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MULTI-PHASE SMOOTHED PARTICLE HYDRODYNAMICS (SPH) MODELLING FOR LASER MICROMACHINING

Copyright Registration Number: 284680429

PRODUCT DESCRIPTION

This invention overcomes the problem to model the laser micromachining process by introducing meshless method. Conventional modelling methods using generated mesh have been problematic in capturing the melt splashing or droplets during the material removal in laser machining.

SPH is differ from the conventional methods due to the meshless characteristics which are able capture the physical process in laser micromachining with high accuracy down to micro/ nano scale without requiring massive computer resources. It is also allows for flexibility in domain creation where water can be included underneath the metal to model wet machining.

COMMERCIAL POTENTIAL

This invention has high potential for laser machining industry which is useful in predicting the process parameters and product quality after laser processing for different type of materials.

NOVELTIES

- The meshless method, SPH is introduced for the first time to capture the physical process in laser micromachining applications provides an important contribution to the field of laser processing.
- Meshless characteristics allows for flexibility in domain creation
- Able to model the physical process of laser micromachining with high accuracy

Physical process to be captured in SPH model

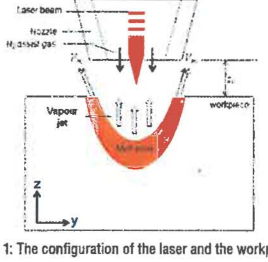

Figure 1: The configuration of the laser and the workpiece.

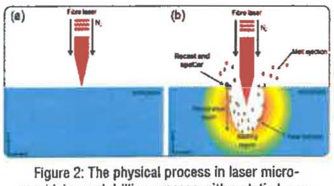

Figure 2: The physical process in laser micro-machining and drilling process with a static beam, (a) initial arrangement (b) Partial penetration depth.

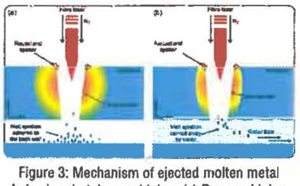

Figure 3: Mechanism of ejected molten metal behaviour in tube machining, (a) Dry machining and (b) Wet machining

PROCESS FLOW

This work developed a smoothed particle hydrodynamics (SPH) model to simulate the three-phase laser micro-machining process. The open-source code SPHysics is used to model the interaction between the laser beam and workpiece. This enables the melt flow behaviour in the non-linear pulsed fibre laser micro-machining process to be modelled. The developed model considers the conversion of laser energy into heat within a very thin surface layer, heat conduction into the parent material and the phase transition between solid, liquid and vapour. Water is also incorporated in this model to help explain the mechanism in laser wet micromachining. It is demonstrated that the meshless characteristics of SPH are able to model the droplets ejected from kerf where it is difficult for conventional modelling.

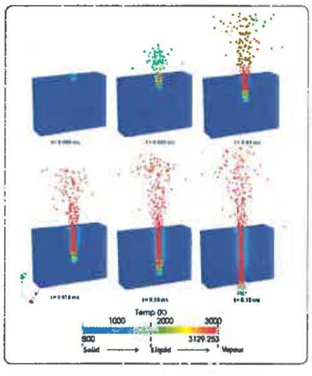

Figure 4: Cross section of the workpiece showing the phase changes. Full depth penetration with single pulse (Peak power, P_p = 100 W, pulse duration, τ = 0.15 ms).

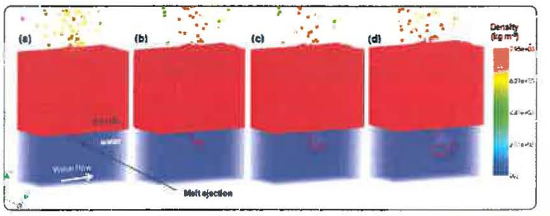

Figure 5: Snapshots of melt ejection time history during wet cutting (water velocity, Vw = 0.241 ms^{-1}), (a) 0.15 ms (b) 0.175 ms (c) 0.2 ms and (d) 0.25 ms.

PRODUCT ADVANTAGES

- Meshless (no mesh or grid required)
- Reduce time (mesh generation, computing time, trial time)
- Reduce cost (computing resources, trial cost)
- High accuracy (able to capture ejected droplets at scales as small as micro/nano scale)

In Collaboration with

MANCHESTER 1824
The University of Manchester

PUBLICATIONS

1. Muhammad, N., Rogers, B.D., and Li, L., Understanding the behaviour of pulsed laser dry and wet micromachining processes by multi-phase smoothed particle hydrodynamics (SPH) modelling, Journal of Physics D: Applied Physics, 2013. 46: p. 1-13. (IF: 2.528)
2. Muhammad, N. and Li, L., Underwater femtosecond laser micromachining of thin nitinol tubes for medical coronary stent manufacture, Applied Physics A: Materials Science and Processing, 2012. 107(4): p. 849-861. (IF: 1.545)
3. Muhammad, N., Whitehead, D., Viejo, F., Boor, A., Oppenlaendar, W., Liu, Z., and Li, L., Characteristics of picosecond laser micromachining of nitinol and platinum for coronary stent applications, Applied Physics A: Materials Science and Processing, 2011. 106 (3): p.607-617. (IF: 1.545)
4. Muhammad, N., Whitehead, D., Boor, A., and Li, L., Comparison of dry and wet fibre laser profile cutting of thin 316L stainless steel tubes for medical device applications, Journal of Materials Processing Technology, 2010. 210 (15): p. 2261-2267. (IF: 1.953)

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