



Effect Of Drilling of Kevlar Aramid Fiber Reinforced Plastics (K-1226) Laminates Using Solid Carbide Step Drill K34

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Abstract: Composite materials are been used for numerous components and structures in aerospace industry. Many of these components require machining during their fabrication. Drilling of composite materials is very difficult to carry out due to damage being induced into the component in the form of delamination, fiber pullout, and local cracks. Further, rapid wear development in the cutting tool also takes place during drilling of composite materials. Conventional machining processes such as turning, drilling or milling can be applied to composite materials, provided proper tool design and operating conditions are adopted. Kevlar Aramid Fiber Reinforced Plastics (K-1226) is widely used in the industry due to its chemical stability at high temperature and resistance to wear. Studies show that conventional cutting of this laminates are extremely difficult due to the frictional force developed via thermal expansion of substrate material which has restricted the use of Kevlar component. In this regard, an attempt has been made to describe the effective method for drilling K-1226 material using solid carbide step drill K-34 to drill a hole of 9mm diameter for varying thickness. The drilled Laminates are examined using C-Scan Analysis. From the analysis it is observed that for lower thickness K1226 laminate with higher feed rate, spindle speed and cutting speed no delamination occurred. Hence, it is be concluded that the solid carbide step drill K34 was found suitable for machining of Kevlar K1226 laminates of 8,10 and 12mm thickness.

1. INTRODUCTION

Kevlar fiber, due to its unique properties such as higher strength to mass ratio and modulus, has become very popular as reinforcement in composite materials and its application has grown considerably. However, for enhancing Kevlar fiber composite usage in various applications, a proper characterization is very important. Many researchers have been conducted in recent years, for characterization of Kevlar fiber and its composites [1]. Aramid fibers are widely used for reinforcing composite materials, often in combination with carbon fiber and glass fiber. The matrix for high performance composites is usually epoxy resin. Kevlar is an alternative in certain parts of (light) aircraft construction. The wing leading edge is one application, kevlar being less prone than carbon or glass fiber to break in bird collision. In machining, drilling is essentially required to join different structures. However, the drilling of Kevlar

laminates may lead to different kinds of damages like surface delamination, fiber pull out, high surface roughness, local cracks. Many researches attempted to minimize machining problems and shown that the defect is influenced by the selection of the machining parameters, the geometry of cutting tool tip and the nature of its material [3]. For drilling the composite laminates, the tool geometry is very important parameter to be considered, the design of solid carbide step drill K34 is developed in [10]. The aim of this work is to study the performance of solid carbide step drill K34 to drill hole on K-1226 laminates and to reduce delamination factor

2.0. EXPERIMENTAL PROCEDURE

Solid carbide drill (K34) used for drilling the holes in KFRP composite laminates and their chemical composition is shown in table 1

Table 1: Chemical composition of Solid Carbide drill (K34)

Material	Percentage
Tungsten (W)	86.8
Cobalt (Co)	7.93
Phosphorus (P)	2.38
Manganese (S)	0.99
Chromium (Cr)	0.29
Nickel (Ni)	0.16
Sulphour (S)	0.96
Chromium(Cr)	0.38

2.1 Tool Geometry of Solid Carbide Step Drill

The solid carbide step drill K34 model as shown in Figure1 (a) is designed for drilling of K-1226 consists of two steps at a distance of $L_1=L_2=16\text{mm}$, and overall length including the holder is 80 mm having the diameters of $d_1=6.5\text{mm}$, $d_2=9\text{mm}$ respectively. The point angle of 120° , helix angle of 30° , The margin of 8% and land of 85% for each diameter is achieved. The developed tool is as shown in Figure 1(b).

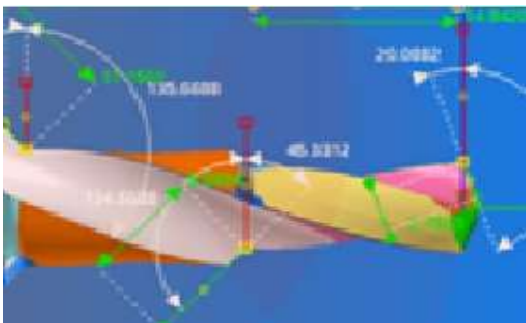


Figure 1. (a) Developed Solid Carbide Step



Figure 1. (b) 3-D Model of Solid Carbide Step drillK3

2.2 Kevlar (K-1226) Laminate Fabrication

2.2.1 Materials Properties

Material properties of Kevlar fabric selected for the study is as tabulated in Table 2.

Table 2: Kevlar Composite Material specification

Material	Kevlar Fabric
Material Specification	913-54%-1226
Prepreg Area Weight (gsm)	245-275
Resin Content (%)	51-57
DSC-Differential Scanning Calorimetry (Ts) (°C)	139-147
DSC-Differential Scanning Calorimetry Peak Temp (Tp) (°C)	149.5-156.5
Thickness in mm (T)	0.18mm
Weight in gms/m ²	6240

2.2.2 Fabrication Method

A batch of 913-54%-1226 Kevlar composite with a cross-ply 0°/90° and 45° stacking sequence Kevlar composites of 42 layer is produced by first preparing (4*14) layer specimen each layer of 0.18mm thickness using hand lay-up technique. The pre-compaction is carried out in autoclave for one hour at temperature of 75° and 2.5 bar pressure. Four pre-compacted laminates are combined and carbon layer of 0.4mm thickness is placed on top and bottom of the pre-compacted laminate as shown in figure 2(a). Vacuum bagging is carried out at room temperature for one hour under -0.8 bar and further Autoclave processing is carried out as per the cure cycle dwell temperature between (75°, 60min) and (135°, 30 min and 5 bar) respectively as shown in figure 2(b). The specimen is cooled at 60° temperature for 3 to 4 hours to obtain 10mm thickness of Laminate. The same process is adapted to achieve 12mm thickness of Kevlar laminate. Autoclave cooling chart is shown in figure 2 (c).



Figure 2. (a) Pre-Compaction Laminates Figure 2. (b) 10mm and 12 mm thickness cured Laminates

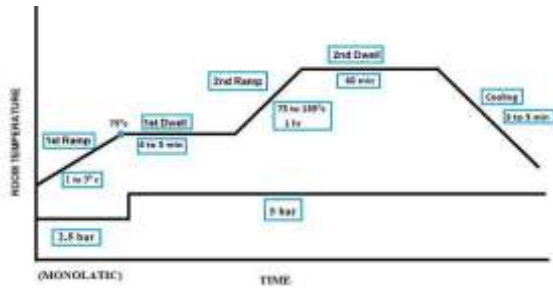


Figure.2(c) Autoclave curing chart

3. EXPERIMENTAL SET UP

The specimen is set on the jig; the solid carbide step drill is fixed to the spindle of radial drilling machine as shown in Figure 3(a). With varying spindle speed and feed rate the drilling operation is carried out to drill holes of 9mm diameter on a Kevlar laminates as in shown figure 3(b) for varying thickness of 10mm and 12mm using solid carbide step drill K34. The experimental conditions are shown in table 3. The drilled laminates are tested for delamination factor using ultrasonic C-scan.



Figure:3(a) Kevlar Laminates setup



Figure:3(b) Setup for Varying Speed and Feed

Table 3: Experimental Conditions

Machine tools:	Radial drilling Machine, Batliboi Ltd, Udhna (Surat), Type- BR615 , Machine no-1040
Cutting tools:	Twist drill, Tungsten carbide K34 Diameter (6.5*9mm), Number flutes:2
Work piece material:	Kevlar Laminates
Cutting fluid:	Dry
Cutting conditions:	Cutting speed: $V_c = 15-65 \text{ m/min}$, Feed rate: $f = 0.125-.5 \text{ mm/rev}$

4. RESULTS AND DISCUSSION

The present study uses C-Scan analysis to determine the quality of holes drilled based on presence of internal and surface defect, cracks and delamination factor. The C-Scan analysis of the Kevlar laminate drilled for varying thickness of 10mm and 12mm at feed rate of 0.125mm/rev 0.25mm/rev and 0.5mm/rev are shown in Figure 4(a) and Figure 4(b) respectively. Each image was computationally processed to identify and characterize the region of interest namely hole, delaminated and non-delaminated regions. The hole region corresponds to the central area, the delaminated region consists on a white border around the machined hole and the non-delaminated regions are colored areas located outside the damaged area. From these figures, it can be clearly observed that there is no delamination occurred at lower feed rates and cutting speed, whereas at higher feed rates and cutting speed top edge delamination was observed for 12 mm thickness Kevlar laminate. Therefore, it is concluded that the solid carbide step drill K34 designed was found more suitable for drilling the composite material.

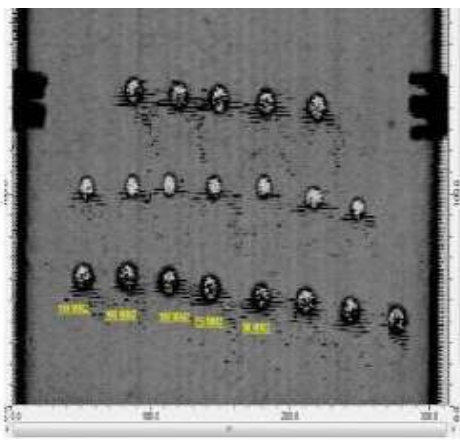


Figure:4 (a) Drilled hole for 10mm thickness

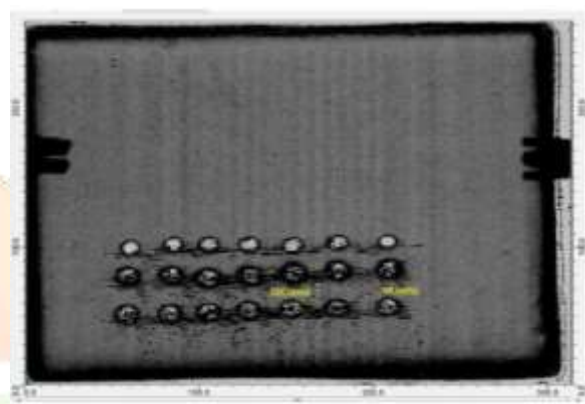


Figure:4 (b) Drilled hole for 12mm thickness

4.0 CONCLUSION

Drilling of composite materials is very difficult to carry out due to damage being induced into the component in the form of delamination, fiber pullout, and local cracks. Further, rapid wear in cutting tool also takes place during drilling of composite materials.

In this context the effective method for drilling K-1226 material using solid carbide step drill K-34 to drill a hole of 9mm diameter for varying thickness has analyzed. From the result it is observed that for lower thickness K1226 laminate with higher feed rate, spindle speed and cutting speed no delamination occurred. Machining of higher thickness K1226 laminate with lower feed rate and higher spindle speed, cutting speed leads to delamination free holes. Whereas machining of higher thickness K1226 laminate with higher feed rate, spindle speed and cutting speed leads to a minor top edge delamination which is in the acceptable range or 10mm thickness. Hence, it is be concluded that the solid carbide step drill K34 was found suitable for machining of Kevlar K1226 laminates of 8,10 and 12mm thickness.

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