STUDYING THE EFFECT OF FLUTES NUMBER ON SELECTION OF ENDMILLS "AN EXPERIMENTAL STUDY" +

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Abstract:

In this research the effect of flutes number of the endmill on tool life and its surface finish for two types of steel ,medium carbon (DIN C45) and high alloy steel (DIN X40 Cr Mo V5) was studied . And this will be carried out by using three types of endmills each one have different number of flutes to machine a slots with specific dimensions into two pieces of steel (high alloy steel and medium carbon steel).
It was found that the endmill with three flutes stand longer than the other two endmills when machining medium carbon steel while the endmill with four flutes stand longer than the other endmills when machining the high alloy steel.
The maximum tool life for the endmill made of HSS was 6300 mm when machining the medium carbon steel while the tool life for the endmill become 1900 mm when machining the high alloy steel.
For surface finishing the endmill with four flutes is better than the others when machining both the medium carbon steel and high alloy steel.

دراسة تأثير عدد الريش على اختيار عدد التفريز الاصبعية
(دراسة تطبيقية)

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المستخلص :

سيتم في هذا البحث دراسة تأثير عدد الريش لعدة القطع الاصبعية على كلٍ من عمر العدة وانهائها السطحي لنوعين من الصلب (الصلب متوسط الكاربون والصلب السبائكي) وذلك باختبار ثلاثة انواع من العدد المختلفة من حيث التصميم في عدد الريش لتشغيل مجرى بأبعاد معينة في قطعتي الصلب.
وقد لوحظ ان العدة التي تتكون من ثلاث ريش كانت قابلية تحملها اعلى عند تشغيل الصلب متوسط الكاربون من باقي العدد الاخرى. بينما العدة التي لها اربعة ريش كانت قابلية تحملها اعلى من العدد الاخرى عند تشغيل الصلب السبائكي.
ان الحد الاقصى لعمر العدة مصنوعة من صلب القطع السريع كان 6300 ملم عند تشغيل الصلب المتوسط الكاربون بينما كان عمر العدة 1900 ملم عند تشغيل الصلب السبائكي.
اما بالنسبة للإنهاء السطحي فان العدة ذات الاربعة ريش اعطت نتائج احسن من العدد الاخرى عند تشغيل الصلب المتوسط الكاربون والصلب السبائكي.

+Received on 19/6/2011 , Accepted on 22/10/2012 .
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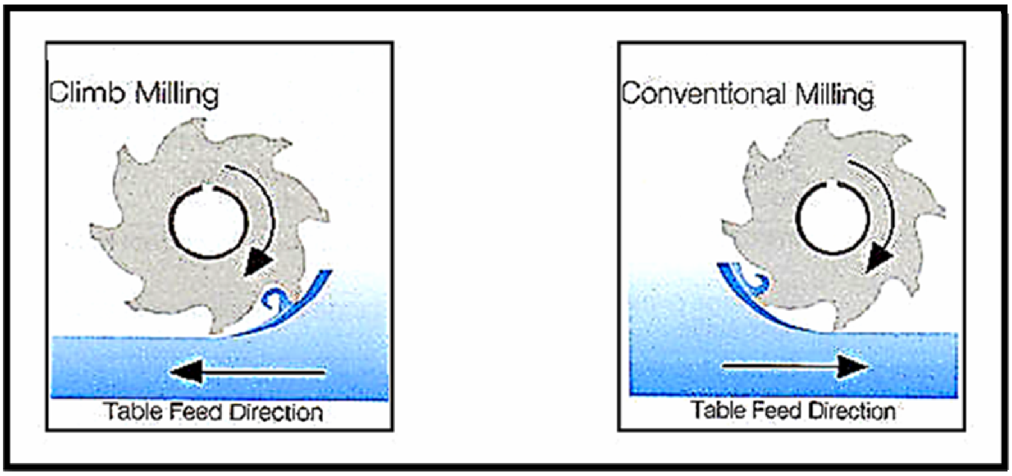
Introduction:

There are two main types of milling approaches ,the conventional milling and the climb milling .In conventional milling(up milling) the endmill engages the workpiece at the bottom of the cut ,the width of the chip starts from zero and increasing .The endmill teeth slide among until sufficient pressure builds up to break through the surface of the workpiece.[1]
In recent years ,milling machines have been greatly improved through backlash elimination and greater rigidity .so that climb milling is now possible ,in climb milling , the tooth meet the work at the top of the cut ,producing the thickest part of a wedge shaped chip first.

Climb milling will provide butter product finish ,permit greater feed per tooth and prolong tool life[2].The conventional and climb milling are illustrated in Fig(1) .

Climb milling cannot be applied to every milling operations and should be attempted if the material and machine setup are not adopted to this type of milling.



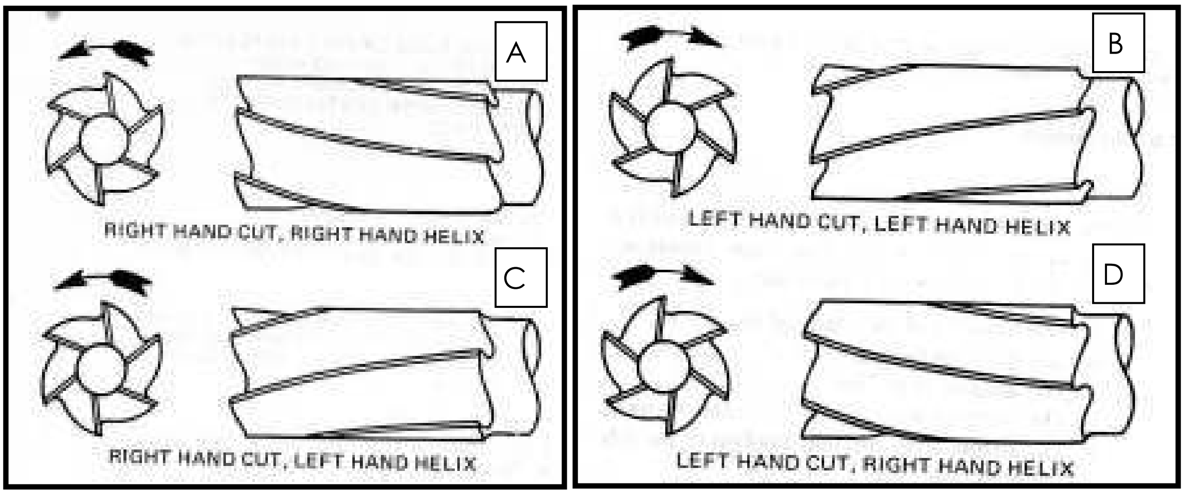
Fig(1) : the climb milling and conventional milling [2]

Endmill GEOMETRY :

When an endmill is viewed from the shank side , a endmill having cutting edge face right is RIGHT HAND , and a endmill having cutting edge face left , is LEFT HAND , both endmill may have right helix type and left helix type ,which makes four types in total as illustrated in Fig(3)[3].

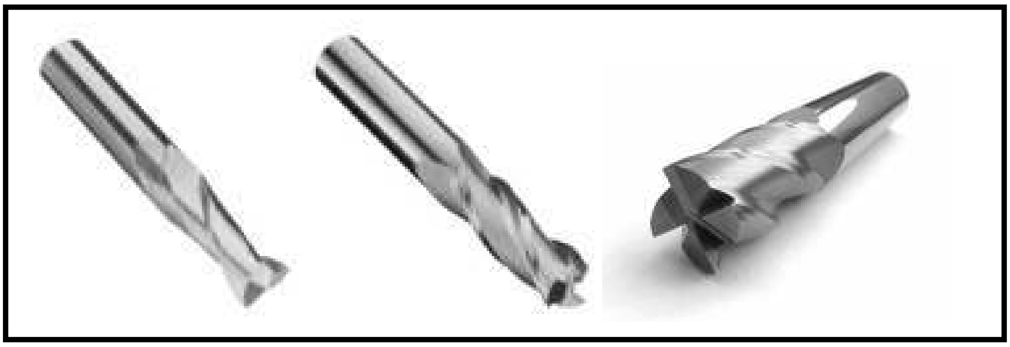
A. Right hand cut – Right hand helix.
B. Left hand cut – Left hand helix.
C. Right hand cut – Left hand helix.
D. Left hand cut – Right hand helix.

Direction of hand and helix should be determind by the material and shape of the workpiece[3] .



Fig(3) shows the types of endmills [3]

In this work type (A) endmill is applied for all the experiment as shown in figure(4).



Fig(4) shows the types of endmills used in experiment [4]

The following formula have been used to set the experimental cutting conditions[□]:-

Cutting speed $$V_c = \frac{D \times \pi \times n}{1000}$$

Spindle Speed $$n = \frac{V_c \times 1000}{\pi \times D}$$

Feed per Tooth $$f_z = \frac{V_f}{z \times n}$$

Cutter feed or table traverse $$V_f = f_z \times z \times n$$

D = Diameter of cutter in mm
z = number of teeth in cutter
n = spindle speed in rpm
V_f = Cutter feed or table traverse in mm
f_z = Feed per tooth in mm
V_c = Cutting speed in meters/min
π = 3.1416

Exerimental Procedure:

The slot milling tests were carried out on a KARL KOLB KK PMM S□00P CNC vertical machining center which was controlled by MACH3 controller. The machining tests were conducted under the conditions shown in Table (1). The two work piece material selected are medium carbon and high alloy steel. The dimension of test pieces is 160x100x40 mm. These test pieces were pre-machined (1 mm) thick of each surface before the experiment in order to remove the residual stress and aging at the outer layer.

Cutting conditions:

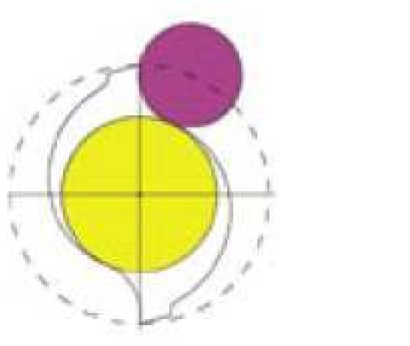
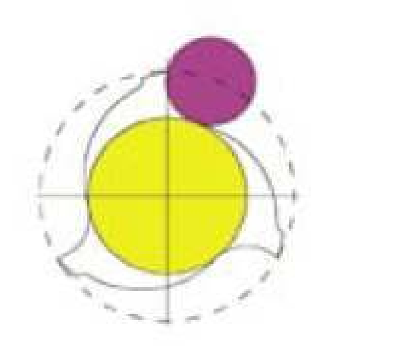
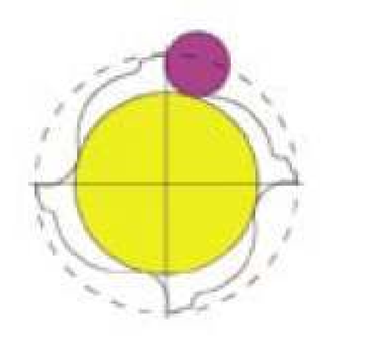
Table (1) shows the cutting conditions used in experiments

Axial depth of cut (mm)	2.□constant
Radial depth of cut (mm)	10constant
Cutting speed (r.pm)	□□0, 1100
Feed rate F (mm/tooth)	0.01 to 0.07
Cutting Fluid	oil lubricant
Cutter Geometry	2flutes, 3flutes and 4flutes
Diameter	10 mm constant

Methodology :

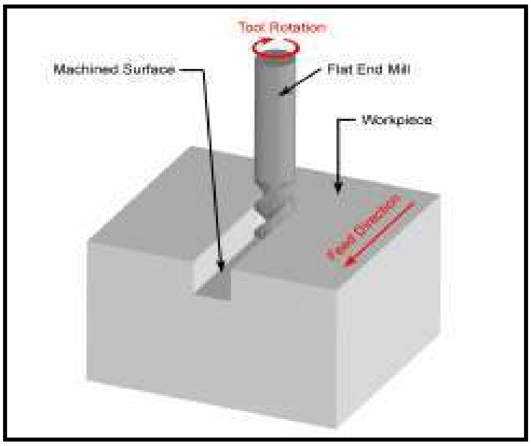
In this paper three types of endmills have been used as shown in fig (□)&fig(6) to study the effect of the number of flutes on selection the proper endmill , in slotting these types are (Endmill Φ10 mm with 2flutes,Endmill Φ10 mm with 3flutes and Endmill Φ10 mm with 4flutes).

Fig(5) shows the endmills having two ,three and four flutes.[6]

2 Flutes	3 Flutes	4 Flutes
		

Fig(6) shows the cross section area for the used endmills[6]

Although there are several types of milling slotting ,the experiments in this work have been subjected in the type of milling as shown in Fig(7)[7].
As illustrated in fig (6) ,it is clearly seems that the cross section area of the two flutes endmill is smaller than for four flutes endmill while the chip space removal is bigger.



Fig(7) shows the slotting operation.[7]

Research Methode:

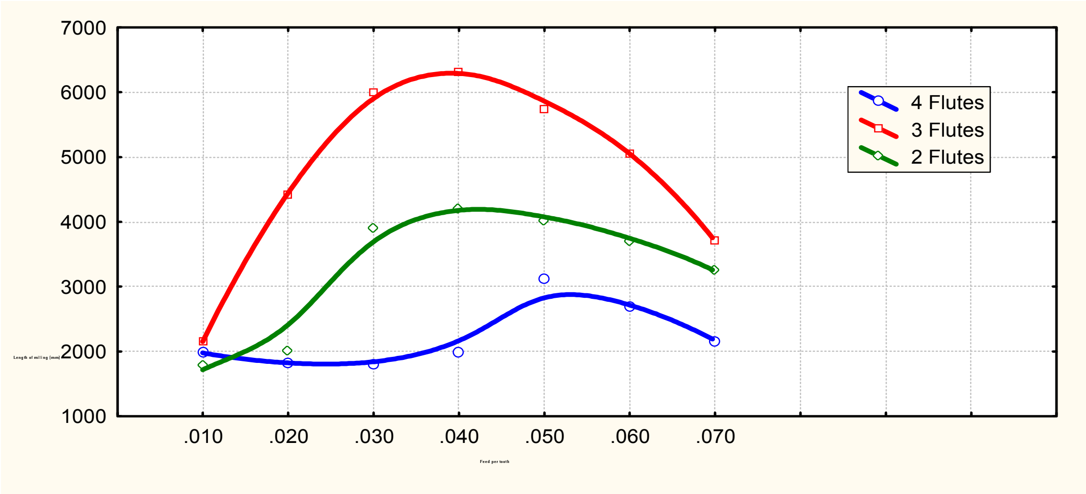
In this work, slot milling tests with lubricant were carried out on medium carbon and high alloy steel with HSS cutting tools. The experimental tests were performed at various cutting speeds of □□0 and 1100 m/min, with constant depth of cuts of 2.□ mm and various feed rates of 0.1,0.2, 0.3,0.4, 0.□, 0.6 and 0.7 mm/tooth . Tool life and the quality of the surface finish were the factors that determine the performance of the cutting tool. Surface finish was studied based on the surface roughness.

The effect of number of flutes of endmill cutter on cutting condition parameters on the medium carbon and high alloy steel machinability characteristics in terms of tool life and surface roughness are investigated using the design matrix factors considered as illustrated in Table (1) . However, it should be mentioned here that the result of the analysis are presented for the HSS endmills only.

After design matrix creation the designed experiments were carried out. The machining was stopped at each cutting path of 100mm and the tool was periodically removed from the tool holder. The flank wear on the tool was measured accordingly. The experiment was stopped when flank wear reached 0.2 mm. The arithmetic surface roughness value (R *a*) was adopted and measured on the machined surface parallel to feed motion with a surface roughness tester. The R *a* values of the machined surface were obtained by averaging the surface roughness values at three locations on the center path of work piece width.

Relation between number of flutes and performance In slotting:

Seven tests have been done for each of the three endmills with different feed per tooth (0.01, 0.02 ,0.03 ,0.04 ,0.0□,0.06 ,0.07 mm/tooth) while the workpiece is medium carbon steel DIN C4□, the tool life is limitated by wear land of 0.2 mm.As shown in fig (8) with cutting conditions shown in table(2).

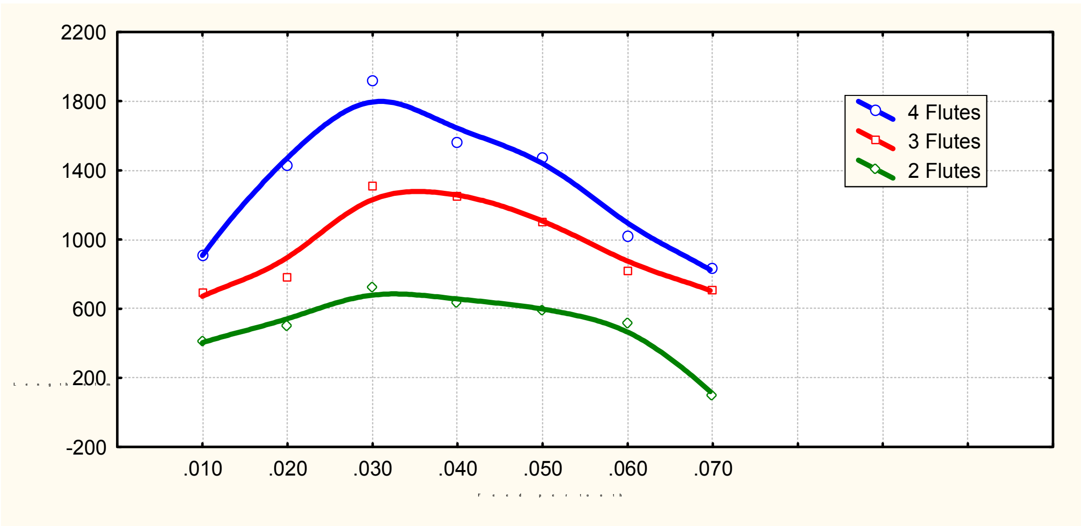


Fig(8) shows the effect of feed per tooth on tool life for medium carbon steel

Table (2) shows the cutting conditions used in experiments for a medium carbon steel

Endmill Φ10mm	type A X40CrMoV12
Type of material	C4□(medium carbon steel)
Depth of cut	2.□mm slotting
Cutting with lubricant	
Limit of wear land	0.2 mm
Speed	1100 r.p.m

The same procedure of experiments have been subjected but the material of the workpiece is harder which is high alloy steel DIN X40 Cr Mo V□as shown in fig(9) with cutting conditions shown in table(3).

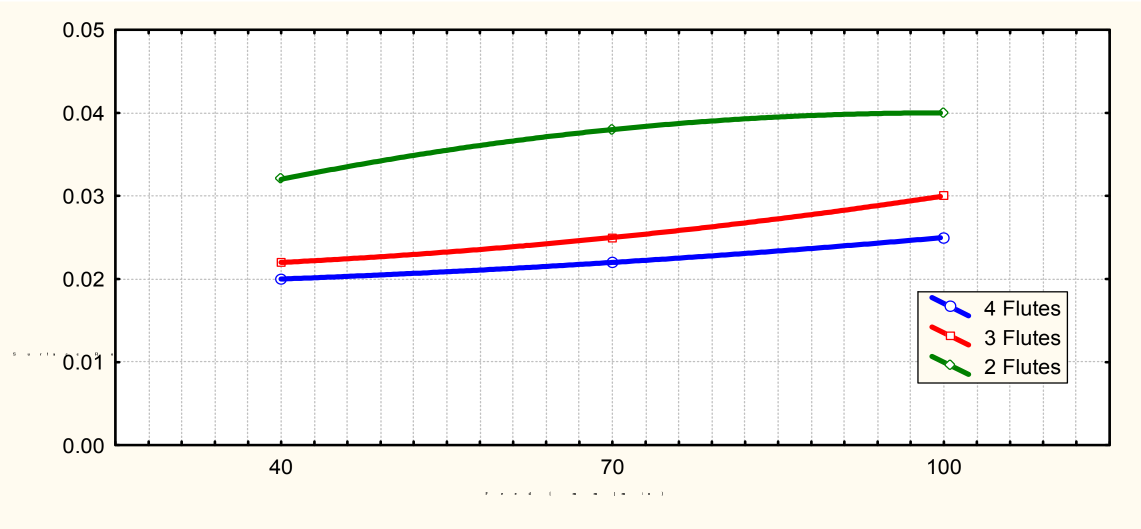


Fig(9) shows the effect of feed per tooth on tool life for high alloy steel

Table (3) shows the cutting conditions used in experiments for high alloy steel

Endmill Φ10mm	type A X40CrMoV12
Type of material	DIN X40 Cr MoV□(High alloy steel)
Depth of cut	2.□mm
Cutting with lubricant	
Limit of wear land	0.2 mm
Speed	□□0 r.p.m

To study the effect of the number of flutes on the surface roughness ,three test for each of the three Endmills have been executed as shown in fig(10) with cutting conditions shown in table(4):-

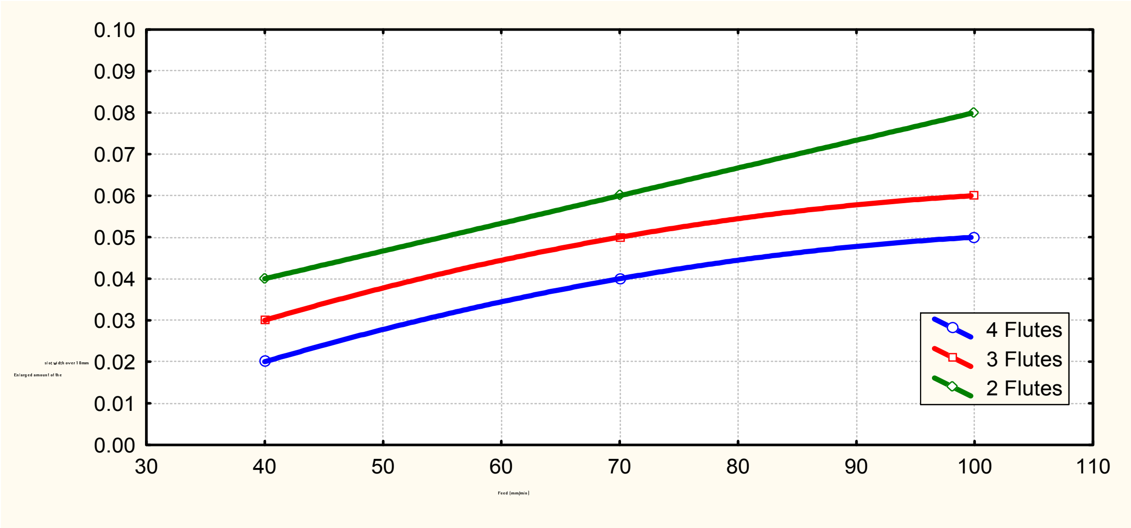


Fig(10) shows the effect of feed on surface roughness in medium carbon steel

Table (4) shows the cutting conditions used in experiments for the surface roughness experiment

Endmill Φ10mm	type A DINX40CrMo V12
Type of material	DIN C4□(medium carbon steel)
Speed	1100 r.p.m
Depth of cut	2.□mm
Milling with lubricant	
Milling type	Slotting

Then to study the effect of number of flutes on the slot dimension ,three test have been carried out as shown in fig (11) with the following conditions shown in Table(□):-



Fig(11) shows the effect of feed on surface roughness in high alloy steel

Table (5) shows the cutting conditions used in experiments for slot dimentions experiment

Endmill Φ10mm	type A DIN X40 Cr Mo V12
Type of material	DIN C4□(Medium carbon steel)
Speed	1100 r.p.m
Depth of cut	2.□mm
Milling with lubricant	
Milling type	Slotting
Limit of mean land	0.2 mm

Result And Discussion:-

Tool life:

In milling medium carbon steel ,chip ejection influences their performance strongly, three flutes endmills perform best as they have great rigidity and big chip space. While four flutes endmills tends to suffer abnormal wear on primary relief caused by chip backing ,these results according to the test shown in Figure(8).
In milling high alloy steels accompanied by high cutting torque. When chip do not influence milling performance , greater number of flutes endmill can put up with long milling , as chip removal per tooth influences on tool life these according to milling tests shown in figure(9).

Surface roughness:

Figure (10) shows the typical surface roughness values recorded when machining medium carbon and high alloy steel with HSS endmills under lubricant cutting conditions. In order to compare the degree of surface variation of the surface roughness, two cutting speeds of □□0 and 1100 m/min at various feed rates of 40 , 70 and 100 mm/tooth, at a depth of cut2.□mm were chosen when slot milling medium carbon and high alloy steel. As shown in Figure (10) Results indicate that the surface roughness values increased as the feed speed increased. The improvement on surface roughness was obtained at the lowest feed rate of (40)mm/tooth when used 4 flutes endmill. This experiment has proved that higher feed rate results in higher value of surface roughness. Increasing the number of flutes makes the load on the single tooth more homogeneous and consequently, this allows for a better finish.The more flutes are the better in surface finishing .this is due to lighter chip load per tooth figure (11).

Recommended number of flutes :

According to the tests and results of this paper ,it is clearly to say that smaller number of flutes is good for deep cut and larger number is good for shallow cut, But in milling test (2) when milling high alloy steel materials, larger number of flutes are good for tool life.

Conclusion:

From this experiment we can conclude that :-
1-with Two Flutes endmill,The two-flute endmill has the greatest amount of flute space allowing for more chip carrying capacity. Used primarily in slotting and pocketing of materials where chip removal is a concern. Large chip space. Easy chip ejection. Good for slot milling. Good for heavy duty milling. Less rigidity due to small section area. Lower quality surface finish.
2- For the three Flutes endmill, While this tool has the same flute space as two flutes, it has a larger cross-sectional area providing for greater strength and the ability to pocket and slot . Chip space almost as large as for 2 flutes. Larger section area – higher rigidity than 2 flutes that improved surface finish.
3- For the Four Flute endmill the best surface finish is found with this type of endmill. So it's Ideal for finish milling. Produces a much finer finish than two and three flute tools. Highest rigidity. Largest section area – small chip space. Gives best surface finish.

References:

1. M.san Juan,F.J.Santos,T.de la Fuente."A new method for determining the chip geometry in milling",*Material Science Forum* Vol.[illegible]26,2006,pages (7-12)
2. H.P.zhang,X.P,Ji,J.Wang,E.I.Liu."Effect of Cutting Speed on Chip fracture Strain in High speed Cutting",*Material Science Forum* Vol.626,2009,pages(6[illegible]-70)
3. Lawrence E.Doyle ,*Manufacturing processes and materials for engineers* ,Prentice – Hall,Inc,Englewood Clifs,N.J.,1969.
4. Kline W. A., R. E. DeVor and I. A. Shareef,"The Prediction of Surface Accuracy in EndMilling", Journal of Engineering for Industry,Vol. 104, pp.272-278, August 1982.

[illegible]. James Anderson,Ear E.Tatro ,*Shop theory* ,McGraw-Hill,Inc , New York,197[illegible]

6. S. Ema, R. Davies ."Cutting performance of endmills with different helix angles", *International Journal of Machine Tools and Manufacture*, Volume 29, Issue 2, 1989, Pages 217-227.
7. F.H.Obeidat, Astudy of machining variables on surface integrity of components produced by milling process, M.Sc. Thesis , Mechanical Engineerin Department, Jordan University of Science and Technology,1997