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Optimizing the Defocused CO_2 Laser Micro channeling Process Using ANN Method

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ABSTRACT

Micro channels were created using a CO2 laser on a transparent xilymeric substance called polymethyl meth-acrylate in this study (PMMA). Many micro fluidic devices, such as gas chrornatographs, biological testing kits, and chemical sensing equipment, use PMMA as a substrate material. it is one of the most popular polymeric materials due to its exceptional optical transparency. Although many studies have utilized CO2 lasers to fabricate micro channels on PMMA for a long time, the poor surface texture of the micro channel walls makes industrial application difficult. Fabricating micro channels in a defocused position is a cost-effective and simple way to achieve a high surface polish in this procedure. The research methodology will be based on ANN method was used as a optimization tool and to verify the observations taken. Using TOPSIS method simple and step by step mathematical formulas were applied to conclude the result and rank the observations according to their importance and ANN method is applied using MATLAB software.

KEYWORDS: Optimization, ANN, Laser, Observations, Materials

Introduction

CO2 lasers are commonly used in industry to cut a wide range of materials. Despite t he fact that high-power co2 lasers are used to mill almost all sorts of materials, low-power CO2 lasers are particularly suitable for polymeric materials. 1n micro fluidic devices, many of these polymeric materials are used as substrates. Although typical materials for such devices have been glass and silicon, transparent polymers such as Polyrnethyl Methy acrylate (PMMA) have emerged as a potential alternative. Micro channel creation on glass and silicon is difficult and time consuming resulting in costly microfluidic devices. Optimization is the methodology for obtaining the best alternative from all possible ones.

Many disciplines of study use optimization methods to find solutions that maximize or minimize particular research characteristics, such as reducing expenses in the manufacturing of a product or service, increasing earnings, reducing raw materials in the development of a product, or increasing productivity.

1.1 Experiment

In a defocused state, a 60w CO2 laser was utilized to generate micro channels on PMMA substrates. A conventional approach was used to measure the diameter of the beam at the focusing plane. The diameter of t he beam was discovered to be 237 microns. Five different defocusing planes, each I mm below the focusing plane, were chosen for testing. More than 5 rum of defocused distance caused excessive micro channel widths, hence using more than 5 mm of defocused distance was found to be more than appropriate. Micro channeling procedures often produce the following output parameters. Microchannel width, depth, surface roughness and heat affected zone (HAZ) are all things to think about. Figure1.1depicts the various defocusing planes used in this experiment. A side from defocusing distance, the energy deposit ion (j/rum) ratio of beam power to scanning speed was chosen as an additional input parameter. Energy deposition was modified at five different 1ebels based o n multiple pilot investigations. 0.1 I/mm, 0.l5J/run, 0.2 I/mm, 0.25 I/mm and 0.3 I/rum are the different units of measurement.

HAZ- heat-affected zone, SR- surface roughness, D- rnicrochannel depth, W- micro channel width, d- defocusing distance, E- energy

Table 1.1 Responses and experimental design

Exp. n»	E fJ/--›	d I--)	W (pm)	D (pm)	SR (pm)	HAZ (pm)
I	0.3	3	35 1	542	0.65	104
2	0.2	5	430	245	0.07	108
3	0.15	2	269	300	I .96	85
4	0.2	2	282	390	I .67	87
5	0.2	1	247	492	4.92	85
6	0.1	5	337	110	0.05	100
7	0.3	1	279	705	3.7	94
8	0.1	2	252	187	2.12	78

9	0.15	3	310	255	4.44	92
10	0.1	3	278	164	0.87	80
1 1	0.25	5	445	334	0.09	1 10
1 2	0.2	4	370	300	0.26	10 I
13	0.2	3	329	340	0.87	96
14	0.15	1	240	355	4.44	80
15	0.25	4	390	385	0.1S	106

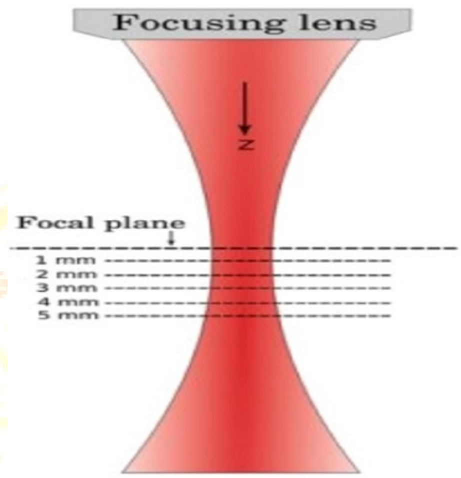

Figure 1.1 Defocused planes that are 1 mm apart were investigated

(Shashi Prakash and Subrata Kumar, 2016)

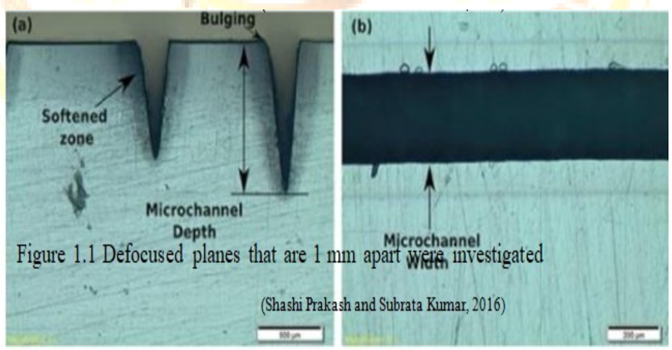

Figure 1.2 On PMMA, the output characteristics of a laser micro channeling

(Shashi Praka sh and subrata K umar, 2016)

1.2 ANN Method

The artificial neural net work (ANN) model uses computations and mathematics to mimic human brain operations. Image and speech recognition, rotxitics, and the usage of artificial neural net works are Just a few of t he recent advances in artificial intelligence research (ANNs). The ANN models architecture is influenced by that of a biological nervous system. Like the real brain, ANN models are made up of a complex and non-linear network of neurons. The neurons are linked together via weighted connections. All of the operations in ANN models, including data collection and analysis, network of hidden layers, network simulation and weights/bias trade-off, are computed using learning and training

Pattern classification, prediction and contro1 and optimization are three areas of ANN applications that handle real-world issues across a wide range of scientific domains, from finance to hydrology. ANN models use a variety of ANN model designs to perform clustering, classification and simulation, Static ANNs, dynamic ANNs and statistical ANNs are the three types of ANN models. Models of multilayer neural net works, Static AN N models include dynamic neural net work models such as tapping delay lines and recurrent neural network models, as well as statistical neural network models such as radial basis function and generalized regression neural network models. 1t's also feasible to combine the ANN model with other optimization methods.

Table 1.2 **Responses and experimental design**

Exp. no	E (J/mm)	d (mm)	W (µm)	D (µm)	SR (µm)	HAZ (µm)
1	0.3	3	351	542	0.68	104
2	0.2	5	430	245	0.07	108
3	0.15	2	269	300	1.96	85
4	0.2	2	282	390	1.67	87
5	0.2	1	247	492	4.92	85
6	0.1	5	337	110	0.08	100
7	0.3	1	279	705	3.7	94
8	0.1	2	252	187	2.12	78
9	0.15	3	310	255	1	92
10	0.1	3	278	164	1.1	80
11	0.25	5	445	334	0.09	110
12	0.2	4	370	300	0.26	101
13	0.2	3	329	340	1.1	96
14	0.15	1	240	355	4.44	80
15	0.25	4	390	385	0.18	106
16	0.15	4	343	235	0.37	95
17	0.3	4	404	450	0.15	114
18	0.25	2	297	524	1	97
19	0.25	3	340	454	0.87	98
20	0.3	5	465	385	0.1	120
21	0.1	1	212	237	6.67	76
22	0.3	2	302	620	1.3	100
23	0.15	5	365	185	0.1	102
24	0.1	4	319	135	0.5	90
25	0.25	1	267	600	3.36	90

Figure 1.3 Neural network

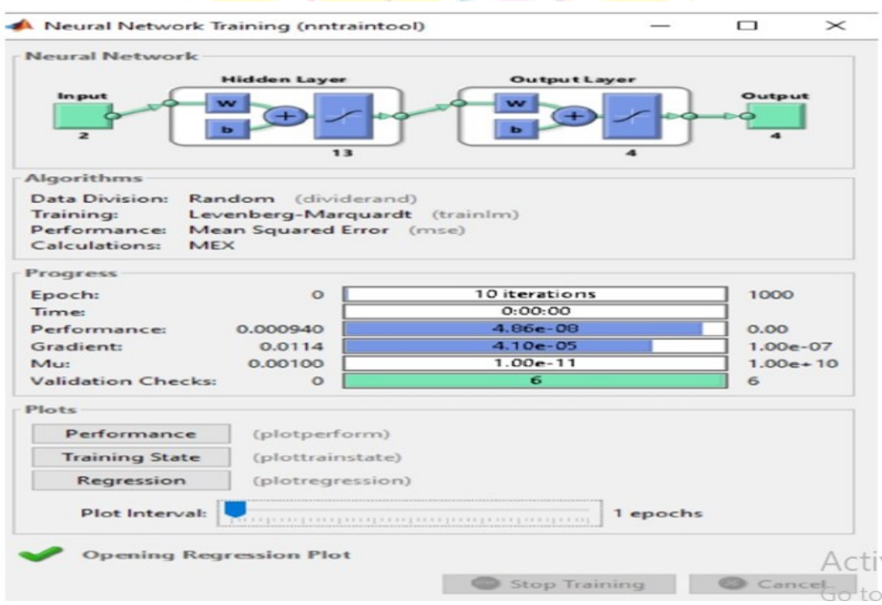

Figure 1.4 Neural network training

Conclusion

According t o ANN analysis, the Best validation performance is 0.00046956 at epoch 4. The performance, training, regression plot coincides with the ideal value line. The ANN output value is approximately similar of that of t he target value set in the starting. ANN error generated is also negligible.

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