Researches Concerning LASER Welding of Diagnosis and Control Module

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This article deals with weld quality in reference to strength and seal using in experiment quasi-simultaneous laser thermoplastic welding, method for PA 6.6 GF 35, base material. In laser welding of thermoplastics, sometimes referred to as „laser transmission welding" or „through transmission IR welding (TTIr)", transparent and absorbing parts are bonded together. The laser beam penetrates the transparent plastic and is converted to heat in the absorbing plastic. Since both parts are pressed together during the welding process, heat is conducted from the absorbing to the transparent plastic, allowing both materials to melt and create a bond. Internal joining pressure is also generated through the local warming and thermal expansion. Almost all thermoplastic materials and elastomeres can be welded with the LASER beam – including ABS, PA, PC, PP, PMMA, PS, PBT, as well as glass fibre reinforced plastics. The strength of the welding seam is comparable with the base material strength.

Keywords: laser thermoplastic welding, transparent plastic, internal joining

These researches were carried out to evaluate quasi-simultaneous welding for use with the PA 6.6 GF 35 base material.

The internal and external joining pressures ensure strong welding of both parts, figure 1.

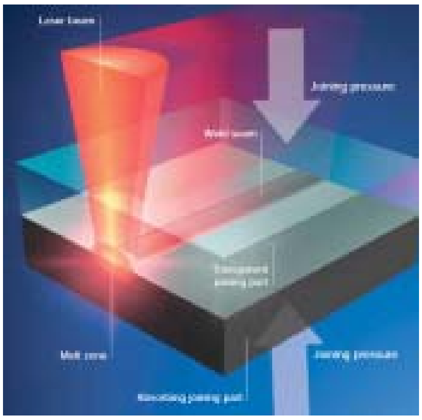

Fig. 1 Thermoplastic laser welding principle

Quasi-simultaneous [1] welding makes use of high-precision, high-accuracy galvo-scanning mirrors. A single laser beam is fed into the mirror system and the laser traces the entire weld seam multiple times rapidly. Because of the high travel speed of the laser the entire joint is essentially being heated "simultaneously," hence the term quasi-simultaneous. This welding method is widely used and has quite a few advantages. The most notable advantage is the flexibility of the method. The scanning mirror system is controlled by software allowing for contour/pattern changes to take place instantly. This is massively important for prototyping, situations where multiple applications run through the same line or frequently changing applications. A secondary advantage is the quick cycle times. Although, not quite as fast as simultaneous welding the cycle times are comparable. This method is mainly used for two-dimensional parts, minor z-axis changes can take place, but the majority of applications have flat upper surfaces, figure 2.

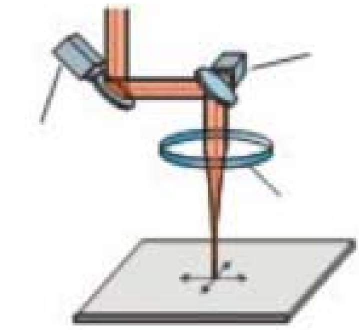

Fig. 2 Quasi-simultaneous welding method

Joint quality can mean a variety of different things depending on who is asking and for what application. A quality weld to one engineer could mean a strong hermetic seal and to another it could refer to a clean and consistent weld for aesthetic reasons.

There are three categories of factors that play into the quality of a weld:

Materials

Concerning material importance for a good quality the factors are:

- melting temperature;
- chemical compatibility;
- fills;
- amorphous v. semi-crystalline;
- additives;
- colors-degree of weld difficulty, figure 3

Part/geometry

Important from this point of view are:

- upper layer thickness;
- collapse rib;

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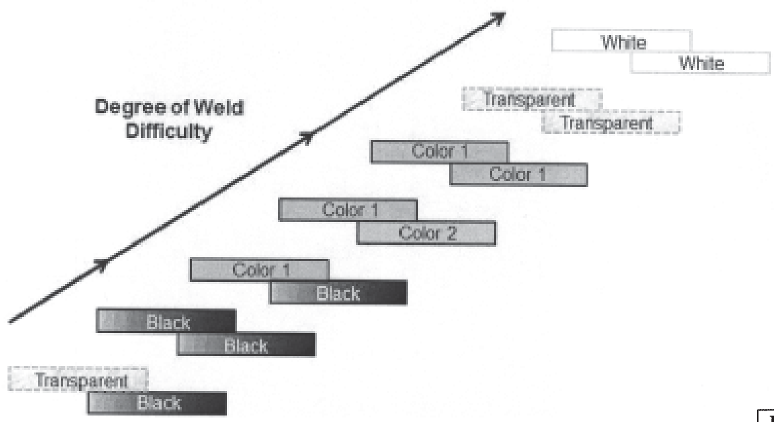

Fig. 3 Thermoplastic laser welding-degree of weld difficulty

- part tolerances;
- beam access;

Process

Characteristics involve the folowing:

- there are 4 major process types: contour welding, simultaneous welding, quasi-simultaneous welding and hybrid welding. See the figure 2, for clarification on this process;
- radiation wavelength - thermoplastics are transmissive to laser radiation between 880 to 1070 nano meters, with variances between types of plastics
- laser power/energy;
- clamp tooling;
- nesting;

Experimental part

The material tested was PA6.6 GF 35, which is glass fibre reinforced polyamide and heat aging resistance injection moulding grade for industrial items such as gear wheels, solenoid valve housings, cable attachments, automative fuel distributors and components for automative gearshift. The test samples were a welding cover and a housing both from PA6.6 GF 35 [4].

Sampling and experimental protocol

A scanning laser system was utilized for the quasi-simultaneous welding process [3]. The laser was a high-power diode laser with the following parameters:

- wavelength: 808 ± 10 nm.
- maximum output power: 150 W continuous.
- beam size: 2.0 mm x 2.0 mm
- maximum speed: 10,000 mm/s

Samples were welded using a single beam a quasi-simultaneous method to compare weld strengths and collapse.

Energy density (1) was used to compare results under various welding conditions. The energy density was calculated as follows:

$$E = \frac{P*N}{B*S} \quad (1)$$

where:

E=energy density
P=laser power
N=number of passes
B=beam size
S=welding speed

where laser power is in watts, beam size in mm, welding speed in mm/sec, and energy density is J/mm^2. The number of passes is the number of times the laser beam scanned across the weld specimen in the quasisimultaneous method.

Table 1
WELDING CONDITIONS

Power (W)	Weld speed (mm/sec)	Number of passes	Clamping Force [N]
130	150	30	2000
140	150	25	2000
150	150	20	2000

Results and discussions

Table 1 shows the welding conditions. The amount of collapse linearly increases at low energy density and becomes level at high energy density [2]. Quasi-simultaneous welding is produced without collapse, figure 4.

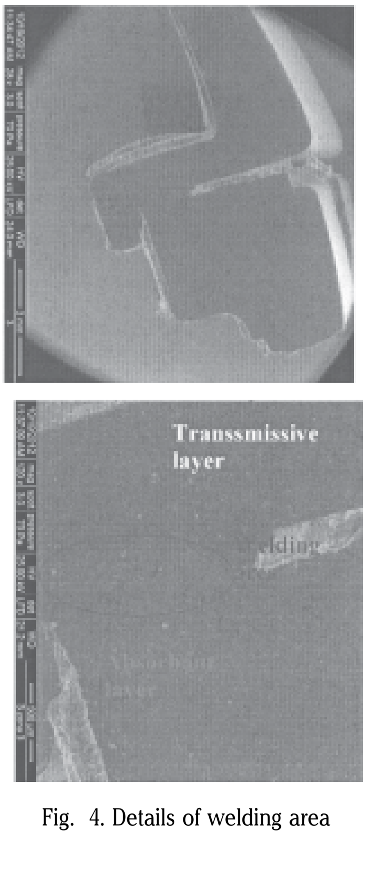

Fig. 4. Details of welding area

The weld strengths like test method was measuring by burst test. For the samples made at 130W power, the test passes at 4 bar. Allways the cracking was in parent material not in the weld. For the samples made at 140W power, the test passes at 5.5 bar. For the samples made at 150W power, the test passes at 8 bar, figure 5

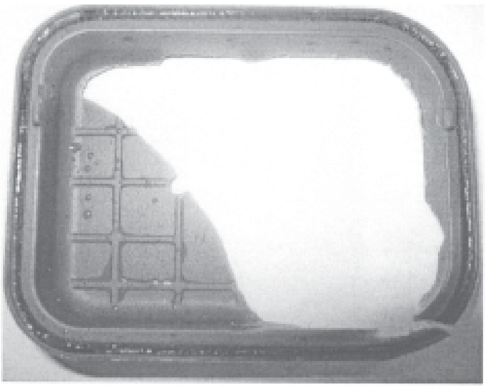

Fig. 5. Cracking cover during burst test

Conclusions

Laser plastic welding has ushered in some great advantages as a new and quickly growing welding technology and each methods has its own set of nuances.

None of the method of laser plastic welding is better than the next. Each method brings its own advantages and drawbacks to the table. Determining which method is right for your application is not typically a difficult process. What you need to consider when determining your laser plastic welding method are your priorities (cycle-time, capital investment, flexibility) and your part geometries.

It is important to point out that a large variety of factors that play into the quality of a joint make it difficult to create universal statements on what makes a good weld or a bad one. All these factors should be considered, but is not necessary to be all applied.

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