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ORIGINAL ARTICLE

Effect of process parameters on the cutting quality in lasox cutting of mild steel

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Abstract Samples of mild steel have been cut on a CO_2 laser machine using the principle of laser assisted oxygen cutting (LASOX). The combined effects of input process parameters (cutting speed, gas pressure, laser power and stand off distance) on cut quality (heat affected zone (HAZ) width, kerf width and surface roughness) have been studied. Regression analysis has been used to develop models that describe the effect of the independent process parameters on cut quality. Using the developed model, we attempted to optimize the input parameters that would improve the cut quality (minimization of HAZ width, kerf width and surface roughness), increase the productivity and minimize the total operation cost. We found from the study that the gas pressure and cutting speed had pronounced effect on cut quality. Low gas pressure produces lower HAZ width, lower kerf width and good surface finish whereas increase in speed results in higher HAZ width, lower kerf width and good surface finish.

Keywords HAZ · Kerf width · Laser cutting · Surface roughness · Thick steel cutting

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1 Introduction

Lasox cutting is achieved by a combination of laser power and the power produced by the exothermic reaction of iron and oxygen. This exothermic reaction produces vast amounts of power which helps in carrying out the cutting process. In the traditional laser cutting process, the exothermic reaction [1, 2] contributes only around 25% of the total cutting power. In lasox cutting process the power produced by the exothermic reaction is increased to around 80% and the laser power is used only to facilitate this exothermic reaction. This produces a vast amount of energy, which can be used for cutting of thick carbon steel greater than 50 mm [3] thickness.

A special nozzle is used which is capable of operating at high stagnation pressure, high exit mass flow rate and high exit velocity. The important factor is to make sure that all the oxygen react with Fe to produce power. This is achieved by having the diameter of the laser foot print higher than the diameter [3] of the gas jet. To achieve this nozzle assembly with a short focal length lens is used. The focal point is kept inside the nozzle assembly and the diverging beam is used for heating the metal surface. Figure 1 shows the schematic arrangement of laser assisted oxygen cutting process.

Of particular interest to manufacturers using lasox cutting are the maximization of the productivity and the obtainment of subsequent quality of components made by the lasox cutting process. Both these aspects are governed by the selection of appropriate process parameters, which are unique for each material and thickness. The combination of the cutting speed, gas pressure, laser power and stand off distance is of paramount interest for obtaining good cut quality. In fact the lasox cutting input parameters determine the quality of cut. These parameters are usually

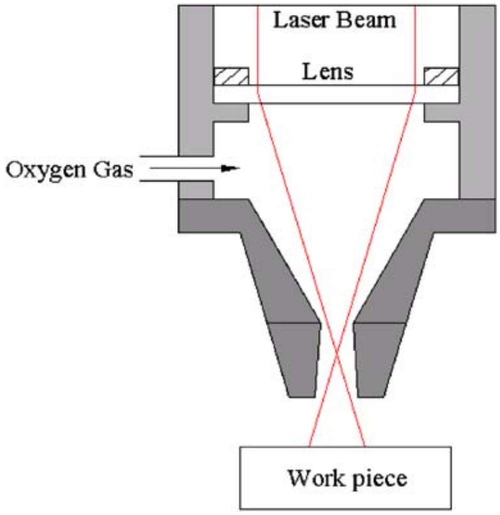

Fig. 1 Schematic diagram of lasox cutting

adjusted and tuned to provide the quality of cut desired, but this consumes exhaustive amounts of time and effort, and still good quality cutting conditions may not be found. If a different type of material is to be cut, then this procedure has to be repeated. Lasox cut quality cannot be easily predicted due to the dynamic nature of the cutting process, and it is particularly obvious when cutting ferrous alloys using oxygen as an assisting gas.

Steen and Kamalu [4] and Decker et al. [5] suggested that there is an optimum range of cutting speeds for a given material, thickness and beam power. In the optimum range, a thermal power balance is maintained between the exothermic burning and laser resulting in a parallel sided kerf and relatively smoother surface. Beyond this range, the thermal balance is not maintained and the cutting process becomes unstable [5]. Ivarson et al. [6] suggested that formation of striations occurs because of cyclic variations in the driving factor of oxidation reactions, which are related to the oxygen partial pressure in the cutting zone. Increasing the assist gas pressure has been shown to increase the cutting speed but to impair surface roughness. Both kerf width and size of the HAZ width are found to decrease with increasing cutting speed and decreasing gas pressure. The optimization of input process parameters for the laser cutting of lower thickness have been studied in the past by many researchers [7, 8]. Statistical methods have been used by various researchers [9–11] for process parameter optimization and prediction in many applications.

In this work a detailed parametric study has been conducted to investigate the combined effects of cutting speed, gas pressure, laser power and stand off distance on HAZ width, kerf width and surface roughness. Statistical analysis has been used to determine the level of significance of the process parameters and to determine correlation models that can be implemented for determining optimum cutting conditions. The statistical models developed and optimized for the cutting quality are very useful to identify the correct and optimal combination of the input variables, in order to obtain superior cut quality at relatively low cost.

2 Experimental setup and experimental design

Experiments have been conducted using an indigenous 2.5 kW CO_2 laser machine at School of Laser Science and Engineering, Jadavpur University, India to study the effect of input process parameters of lasox cutting process. The nozzle has been aligned so that the laser beam is at the centre and the diverging laser beam is focused on the surface of the plate. The beam diameter at the surface of the plate is set at 3.0 mm to facilitate all the oxygen gas react with Fe to produce power. The lens system used to focus the laser beam onto the work piece consists of a ZnSe lens with 50 mm focal length. The beam, together with the coaxial assisting gases (oxygen), passes through a cutting nozzle. Figure 2 shows the photograph of lasox cutting in operation cutting 50 mm thick low carbon steel.

Trial runs have been carried out by varying one of the process parameters while keeping the rest at constant values. The working range has been decided upon by inspecting the cut surface for acceptable surface roughness. The process variable levels [12, 13] with their units and notations are given in Table 1. Medium carbon steel with chemical composition of 0.17% C, 0.23% Si,

Fig. 2 Photograph of lasox cutting in action

Table 1 Process parameters and limits

Parameters	−2	−1	0	1	2
Cutting speed (mm/min)	400	410	420	430	440
Gas pressure (bar)	5.5	6	6.5	7	7.5
Laser power (W)	900	950	1000	1050	1100
Stand off (mm)	2	2.2	2.4	2.6	2.8

0.052% S, 0.6% Mn and Fe balance has been used as work piece material. The size of each plate is 500 mm long× 100 mm width with thickness of 40 mm. Cutting speed (400–440 mm/min), gas pressure (5.5–7.5 bar), laser power (900–1100 W) and stand off distance (2–2.8 mm) are the independent input variables.

Table 1 shows at a glance the parameters and their levels. The experiment has been carried out according to the design matrix (Table 2) in a random order to avoid any systematic error [14]. To study the HAZ width the samples have been metallurgically polished and then etched with 4% Nital solution. The samples are then placed one by one under an optical microscope (least count 0.001 mm), and the average HAZ width has been noted by taking readings at various points at the top & bottom and the average is taken. The kerf width is measured by low resolution microscope fitted with an x-y table. The surface roughness has been measured using a portable surface roughness tester (Taylor–Hobson Surtonic 3+ surface profilometer). Roughness measurements have been taken along the length of the cut at three places and average of three Rz values is recorded. Cut-off length for roughness measurements has been set to be 16 mm.

3 Results and discussion

3.1 Effect of process factors on HAZ width

The HAZ is the area of base material which has its microstructure and properties altered by the heat produced

Table 2 Input design matrix and experimental results

	Input parameters				Output results		
	Cutting speed (mm/min)	Gas pressure (bar)	Laser power (W)	Stand off (mm)	HAZ width (mm)	Kerf width (mm)	Rz (µm)
1	−1	−1	−1	−1	2.53	4.505	31.5
2	1	−1	−1	−1	2.74	4.23	31.5
3	−1	1	−1	−1	2.655	4.955	30.56
4	1	1	−1	−1	2.735	4.895	29.56
5	−1	−1	1	−1	2.385	4.31	29.76
6	1	−1	1	−1	2.52	4.03	28.3
7	−1	1	1	−1	2.465	5.055	26.5
8	1	1	1	−1	2.64	4.49	24.36
9	−1	−1	−1	1	2.225	4.18	32.1
10	1	−1	−1	1	2.505	3.975	30.75
11	−1	1	−1	1	2.54	4.84	31
12	1	1	−1	1	2.66	4.49	28.5
13	−1	−1	1	1	2.095	3.965	28.5
14	1	−1	1	1	2.36	3.81	27
15	−1	1	1	1	2.315	4.605	25.3
16	1	1	1	1	2.525	4.29	23
17	−2	0	0	0	1.585	5.165	22
18	2	0	0	0	2.855	3.515	32
19	0	−2	0	0	1.675	3.975	30.85
20	0	2	0	0	2.625	4.89	22.3
21	0	0	−2	0	2.565	4.895	31.8
22	0	0	2	0	1.94	4.015	23.2
23	0	0	0	−2	2.52	4.1	27.2
24	0	0	0	2	1.865	4.54	26.1
25	0	0	0	0	2.1	4.2	27.2
26	0	0	0	0	2.2	4.02	26.5
27	0	0	0	0	2.055	4.325	26.2
28	0	0	0	0	2.325	4.235	28
29	0	0	0	0	2.16	4.2075	27
30	0	0	0	0	2.22	4.025	27.6
31	0	0	0	0	2.175	4.27	27.2

during cutting and subsequent working. The heating during the cutting process and subsequent re-cooling causes this change in the area near the surface of the cut. The effect of cutting speed, gas pressure, laser power and stand off on the width of HAZ is shown from Figs. 3, 4, 5 and 6. Each data point in these figures has been obtained by averaging the HAZ width data along the length of cut and then averaging the top and bottom HAZ width. An increase in gas pressure and cutting speed results in an increase of HAZ width. As the gas pressure increases the power produced due to the exothermic reaction becomes higher and produces higher HAZ width.

In all the cases the top HAZ width is much less than the bottom HAZ width. At the top the cutting of the material is mostly due to the laser power and at the bottom it is due to the exothermic reaction. Obviously the cutting due to laser power produces low HAZ width and the cutting due to exothermic reaction produces higher HAZ width. From the Fig. 4 and Fig. 6 it is well understood that the increase in laser power and stand off distance results in decrease of HAZ width but their effects seems to be negligible than the effect of cutting speed and gas pressure. There is a distinct change in process performance as the laser power level is increased above 900 W. Below 900 W the process is unstable with irregular kerf widths, heavy gouging and rough cut edges. As the laser power is increased above 1050 W the process result is very consistent and the process is independent of any further increase in laser power.

3.2 Effect of process factors on kerf width

Kerf width defines the gap that is produced during cutting. The effect of cutting speed, gas pressure, laser power and stand off distance on kerf width is revealed from Figs. 7, 8, 9 and 10. Each data point in these figures has been obtained by averaging kerf width data perpendicular to the length of cut and then averaging the top and bottom kerf. An increase in cutting speed results in decrease of the kerf width. This is due to the general fact that an increase in cutting speed results in a decrease in side burning. At higher cutting speed the time available for side burning falls, which leads to lower kerf width. In the case of lower cutting speed, the material is heated up to the ignition temperature within a relatively wide zone around the laser beam. This results in the formation of a relatively wide cutting gap at the top surface. Because of the finite thermal conductivity, the width of ignition zone, and thus the kerf width, decreases with an increase in cutting speed. An increase in gas pressure results in an increase in kerf width. As the gas

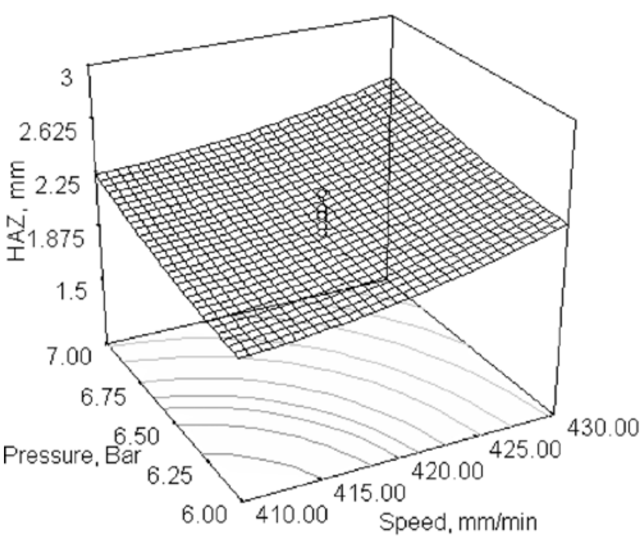

Fig. 3 Effect of cutting speed and gas pressure on HAZ width

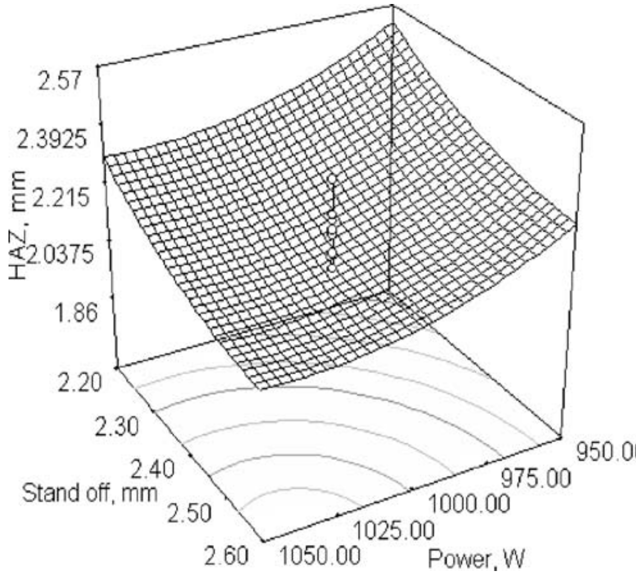

Fig. 4 Effect of laser power and stand off on HAZ width

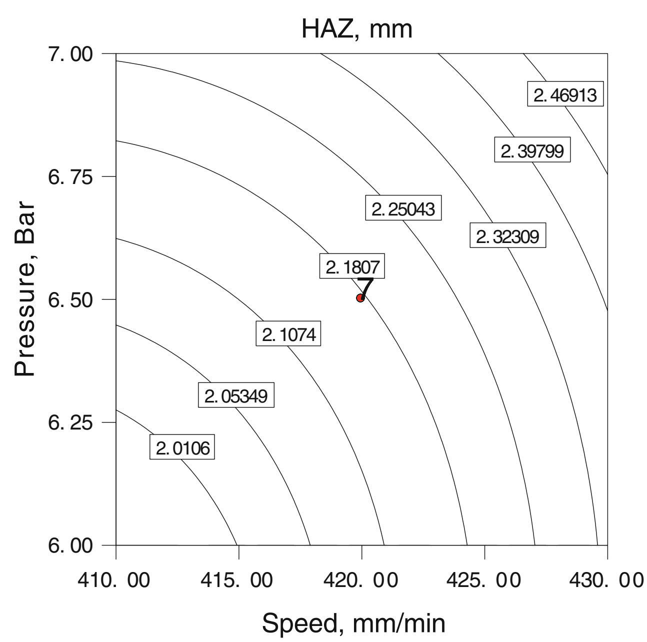

Fig. 5 Effect of cutting speed and gas pressure on HAZ width

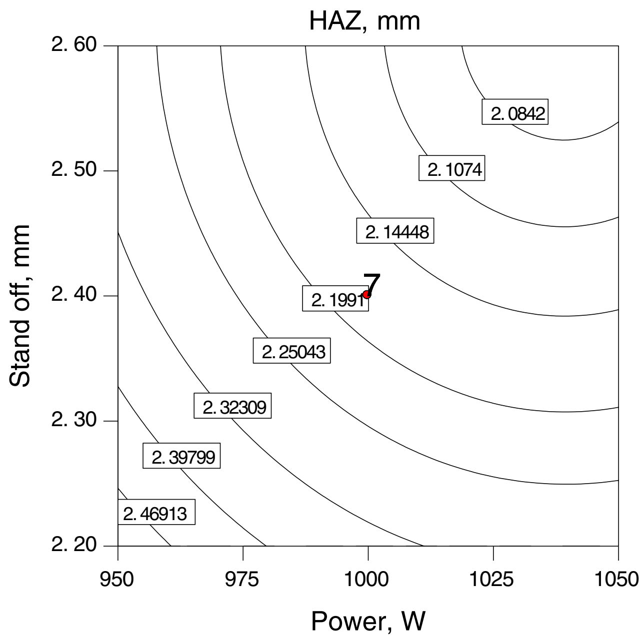

Fig. 6 Effect of laser power and stand off on HAZ width

pressure increases the heat generated by the exothermic reaction increases which leads to high side burning which results in wider kerf width.

There is a noticeable decrease in kerf width with an increase in laser power. Higher powers per unit area increase the thermodynamic stability which results in lower kerf width. As the stand off distance increases kerf width increases to some extent and then its effect becomes insignificant. With high stand off distance the size of the beam impingement over the job increases but the power per unit area decreases. This creates a thermodynamic imbalance which results in an increase in kerf width. Beyond 2.5–2.6 mm the stand off becomes insignificant.

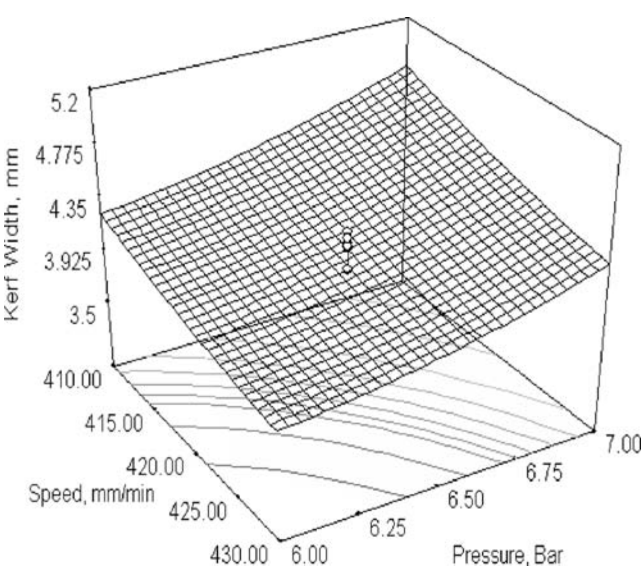

Fig. 7 Effect of cutting speed and gas pressure on kerf width

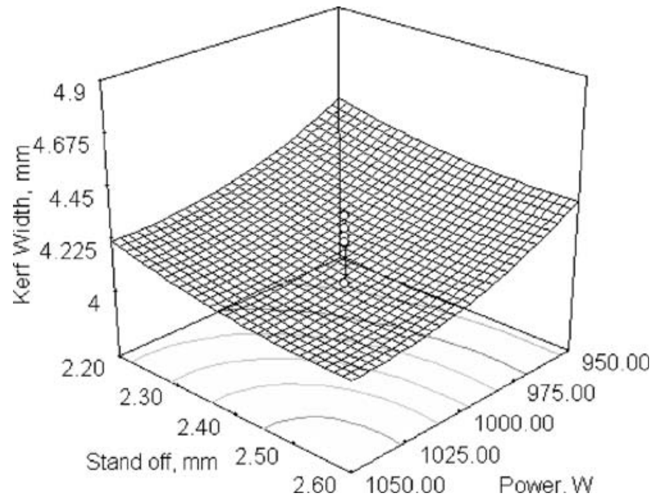

Fig. 8 Effect of laser power and stand off on kerf width

3.3 Effect of process parameters on roughness

The roughness is measured in terms of average maximum height of the profile (Rz). The effect of cutting speed, gas pressure, laser power and stand off on roughness is revealed in the Figs. 11, 12, 13 and 14. Each data point in these figures are obtained by averaging surface roughness measured along the length of cut, for both sides of the cut at three different places. Decrease in gas pressure shows a good decrease in surface roughness. With lower or correct gas pressure there is negligible or very little side burning which results in lower roughness value. An increase in gas pressure produces higher amount of heat than required which give rise to higher roughness. Higher cutting speed

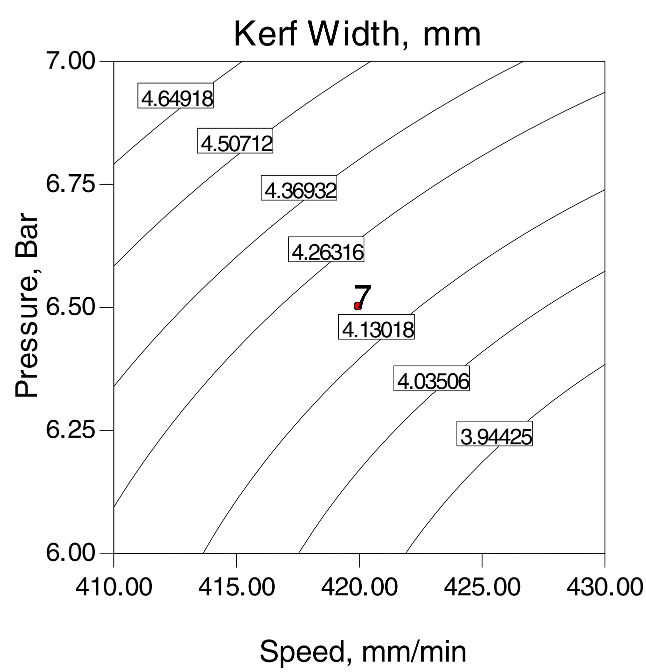

Fig. 9 Effect of cutting speed and gas pressure on kerf width

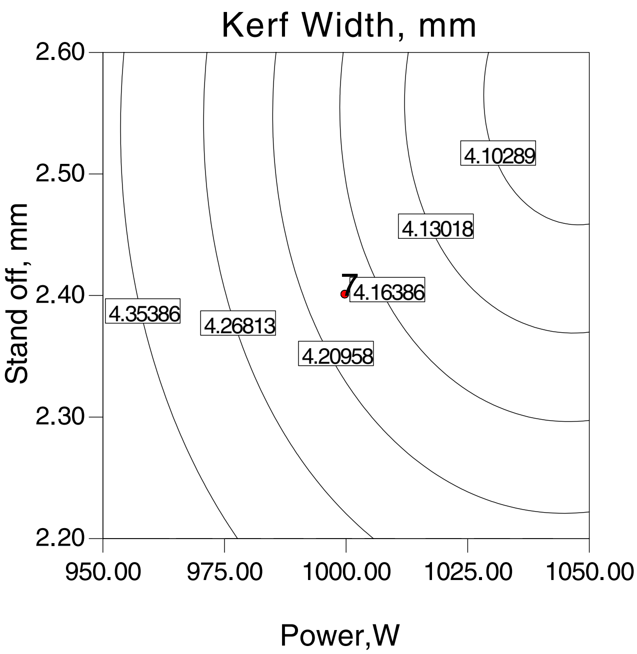

Fig. 10 Effect of laser power and stand off on kerf width

produces low surface roughness value this is due to the fact that as the speed increases the heat generation decreases which leads to minimum side burning.

The effect of laser power on surface roughness appears to be more significant at low laser power levels. An increase in laser power gives good surface roughness in the lower laser power levels. This is because laser cutting is less stable at low laser power levels beyond a range of 1000 W increase in laser power becomes insignificant. This is because the threshold of the good exothermic reaction lies in 1000 W beyond that the laser power doesn't contributes much for cutting. The effect on stand off distance on roughness seems to be very less significant.

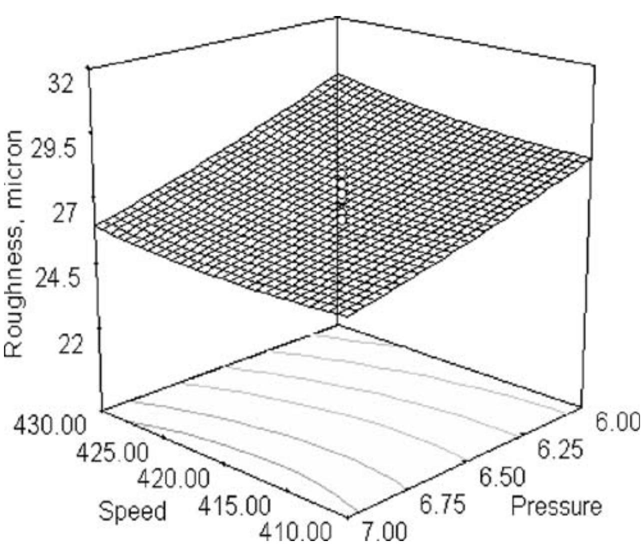

Fig. 11 Effect of cutting speed and gas pressure on surface roughness

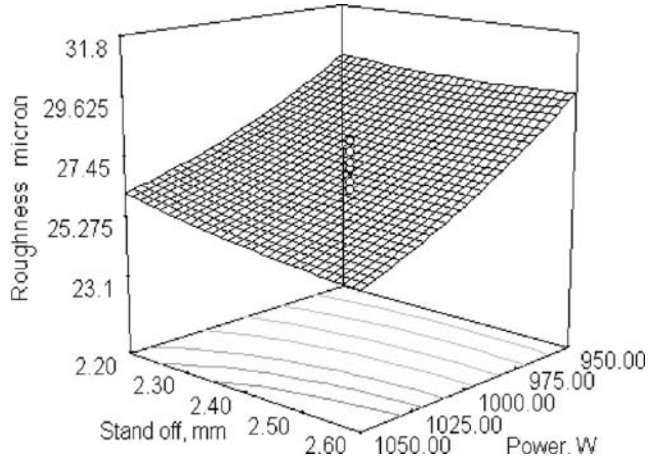

Fig. 12 Effect of laser power and stand off on surface roughness

4 Statistical analysis of results

The test for significance of the regression models, the test for significance on individual model coefficients and the lack-of-fit test were performed using Design-Expert statistical package. By selecting the step-wise regression method, which eliminates the insignificant model terms automatically, the resulting ANOVA Tables 3, 4, and 5 for the reduced quadratic models summarise the analysis of variance of each response and show the significant model terms. The same tables show also the other adequacy measures R^2, adjusted R^2 and predicted R^2. The entire adequacy measures are close to 1, which is in reasonable agreement and indicates adequate models. The adequate precision compares the range of the predicted value at the design points to the average prediction error. In all cases the

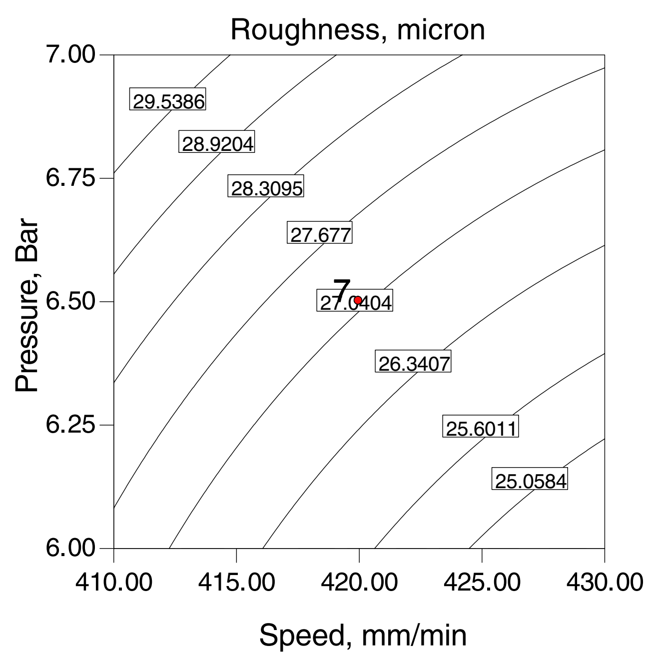

Fig. 13 Effect of cutting speed and gas pressure on surface roughness

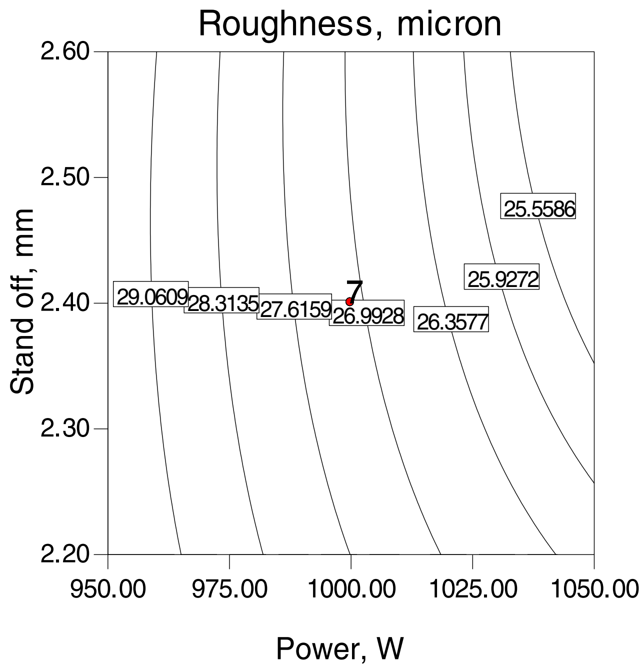

Fig. 14 Effect of laser power and stand off on surface roughness

value of adequate precision are dramatically greater than 4. The adequate precision ratio above 4 indicates adequate model discrimination.

The analysis of variance indicates that, for the HAZ width model, the main effects of all the parameters are significant, but the effect of cutting speed seems to be highly significant. Secondly for the Kerf width model, the analysis indicates that there is a linear relationship between the main effects of the laser power, cutting speed, gas pressure. Moreover the two-level interaction of the laser power and cutting speed are also the significant model terms. Finally, the main effect of cutting speed and the main

Table 3 Anova table for HAZ width

Source	Sum of squares	df	Mean square	F Value	Prob > F
Model	1.95	14	0.14	2.29	0.0572
A-speed	0.67	1	0.67	11.03	0.0043
B-pressure	0.39	1	0.39	6.47	0.0217
C-power	0.27	1	0.27	4.4	0.0523
D-stand off	0.32	1	0.32	5.19	0.0368
AB	5.8E-3	1	5.8E-3	0.095	0.7614
AC	5.6E-4	1	5.6E-4	9.2E-3	0.9245
AD	4.7E-3	1	4.7E-3	0.078	0.7842
BC	1.5E-6	1	1.5E-6	2.5E-5	0.996
BD	0.018	1	0.018	0.29	0.5953
CD	1.4E-5	1	1.4E-5	2.3E-4	0.9881
A2	0.1	1	0.1	1.64	0.2181
B2	0.05	1	0.05	0.82	0.38
C2	0.13	1	0.13	2.13	0.1642
D2	0.078	1	0.078	1.28	0.2738
Residual	0.97	16	0.061		
Lack of fit	0.93	10	0.093	12.28	0.0031
Pure error	0.045	6	7.5E-3		
Cor total	2.93	30			

R-squared=0.6671, Adj, R-squared=0.3759, Pred R-squared=−0.8491, Adeq precision=6.009

Table 4 Anova table for kerf width

Source	Sum of squares	df	Mean square	F value	Prob > F
Model	3.84	14	0.27	4.41	0.0029
A-speed	1.26	1	1.26	20.28	0.0004
B-pressure	1.73	1	1.73	27.8	<0.0001
C-power	0.45	1	0.45	7.18	0.0165
D-stand off	0.086	1	0.086	1.38	0.2576
AB	8.7E-3	1	8.7E-3	0.14	0.712
AC	0.211	1	0.211	1.12	0.3759
AD	1.5E-3	1	1.5E-3	0.024	0.8785
BC	7.6E-5	1	7.6E-5	1.2E-3	0.9725
BD	3.9E-5	1	3.9E-5	6.2E-4	0.9803
CD	8.2E-4	1	8.2E-4	0.013	0.9097
A2	0.055	1	0.055	0.88	0.3626
B2	0.13	1	0.13	2.05	0.1712
C2	0.15	1	0.15	2.41	0.1399
D2	0.043	1	0.043	0.69	0.4187
Residual	1	16	0.062		
Lack of fit	0.91	10	0.091	6.61	0.0156
Pure error	0.083	6	0.014		
Cor total	4.84	30			

R-squared=0.7941, Adj R-squared=0.614, Pred R-squared=−0.1106, Adeq precision=7.999

Table 5 Anova table for surface roughness

Source	Sum of squares	df	Mean square	F value	Prob > F
Model	222.17	14	15.87	6.98779	0.0002
A-speed	47.46	1	47.46	20.89912	0.0003
B-pressure	57.75	1	57.75	25.43118	0.0001
C-power	101.89	1	101.89	44.86556	<0.0001
D-stand off	2.40	1	2.40	1.056973	0.3192
AB	0.28	1	0.28	0.124862	0.7284
AC	0.07	1	0.07	0.030342	0.8639
AD	0.15	1	0.15	0.06612	0.8003
BC	4.70	1	4.70	2.068759	0.1696
BD	0.06	1	0.06	0.025895	0.8742
CD	1.47	1	1.47	0.647374	0.4328
A2	1.85	1	1.85	0.812782	0.3807
B2	0.62	1	0.62	0.275116	0.6071
C2	4.11	1	4.11	1.809318	0.1973
D2	0.79	1	0.79	0.349339	0.5627
Residual	36.34	16	2.27		
Lack of fit	34.08	10	3.41	9.046529	0.0070
Pure error	2.26	6	0.38		
Cor total	258.50	30			

R-squared=0.6969, Adj R-squared=0.4317, Pred R-squared=−0.7076, Adeq precision=6.329

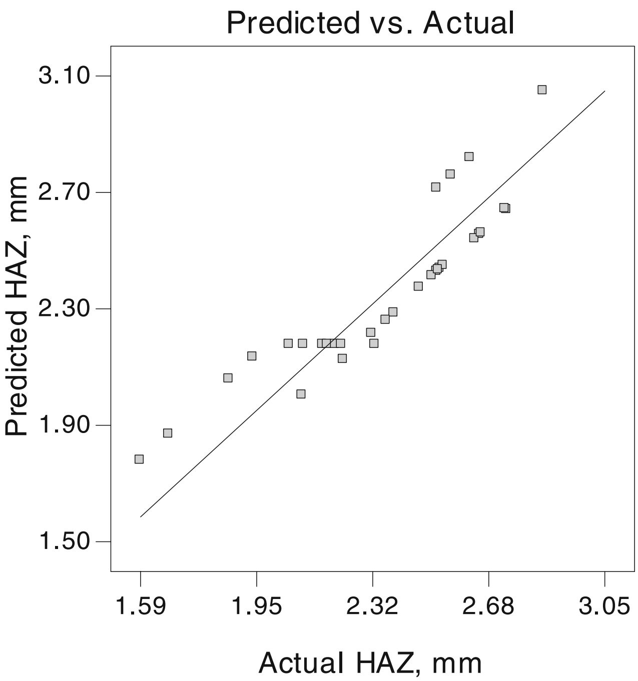

Fig. 15 Scatter diagram of HAZ width

effect of gas pressure are the most significant factors associated with the surface roughness. The Prob > F values, which are greater than 0.1 indicate the model which are all not significant. Values of Prob > F less than 0.0500 indicate that the model terms are significant. A negative "Pred R-squared" implies that the overall mean is a better predictor of the response than the current model.

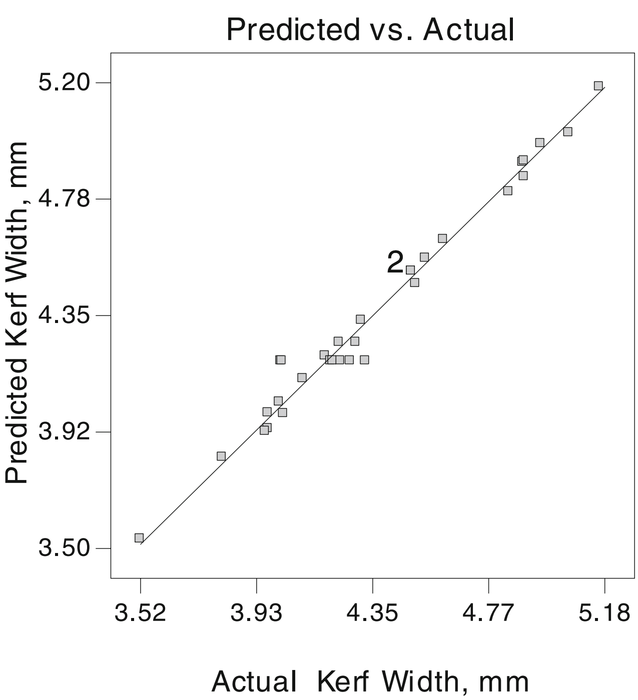

Fig. 16 Scatter diagram of kerf width

The final mathematical models in terms of actual factors as determined by Design-Expert software are shown below:

$$\begin{aligned}\text{HAZ width} = {} & 151.45 - 0.488 \times S - 1.09955 \\ & \times P - 0.061083 \times Po - 12.726 \\ & \times So - 3.8125E^{-3} \times S \times P + 1.187E^{-5} \\ & \times S \times Po + 8.593E^{-3} \times S \times So \\ & - 1.25000E^{-5} \times P \times Po + 0.33438 \\ & \times P \times So + 9.375E^{-5} \times Po \times So \\ & + 5.91741E^{-4} \times S^2 + 0.1667 \times P^2 \\ & \times 2.69196E^{-5} \times Po^2 + 1.30748 \times So^2\end{aligned}$$

$$\begin{aligned}\text{Kerf width} = {} & 105.14 - 0.318 \times S - 1.020 \times P - 0.0372 \\ & \times Po - 6.160 \times So - 4.687E^{-3} \times S \\ & \times P - 5.31250E^{-5} \times S \times Po + 4.843E^{-3} \\ & \times S \times So + 8.75E^{-5} \times P \times Po - 0.0156 \\ & \times P \times So - 7.187E^{-4} \times Po \times So \\ & + 4.372E^{-4} \times S^2 + 0.267 \times P^2 + 2.89E^{-5} \\ & \times Po^2 + 0.9681 \times So^2\end{aligned}$$

$$\begin{aligned}\text{Roughness} = {} & 806.08 - 2.20 \times S - 38.896 \times P - 0.3574 \\ & \times Po + 25.146 \times So + 0.0266 \times S \\ & \times P - 1.3125E^{-4} \times S \times Po - 0.0484 \times S \\ & \times So + 0.0216 \times P \times Po + 0.606 \times P \\ & \times So - 0.0303 \times Po \times So + 2.540E^{-3} \\ & \times S^2 + 0.591 \times P^2 + 1.516E^{-4} \\ & \times Po^2 + 4.164 \times So^2\end{aligned}$$

where S is the cutting speed, P is the gas pressure, So is the stand off and Po is the laser power.

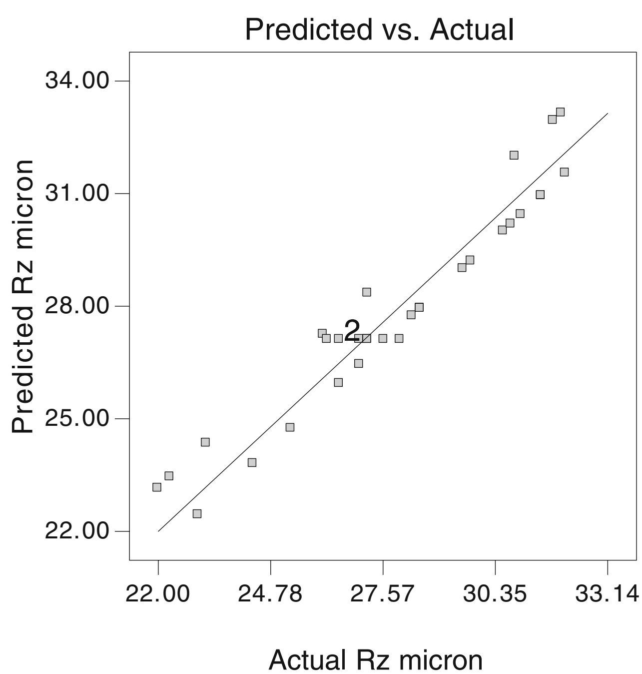

Fig. 17 Scatter diagram of surface roughness

Table 6 Criterion of numerical optimization

Constraints						
Name	Goal	Lower lmit	Upper limit	Lower weight	Upper weight	Importance
Cutting speed	Maximize	410	430	1	1	3
Gas pressure	Minimize	6	7	1	1	3
Laser power	Is in range	950	1050	1	1	3
Stand off	Is in range	2.2	2.6	1	1	3
HAZ width	Minimize	1.585	2.855	1	1	4
Kerf width	Minimize	3.515	5.165	1	1	5
Roughness	Minimize	22	32.1	1	1	3

4.1 Validation of the statistical models

Figures 15, 16 and 17 shows the relationship between the actual and predicted values of HAZ width, kerf width and surface roughness, respectively. These figures indicate that the developed models are adequate because the residuals in prediction of each response are minimum, since the residuals tend to be close to the diagonal line.

5 Optimization

The optimization module in Design-Expert searches for a combination of factor levels that simultaneously satisfy the requirements placed (i.e., optimization criteria) on each of the responses and process factors (i.e., multiple response optimization). Numerical optimization methods have been used in this work by choosing the desired goals for each factor and response. The optimization process involved combining the goals into an overall desirability function. The numerical optimization finds a point or more that maximize this function.

The criterion introduced in optimization minimize HAZ width, kerf width and surface roughness, which are all important for a quality cutting. As seen from the effect of process parameter to achieve this cutting speed is to be kept at maximum, gas pressure should is to be minimum and the laser power and stand off are kept with in the range. The effect of gas pressure and cutting speed seems to be more significant for achieving good quality cut rather than stand off distance and laser power. Table 6 illustrate the goal, lower and upper limits as well as the importance for each response.

Optimization of the cutting process in terms of the output variables of interest means adjusting the process parameters in order to achieve minimum HAZ width, kerf width and surface roughness while maintaining high cutting speeds (high productivity) and low gas pressure. However, the correlation models developed show that optimization of any one quality measure, surface roughness for example, does not mean that the other quality measures will be optimized. It is apparent from Table 7 that process parameters for obtaining minimum width of HAZ will produce maximum surface roughness and low, but not minimum, kerf width. Alternatively, optimizing the cutting process may be performed by defining acceptable values (other than minimum) for the quality measures and by aiming at achieving them by model utilization. The models show that low levels of HAZ width and kerf width are obtained at high cutting speed and low gas pressure, where

Table 7 Optimised parameters

Sl. No	Cutting speed (mm/min)	Gas pressure (bar)	Laser power (W)	Stand off (mm)	HAZ width (mm)	Kerf width (mm)	Roughness (µm)	Desirability
1	427.78	6	1050	2.6	2.158	3.741	27.544	0.718
2	427.09	6	1049.99	2.6	2.132	3.752	27.499	0.718
3	428.76	6	1048.86	2.6	2.150	3.727	27.632	0.717
4	428.02	6	1046.53	2.6	2.165	3.739	27.643	0.716
5	429.77	6	1050	2.6	2.219	3.718	27.673	0.716
6	429.66	6	1050	2.59	2.257	3.713	27.677	0.716
7	429.93	6	1049.76	2.6	2.223	3.714	27.691	0.716
8	425.55	6	1050	2.6	2.095	3.778	27.421	0.715
9	428.93	6	1050	2.56	2.190	3.721	27.707	0.714
10	427.79	6	1050	2.55	2.135	3.739	27.647	0.713

the effect of laser power and stand off is also moderate. By setting an acceptable surface roughness value (other than the minimum), one can select proper settings for cutting.

6 Conclusions

The effects of cutting speed, gas pressure, stand off and laser power on the quality characteristics of lasox cut steel specimens have been studied in this work. Cutting speed and gas pressure plays important role in achieving the desire cut quality in cutting of thick carbon steel.

1. Cutting speed has a major effect on roughness and kerf width. An increase in cutting speed increases HAZ width, decreases kerf width and decreases surface roughness. So the selection of speed should be performed considering optimal HAZ width, kerf width and roughness.
2. Gas pressure has a major effect on all the quality parameters, i.e., HAZ width, kerf width and roughness. An increase in gas pressure from 6.0 to 7.0 bar with a constant laser power, cutting speed and stand off results in an increase of HAZ width from 2.53 mm to 2.655 mm, an increase of kerf width from 4.505 mm to 4.955 mm and surface roughness from 31.5 μm to 30.56 μm.
3. Stand off distance has little effect in determining the cut quality. Laser power contributes an important role only in initiating the exothermic reaction. The exothermic reaction starts only beyond the laser power of 850 W and reaches its optimal point at 1000 W.
4. Regression models for the effect of cutting speed, gas pressure, stand off and laser power on the quality characteristics have been developed. The model predicts the result to good agreement. Based on these models a good understanding of the physics of the laser material interactions, in terms of the quality of the cut and the significant parameters that affect the cut quality can be obtained.
5. The desired high quality cutting can be achieved by choosing the appropriate working condition using the developed models.

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