emitted during the running of the car ~~the overall~~ ~~to~~ due to the aluminium. But the manufacture of aluminium requires electrolysis which is a very energy dependant process. Aluminium is predominantly produced in China due to their cheaper energy costs by using coal power compared to Scandinavias reliance on renewable energy. This ~~reduces~~ reduces the aluminiums cost but increases the overall carbon produced for the lifetime of the car. Carbon exporting is the term used to describe this increase in carbon emissions due to the ~~economic~~ financial gain of the companies.

b)

Toyota

$$\text{emissions } 0.258,5 \times 250,000 = 64,625 \text{ kg}$$

material	$800 \times 1.2 =$	960 kg
	$800 \times 14.5 =$	11,600
	$300 \times 1.2 =$	360
	$50 \times 9 =$	450
	$120 \times 1.5 =$	180
		78,175 kg of carbon.

Land Rover

$$\text{emissions } 0.240 \times 250,000 = 60,000 \text{ kg}$$

Materials	$375 \times 14.5 =$	5,437.5
	$800 \times 14.5 =$	11,600
	$300 \times 1.2 =$	360
	$50 \times 9 =$	450
	$120 \times 1.5 =$	180
		78,027.5 kg of carbon.

c)

Aluminium recycling uses far less energy than (95%) making Aluminium from raw material, therefore producing vehicles from recycled materials would reduce carbon emissions.

As aluminium production is mostly done in China and imported due to their ~~car~~ fossil fuel electrical supply, countries export their carbon production by importing from China. This carbon footprint could be reduced by paying more for the material to allow greener energy sources to be used to manufacture the aluminium.

The lifecycle carbon footprint could be reduced by manufacturing electric cars instead of fossil fuel cars out of the aluminium.