Vitronics Soltec

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Determination of the allowable load on component leads in upside down reflow

Introduction

In case of double sided reflow it is interesting to know if a component that will be upside down transported in the second reflow process will keep its position without fixing the component by glueing.
This depends on the weight of the component and on the amount and design of the soldered joints.

The bonding mechanism

Due to the surface tension, liquid solder that wetted metal parts has the capability to 'hold' these parts in contact with the liquid as long as the separation force between these parts and the liquid is not exceeded.
When the solder is in a liquid state, this separation force depends on the fysical dimensions of the parts to be joined and on the surface tension of the solder.

A practical test to get an idea how strong that force will be is to look at the last part of a wetting balance test force curve, where the product is removed from the solder.
The 'spike' in the graph represents the separation force.
When we compared this force with the circumference of the tested product from different tests, we found values in a range of 9 - 13 mg/mm. The lower value was found for smaller components which is in agreement with paragraph 2.2.2 from the book 'Soldering in Electronics Second Edition' by R.J. Klein Wassink, where we see that smaller leads gives a relative lower adhesion force due to less solder rise at smaller leads.

In fact wen the part has a very small surface or circumference this value approaches to zero.
Due to this it is theoretically not possible to give a fixed calculation value which can be used over the whole range of joint structures. On the other hand in most cases even small leaded SMD-solderjoints have a circumference that is > 1 mm per joint.

Practical calculation value

If we take a safety factor of at least 2 into account for small vibrations etc., we can use a component weight calculation value of 4 mg/mm joint circumference.
It is important that here the smallest joint dimension should be used for the calculation. This is in most cases the lead (footpad) circumference and not the pad dimension on the board.

If we assume that the measured circumference for a lead will get (for the liquid solder) the shape of a 'circular' surface, we can calculate that the load for joints with a circumference of 1 mm is about 50 mg/mm^2.

This figure fits well with the formula used by P. Zarrow, where Cg/Pa < 30 g/in^2.
Cg is component weight in grams and Pa is the sum of the joining pad surfaces in square inches.
(30 g/in^2 = 46.5 mg/mm^2)

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As long as each individual joining surface is small (< 0.1 mm^2) this formula can be safely used.
In other cases it is better to use the joint circumference as basis for the calculation of the allowable component weight, since that will end up in a lower allowable weight value G.

In other words: as long as the component weight G (expressed in mg) is smaller than 4 times the total circumference of the lead parts in the solderjoints (expressed in mm), the component can be used for upside down reflow in a second reflow process.

In formula: **G (mg) < 4 × Total joint circumference (mm)**