Finite Element modeling of Welding processes
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Lecture - 06
Advances in laser micro welding

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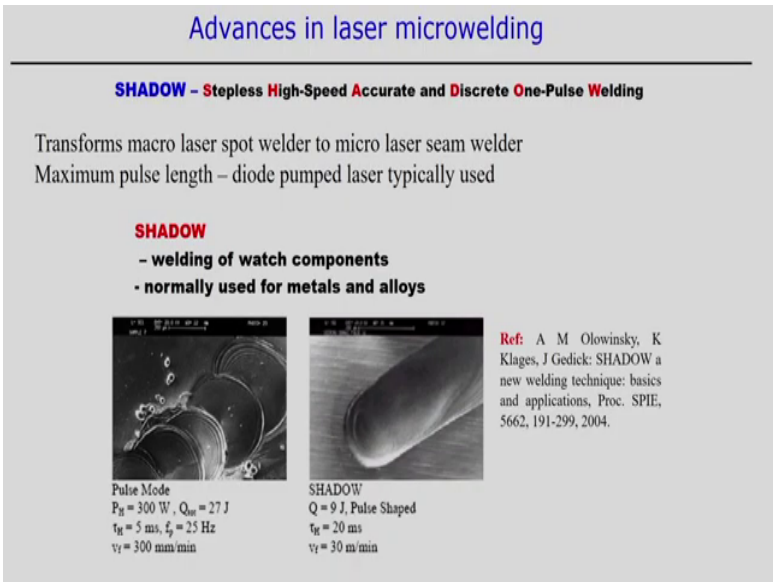

We can see that there are lots of application of micro joining in several medical devices and we find out that typical microwelding process all associated with the laser microwelding processes and most of the cases. Now, we will try to look into that what are the Advances in laser microwelding process which is can be used in a very specific application that we will try to look into that; one of them is that is called SHADOW technique.

SHADOW technique is full form is here Stepless High speed Accurate and Discrete One pulse Welding. Which is simply conversation of macro spot welding to the linear microwelding process.

So, its like that only by utilizing the optimum length of the pulse duration. So, how it works? We can see that most of the cases this SHADOW technique has been developed using the diode pump laser normally typically used and mainly applicable for the metallic materials.

So, simple application we can see that welding of the watch components and we can find out the application of this SHADOW technique.

But how it works? If we look into this picture, we can see that first one it is the pulse mode welding also, but in this case it is spot welding's overlapping of the spot and the surface appearance does not seems or good.

And pulse energy is around we can see that 27 Joule and pulse power peak power can be used 300 Watt. Similarly, some frequency is there and the pulse duration or even velocity also there and even that is the velocity is 300 millimeter per minute. So, in that condition we can see simply overlapping of the pulse already it is joining, but the appearance is very bad in this sense.

But now the same laser can be converted to in the SHADOW technique in such a way that utilize this duration of the on single pulse duration which pulse on time. Then expand these things over the substrate material, but at very high speed; that means, such that total pulse duration can be used, but at the same time within that duration, it will cover in certain distance.

Then, the appearance of the surface can be very good also as compared to the what we used earlier. So, that is called the SHADOW technique simple pulse laser can be converted to the SHADOW technique. We can see the right hand side figure also, in this case is Q equal to 9

Joule only; pulse shape, definitely pulse welding use and pulse duration 20 millisecond and v f is very high 30 meter per minute.

Until we can see the appearance and the total length over which the energy is laser energy is deposited it seems very smooth, as compared to the what was the earlier. So, this is called the simple called the shadow technique we normally used in the metallic materials.

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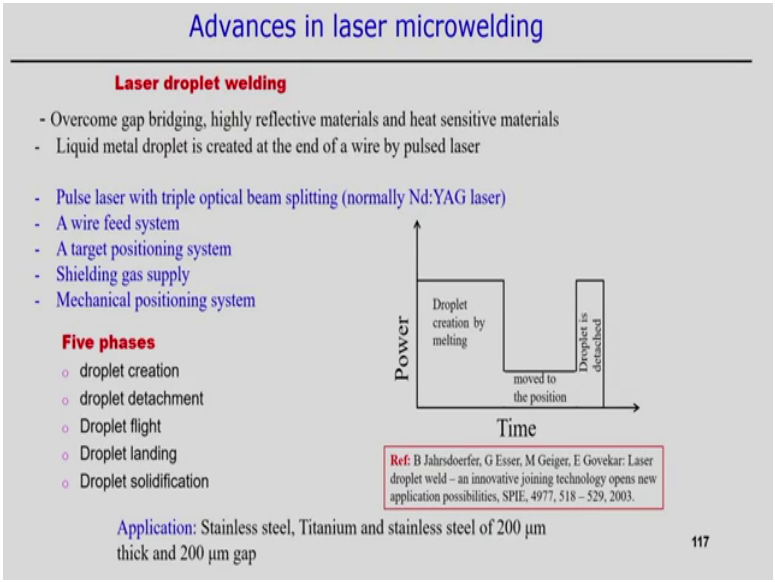

There are other advances also in laser microwelding that is one of them is the laser droplet welding. In this case, laser droplet welding overcome the gap bridging it is a gap between these two components of situation or some devices; it is like that only or highly reflective material and high heat sensitive material. In that particular situation, the laser droplet welding can be used to join the to micro component.

So, in this case what way we can; what way it works is the liquid metal droplet is created and that exactly droplet is projected in the particular position, at the end of the wire by the pulse laser. So, by using the pulse energy or during the pulse energy period, there is a droplet transfer happens and droplets is transported to particular or projected to a particular position such that some specific welding.

For example, very high heat sensitive material and there is a gap between these two components is there such that two metals can be joined using this droplet.

But there are several phases for droplet creation; in this case the laser all energy not directly used for the creation of the droplet the; in this cases the optical beam can be splitted in the three different split beam can be created, a wire feed system is also required a target positioning system. So, where the droplet has to be transport at this that positioning system is required; at the same time laser welding associated some amount of the shielding gas supply.

And of course, mechanical positioning system such that the droplet can be exactly positioned in the particular position; in the required position. So, there are five phases; first droplet creation we can see that how the power varies with respect to time in this particular process. So, droplet creation by melting at; the by using some wire in this case so that maximum power can be used here.

Then, droplet detachment; once the droplet created then detachment of the droplet has to be there. Then droplet flight, so droplet can transferred from the detached at the end of the wire, to a particular position.

Then droplet landing is at which point droplet is landing or the substrate material, after landing the in proper position then after solidification happens. So, these are the typical five phases are involved in the laser droplet welding process and we can see that how power varies with respect to time also.

Once the droplet creation by melting, then move to the position then requirement of power is very less and then over a short span of time; the droplets detached means power requirement is various such that droplet can be detached from the solid wire, then it is transported to the particular position. So, this the typical nature of the power versus time in this particular laser droplet welding process; application; stainless steel, titanium and stainless steel up to micrometer thick and to 200 micrometre gap.

So, if 200 micrometre thickness steel and in that cases; if you want to join, if there is a 200 micrometre gap, this is big enough as compared to the thickness of the material and that may be significant in case of the microwelding application. So, in that case 200 micrometre is a huge gap and that kind of situation can be handled by using the laser droplet welding process.

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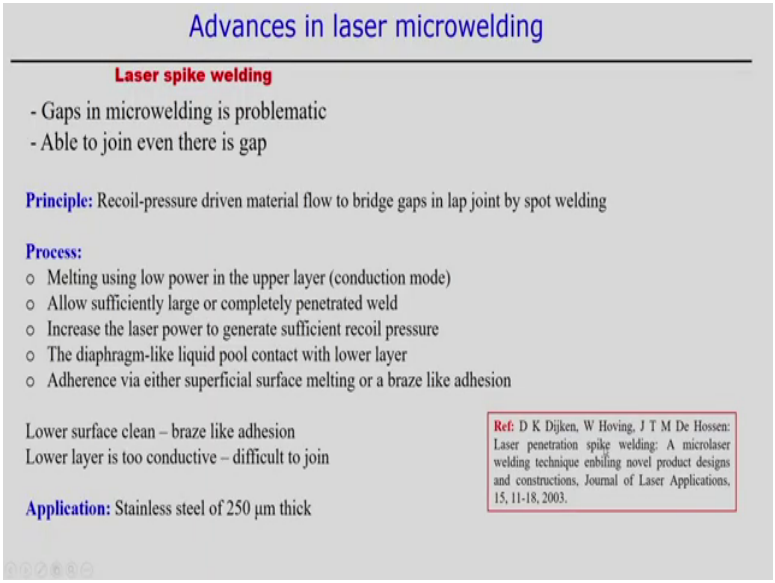

Similarly, other also laser spike welding that is also has also been developed in the for the microwelding application. In this case, gaps in microwelding is problematic definitely; it is always problematic and able to join even there is a gap; that means, this is also one kind of the if there is a gap; then using the laser spike welding the join metals can be joined together.

In this case, recoil pressure driven material flow to bridge the gaps in the lap joint configuration. So, this particular process is mainly developed in case of the lap joint configuration is there; the suit to see it can be joined together simply so, by using the recoil driven material flow on the top surface and that will bridge the gap between these two components..

It is just simply if in the lap joint configuration; if two sheets are there, but if there is some gap between these two sheets; so we try to make on the top layer melt it and then create the recoil pressure such that it will the molten material from the top layer, it will attach to the bottom layer. Its a kind of; then two materials can be joined, in this cases even there is a gap between these two sheets.

So, melting using low power in the upper layer; conduction mode and alloy sufficient large or completely penetrated weld because upper layer has to be in such a way that complete penetration should happen in this cases. Then increase the laser power to generate the sufficient recoil pressure such that gap can be the gap between these two can be filled by using the molten material. The diaphragm like liquid pool is basically contact with the lower layer. So, it is a kind of diaphragm some curvature has been created by using the from top layer and that it is contact with the bottom layer.

So, adhesion like the via either superficial surface melting or braze like adhesion can also be possible. So, in principle; the join can be done what which principle the brazing normally happens. So, that is why bridge like joint can be possible using this laser spike welding process. Lower surface clean; the bridge like adhesion is there if the surface clean is not good enough, then lower layer is too conductive then it is very difficult to join.

See, if lower layer is too conductive; then heat will be conducted a then very difficult to join in this particular process; these are the two issues associated with this process. Even application stainless steel 200 micrometre thick in lap joint configuration can be joined using the laser spike welding process.

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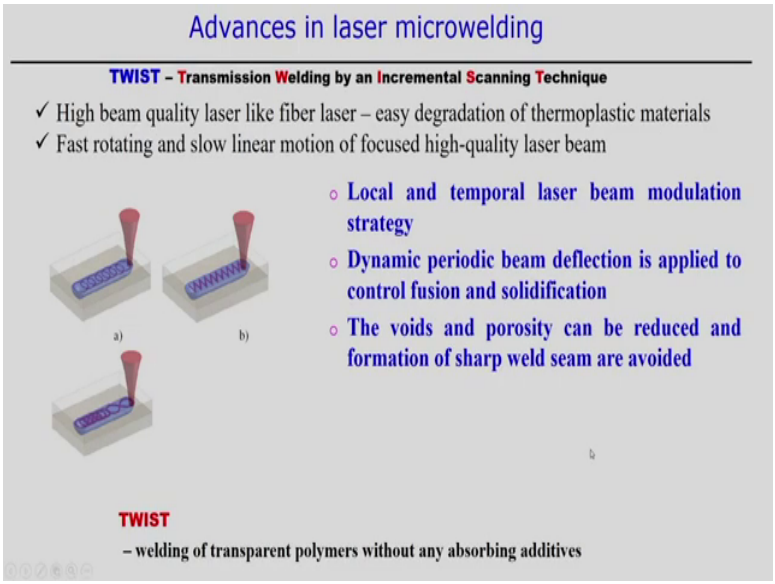

Similarly, other advancement also happens in the laser microwelding process and that is normally associated with the polymeric material; that is called the twist technology. Twist technology is transmission welding by an incremental scanning technique. So, in this case high beam energy like fiber laser and may be used and easy degradation of the thermoplastic material in the normally happens using this fiber laser.

But in this case, first rotating and the slow linear motion of the focused high quality laser beam such that; if we look into this figure, the beam can be deflected in such a way that it is not exactly moving you know one linear path, rather the beam can move with the zigzag way.

So, therefore, both local and temporal laser beam modulation strategy has to be adopted in this case of the twist technology and dynamic periodic beam deflection is normally applied to control the fusion and solidification.

So, once dynamic periodic beam deflection is associated with such that solidification can be controlled in these cases; if there is a voids and porosity can be reduced by using this technique and even formation of the sharp weld seam can also be avoided because formation of the sharp weld seam; it is a continuously move in an particular in a scanning path in the linear state scanning path; so sharp interface can produce.

But rather in this case, if the beam is deflected in such a way that it will cover the zigzag way; then bonding between the two surfaces can be well enough such that distortion can be minimized in this particular process. So, that is called the twist technology and this welding of the transparent polymers without any absorbing additives can be used.

Because actually it is a variant of the laser transmission welding and which is normally used for the polymeric material. In this cases, the laser light is transparent to the particular polymer; then it is very difficult to make the absorption of the laser interface. But once you develop the twist technology; instead of looking moving in a particular linear path, if it is possible to follow some kind of the zigzag path; then absurdity of the laser may happen at the interface or even for a transparent material or for a particular laser light.

So, that is why this without using any additive absorbing additives at the interface between the two surfaces, this kind of laser; this technology can be used the absorption of the laser and making the variation of the laser transmission welding; of course, the mostly it is applied in case of the in for microwelding component; microwelding purposes.

So, thank you very much for your kind attention and we have actually discussed on the last part; the simply advancement of the several laser welding processes. Now, we will try to see the remaining part of the module maybe you can say the last part of the module 1; that is to some extent related to the additive manufacturing technologies.

So, thank you very much you.