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Experimental Investigation into LASER Marking on Aluminium 7075 Alloy

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ABSTRACT: Laser marking is one of the best solutions for marking on metals to get the required shape in major industries. In this present work the parametric analysis of laser marking process on the aluminum 7075 has been investigated. Laser power, pulse frequency, duty cycle and cutting speed have been taken as input process parameters to conduct the test. Width and depth of the marked area have been taken as output parameters. An optical microscope, scanning electron microscope (SEM) and surface profile instruments are used to measure the effects of process parameters on the depth and width of the mark. An image-analysis system used to measure the difference marked with a frame-grabber card and a charged-coupler-device (CCD). It was found that the difference in width and marking depth depends on the interaction process of the laser beam and the material, which was dramatically affected. Central composite design (CCD) of response surface methodology (RSM) was taken to generate design of experiment (DOE) to conduct the marking process. Analysis of variance (ANOVA) table has been generated which proves the adequacy of the evaluated regression equation based on the responses. After the test and measurement, optimized set of parameters has been evaluated based on the results. At 88.26 W power, 55 Hz pulse frequency, 90 s duty cycle and 1 mm/s cutting speed an optimum value of 0.19 mm depth can be achieved. 0.06 mm width which is optimum can be reached with 71.80 W power, 69.69 Hz pulse frequency, 56.81s duty cycle and 1.15 mm/s cutting speed.

KEYWORDS: LASER marking; SEM; Response Surface Methodology (RSM); DOE; Al 7075.

I. INTRODUCTION

Marking is the process of creating a mark for a product, the purpose of product identification. There are so many markings methods available, such as ink-marking, mechanical engraving and Electro-chemical methods. Laser marking is a new shining method. The laser is suitable for a variety of operations. Laser marking is one of them. It is the process of using a laser beam to mark or engrave on different surfaces. Today, a number of applications have emerged from this possibility. Laser marking has many advantages comparison with conventional marking methods, e.g. wear equipment, high degree of automation, free programming and character choice. Includes laser TEA CO₂ used in industry for identification of Laser, pulsed or Q-switched Nd: YAG laser and exciter Laser. In recent years, some laser marking experiments reported with different lasers. Tam et al. and Tezuka and Yoshikawa studied laser marking of the interior. Vibrated Nd: Grated Circuit (IC) package with YAG laser or Q-switched YAG laser, respectively. Wayne et al. Stud-Enamel laser marking of enamelware with exciter Laser. Extensive research on plastic laser identification. Various lasers were carried by Hoffman et al. Mark qualities, especially mark clearance, are the most Important in the identification process. To get a clean mark, the appropriate processing parameters must be selected. Laser mainly uses three processing parameters Identification: pulse frequency, electric current and scanning Speed, where the pulse frequency of the laser is a significant impact on mark quality.

Laser identification which is a flexible, programmable and environmentally clean method employs a thermal process that uses a high intensity beam of focused laser light make a reverse mark on the material surface and are used to mark primarily or Print bar codes, matrix codes, universal product codes (UPC) and serial numbers, Etc. (Restrepo et al. 2006). The main application of laser marking is for this purpose Product identification and traceability (Chen and Darling 2005) To compare Traditional marking techniques, such as inkjet, hot stamping or mechanical scribbling, Laser marking offers many advantages such as flexibility, speed, rigidity, reliability-Power, Consumables Free and High Hygiene (Ng and Yeo 2001). Nd: YAG Laser marking has a lot of potential in different types of applications, i.e.

electronics materials, automotive products, jewelry, medical etc. implants and surgeries Instruments, etc. Nd: The width of the line produced by the YAG laser is narrower than this CO₂ laser, which is a major factor for higher resolution. In some cases, the second and Third harmonic ND: YAG laser at 532 and 355 nm, as well as ultraviolet excimer Lasers are the best choice for identifying highly transparent materials. Application Laser technology is pacing the demand from the industry for small geometry an increasingly stringent specification. At the same time, related requirements Quality, flexibility, speed and production cost of marking process. The range of applications in its area is becoming increasingly rigid Product recognition and identification is as follows:

(a) Computer equipment Identify text and graphics in plastic computer peripherals. A complete keyboard can be identified in a single operation.(b) Automotive products Identify text, graphics and part numbers in ball and roller bearing races, Gears, shafts, instrument displays and audio bezels for detection. To mark Fuse box cover layout, current rating and safety information. (c) Electronic components Identify epoxy packaged IC and other micro components with text Graphics for detection. Clean the epoxy flash material from the feet of the capacitor to ensure the integrity of the electrical connection. (d) Electrical switch gear Text and graphics production in plastic relays, circuit breakers and switches Covers to meet the specific requirements of approval bodies in different markets. (e) Communication equipment Creating graphics and text and logos on mobile phone keypads in the plastic body of the telephone headset. (f) A machinery Replace hot foil marking to create text, graphics and bar codes Livestock identification tag.(g) Promotional products and gift items Origin of text and graphics in pen barrels, key rings, knives, trophies, Photo frames, plaques, etc.(h) Light show Remove the metallic coating from the glass disc to create goblins graphics Used in laser light shows. Technological demands from electronics, medicine, aerospace and other industries pushing the boundaries to the micron level for the smaller components needed Fine marking with more precise tolerance.

Laser detection is a very versatile process. Laser marking is a general term used interchangeably for various processes such as extrusion, engraving, foaming, coloring, staining, carbonizing, etc. The method selection depends on the material and quality requirements. The marks produced with lasers have a permanent and high contrast. They can withstand heat, abrasion and even acid. They are fade-proof and water-resistant. Laser marking can be successfully used to identify a large number of products, including a set design in a mass production setup. The system is easy to integrate into the production line.

Paper is organized as follows. Section II describes the ideas about LASER marking procedure along with a few ideas already been developed. In section III it is shown how this is supposed to work and methodology and purpose of the study. The diagrams and some data representing what exactly the variation of some parameters with respect to other parameters associated with LASER. A result along with a few data that has been taken from the experiments is given in Section IV. Finally, Section V presents conclusion.

II. RELATED WORK

A few works has been introduced by several researchers. Maximum of them has put an idea and implementation about LASER cutting. According to **Arindam Ghosal & Alakesh Manna[1]**: Arindam Ghosalet.al has investigated results on machining of Al/Al₂O₃ MMC by ytterbium fiber laser. The effects of the different parameters on the response characteristics are explained. A comprehensive mathematical model force relating the interactive and higher-order influences of various machining parameter such has laser power, modulation frequency, gas pressure, wait time, pulse width on the machining performance criteria e.g. metal removal rate and tapering phenomena has been developed for achieving controlled over fiber laser machining process. The response surface methodology (RSM) is employed to achieve optimum responses i.e., minimum tapering and maximum material removal rate. The parameters wait time and modulation frequency are identified as the most significant and significant parameters for MRR. Modulation frequency range from 600 to 680Hz taper is minimum.**Fallah, Corbin & Khajepour et. Al[2]**: has used fiber laser to modify the surface composition of a Ti6Al4V plate the rough deposition the blown powder mixture of Ti45wt.%Nb. Scanning electron micro copy and energy dispersive spectra's copy (EDS) were employed to examine the clad sections microstructure and chemical composition. The optimized set of laser processing parameters, including the laser power of 1100W, the lasers can speed of 350mm/min (or ~5.83mm/s), the laser spot diameter of 2mm and the powder feed rate of 0.1g/s was found with the identification of combined parameters, the laser specific energy, the powder density and the new identified laser supplied energy (i.e. Representing the amount of energy given to the unit mass of the blown powder). It is shown that, with the parameters, continuous beds can be formed with pore free sections and a homogeneous composition corresponding to that of (Ti,Nb) solid solution phase. Furthermore, A land V elements are thoroughly replaced with a more bio compatible element, Nb, in these Cond layer of a Ti-Nb cladding build-up on the surface of the Ti-6Al-4V plate (i.e. after ~1mm clad thickness from the clad/subs trade interface). **Powell, Al-Mashikhi, Kaplan & Voisey et. Al [3]**: has presented the results of an experimental and the critical investigation into the phenomenon of striation free cutting', which is a feature of fiber laser/oxygen cutting of thin section mild steel. The



paper concludes that the creation of very low roughness edges is related to an optimization of the cut front geometry when the cut front is inclined at angles close to the Brewster angle for the laser–material combination. **C. Leone (2010)[4]: C. Leone et. al** has been investigated AISI 304 stainless steel marking by a Q- switched diode pumped Nd: YAG laser. The aim was to determine the correlation occurring between working parameters like pulse frequency, beam scanning speed and current intensity and resulting mark visibility. To characterize mark features width and roughness were estimated and analyses optical and scanning electron microscopy coupled with energy were dispersive X-ray technique was carried out. Laser marking tests were carried out on AISI 304 steel, using a Q- switched diode pumped Nd: YAG laser, in order to determine the best working parameters to obtain a given visibility. The present study is regarding the parameters and its variance like power, frequency, duty cycle, width, depth and cutting speed. Finally the study measures the marking depth and width with the optimize value of power, frequency, duty cycle and cutting speed.

III. METHODOLOGY

Data have been collected from the investigation for fiber laser marking process parameters. Then discussing the parameters like pulse frequency, scanning speed, focused spot size etc. Then a few discussion has been carried out for LASER cutting procedure and LASER cutting. Then the study is set a plan for planning and estimation and execution. The present study is organized like follows:

- (i) Data implementation from investigation in Laboratory.
- (ii) Based on the data proper planning for better execution for laser marking.
- (iii) Conclusions.

IV. DISCUSSIONS AND RESULTS

The following experimental observation has been done and it is shown in a tabulated form along with several parameters.

Power	Frequency	Duty Cycle	Cutting Speed	Width	Depth
75	60	60	1.5	0.0947	0.1437
85	60	60	1.5	0.1162	0.152
75	70	60	1.5	0.1015	0.1673
85	70	60	1.5	0.123	0.1685
75	60	80	1.5	0.1251	0.1454
85	60	80	1.5	0.1389	0.1645
75	70	80	1.5	0.1231	0.1501
85	70	80	1.5	0.1362	0.161
75	60	60	2.5	0.0911	0.1177
85	60	60	2.5	0.1141	0.1255
75	70	60	2.5	0.1211	0.1322
85	70	60	2.5	0.1414	0.1301
75	60	80	2.5	0.1351	0.1411
85	60	80	2.5	0.1426	0.1573
75	70	80	2.5	0.1498	0.1321
85	70	80	2.5	0.1612	0.1431
70	65	70	2	0.1365	0.1207
90	65	70	2	0.1668	0.1379
80	55	70	2	0.0971	0.1312
80	75	70	2	0.1199	0.1402
80	65	50	2	0.1215	0.1598
80	65	90	2	0.1698	0.1732

80	65	70	1	0.099	0.1792
80	65	70	3	0.1265	0.1348
80	65	70	2	0.1573	0.1452
80	65	70	2	0.1571	0.1458
80	65	70	2	0.1536	0.1432
80	65	70	2	0.1547	0.1465
80	65	70	2	0.1589	0.1438
80	65	70	2	0.1511	0.1441
80	65	70	2	0.1564	0.1417

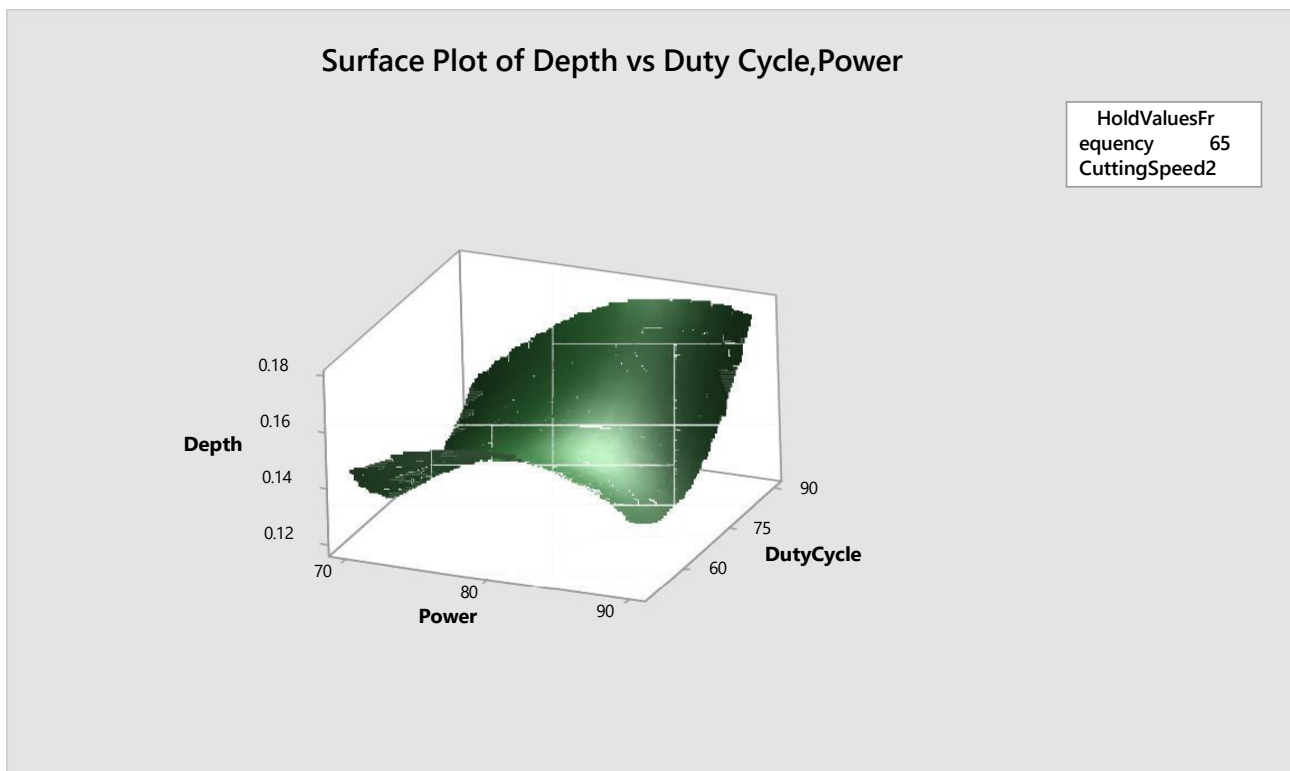


Figure 1: Surface Plot of Depth Vs Duty Cycle and Power

In the above figure surface plot of Depth vs. duty cycle and power speed has been shown. Here power is shown along X axis, duty cycle is shown along Y axis and corresponding Depth is shown along Z axis. It is seen that Depth of the cut is gradually increasing with cutting power from 70 up to 80 but depth of the cut is gradually increasing with power from 800 up to. It is also seen that depth of cut is gradually increasing with duty cycle from 60 up to 80.

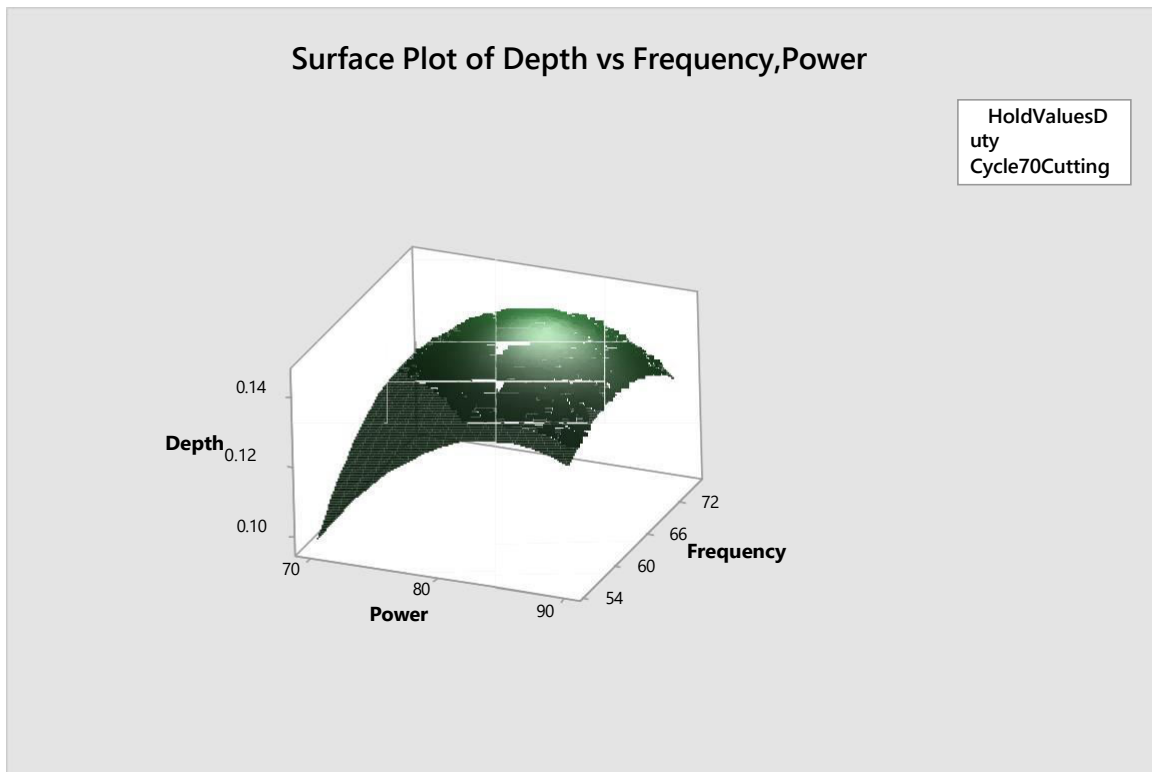


Figure 2: Surface Plot of Width Vs Depth Vs frequency and Power

In the above figure surface plot of Depth vs. frequency and power speed has been shown. Here power is shown along X axis, frequency is shown along Y axis and corresponding Depth is shown along Z axis. It is seen that Depth of the cut is gradually increasing with power from 70 up to 80 but decreasing gradually up to 90. It is also seen that depth of cut is gradually increasing with frequency from 54 up to 66 and then decreases up to 72.

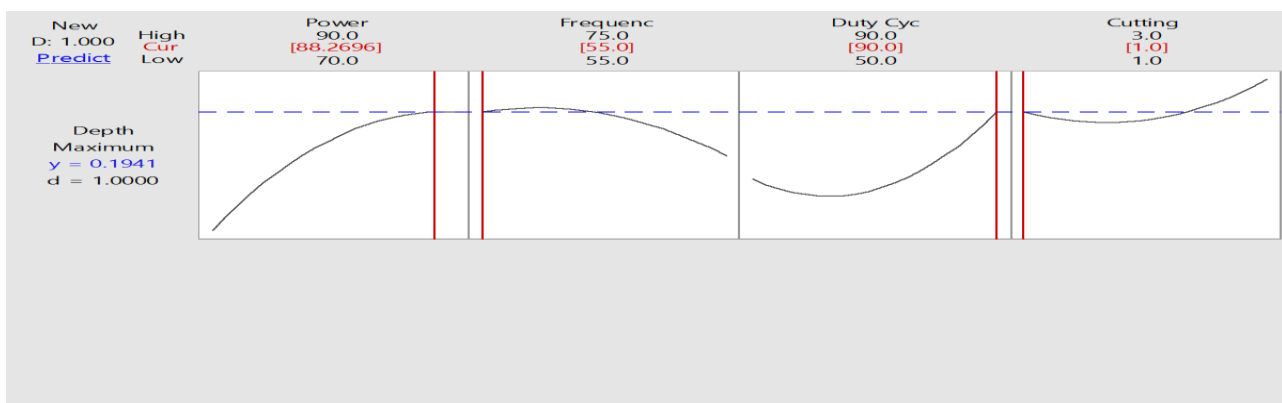


Figure 3: Variation of Depth with Optimized value of Power, Frequency, Duty Cycle and Cutting Speed

From the above figure it is seen that when power is increasing corresponding depth is increasing and when frequencies are increasing depth of cut is gradually decreasing. It is also seen that when duty cycle is increasing depth of cut is decreasing first and then starts to increase. When cutting speed increases corresponding depth starts to decrease and then starts to increase.

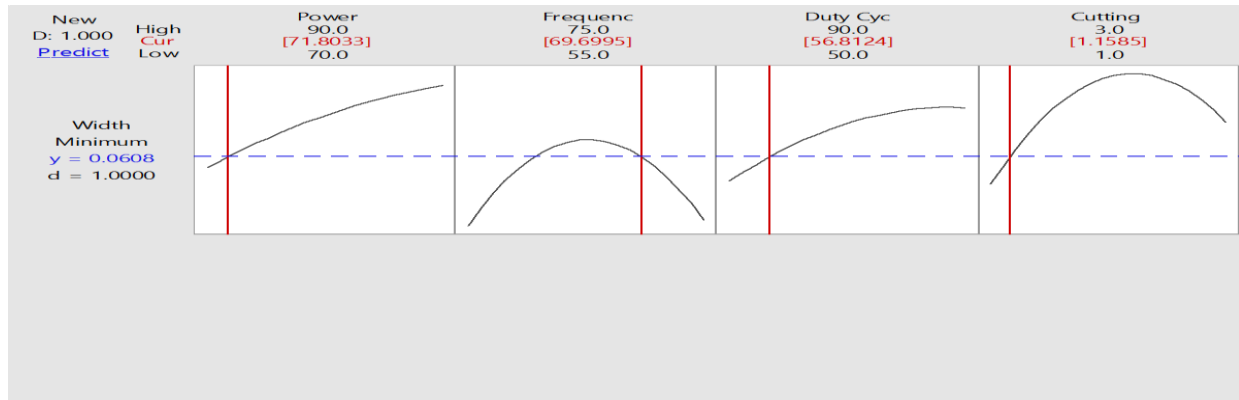


Figure 4: Variation of Width with Optimized value of Power, Frequency, Duty Cycle and Cutting Speed

From the above figure it is seen that when power is increasing corresponding width is increasing and when frequency is increasing width is increasing and then starts to decrease. It is also seen that when duty cycle increases the width is increasing and when cutting speed increases width starts to increase and then gradually decreases.

V. CONCLUSION

A growing number of companies are interested in the industry application of laser technology, primarily in mechanical engineering, automotive and electronics. More and more new products have emerged, using lasers as one of the most important tools in their production. Well established techniques for industrial laser applications, mainly cutting, welding and marking. Currently, laser marking is one of the most widely used methods in processing a variety of materials using lasers. It provides higher quality identification than the traditional method. Nowadays, lasers are effective as a tool for marking and engraving, as well as their application in marking plastics, metals, alloys, silicone, and ceramics. Laser technology meets the requirements of speed, quality, flexibility and price. Some of these qualities are impossible to implement with traditional technology. The development and production of new technological systems that meet these requirements are required for the processing of specialty materials for the implementation of marking processes in new areas of industry. Advances in laser equipment and technology provide a wide range of new options for users to quickly identify. Currently, several new lasers are under development; their presence will result in lower investment and operating costs and improve product identification quality. New green lasers are being developed to identify special products, such as silicon wafers, without damaging the base material, and lasers emitted in the blue and purple ranges of electromagnetic waves, so that the amount of markings can be significantly reduced with their help. This led to an uninterrupted development in laser marking.

REFERENCES

- [1] Environment Technology. Resources, Rezekne, Latvia. Proceedings of the 10th International Scientific and Practical Conference Volume I, 108-115.
- [2] A review of the Nd: YAG laser marking Plastic and ceramic IC packages; Journal of Materials Processing Technology 42 (1994) 95-133.
- [3] A study on the laser marking process of stainless steel; Journal of Materials Processing Technology 139 (2003) 273-276.
- [4] Preparation Of Laser Marking Properties Of Poly (Propylene)/ Molybdenum Sulfide Composite Materials.
- [5] Rapid and Flexible Laser Marking and engraving of tilted and curved surfaces ; Janez Diaci, Drago Bracum, Ales Gorkic.
- [6] Correction of field distortion of Laser marking systems using surface compensation Function; Ming-fei Chen, Yu-Pin Chen*, Wen-Tse Hsiao.
- [7] Experimental investigation on Laser micro-machining of Al 7075 Al.
- [8] Rapid and Flexible Laser Marking and engraving of tilted and curved surfaces ; Janez Diaci, Drago Bracum, Ales Gorkic.



- [9] Correction of field distortion of Laser marking systems using surface compensation Function; Ming-fei Chen, Yu-Pin Chen*, Wen-Tse Hsiao.
- [10] Experimental investigation on Laser micro-machining of Al 7075 Al; K.K Mandal*, A.S. Kumar, S; K.K Mandal*, A.S. Kumar, S.Mitra
- [11] www.elsevier.com/locate/optlastec



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