Available online at www.sciencedirect.com
SciVerse ScienceDirect
Procedia CIRP 2 (2012) 55 – 59
www.elsevier.com/locate/procedia

1st CIRP Global Web Conference: Interdisciplinary Research in Production Engineering

Machinability of Multiphase Microalloyed Steel

V. Sivaraman[a]*, S. Sankaran[b], L. Vijayaraghavan[c]

[a,c]*Department of Mechanical Engineering, Indian Institute of Technology Madras, Chennai 600036, India*
Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras, Chennai 600036, India
* Corresponding author. Tel.:+91-44-22574687; fax: +91-44-22574652 *E-mail address*: iitmvs@gmail.com

Abstract

The machining of multiphase (ferrite-bainite-martensite) microalloyed steel was carried out in a high speed lathe to assess the machinability. The mechanical properties of multiphase (ferrite-bainite-martensite) microalloyed steel were analogous to those of quenched & tempered steels. The influence of machining parameters such as cutting speed, feed rate and depth of cut on cutting force and surface roughness was studied. The result shows that the feed rate and depth of cut influence more on cutting force and for surface roughness the only influencing parameter is feed rate. Optical and scanning electron microscope were used to find the microstructure and surface topography.

Keywords: Multiphase microstructure; machinability; cutting force; surface roughness.

1. Introduction

Microalloying elements are added to structural steels to refine the austenite grain size, to lower the transformation temperature and to impart precipitation hardening [1]. Vanadium microalloyed (MA) medium carbon steels are widely used in automotive industry due to their improved mechanical properties [2]. The multiphase (ferrite-bainite-martensite) microalloyed steel was produced through two step cooling (TSC) procedure after forging followed by annealing [3]. The mechanical properties were comparable to those of quenched and tempered steels. In the present study machining characteristics of the multiphase microalloyed steel are evaluated.

1.1. Experimental Procedure

The experiments were conducted in a high speed lathe to assess the cutting force. The chemical composition of the work material is C 0.38, Si 0.68, Mn 1.5, P 0.022, S 0.06, V 0.11, N 0.066, Cr 0.18, Fe balance. The hardness of the material is in the range of 400 to 430 HV. The yield strength of the material is 1384 MPa.

Uncoated tungsten carbide cutting tool of SNMG 120408 was used to machine the work material. Kistler dynamometer was used to measure the cutting force and Mahr perthometer was used to measure surface roughness. To reduce noise in the acquired signal a low pass filter was used. The process parameters considered were speed, feed and depth of cut and their levels are shown in Table 1. Taguchi L9 orthogonal array was employed for experimental design and smaller the better quality characteristics were chosen to find the signal to noise ratio [4]. Optical and Scanning electron microscope were employed to study the microstructure of work material and morphology of the chips. The experimental results obtained for various cutting parameters are shown in Table 2.

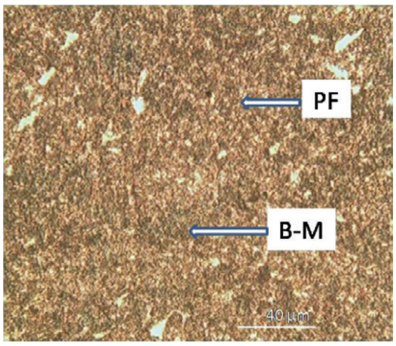
Table 1 Cutting Parameters

Cutting Speed (m/min)	Feed Rate (mm/rev)	Depth of Cut (mm)
60	0.1	0.2
80	0.2	0.4
100	0.3	0.6

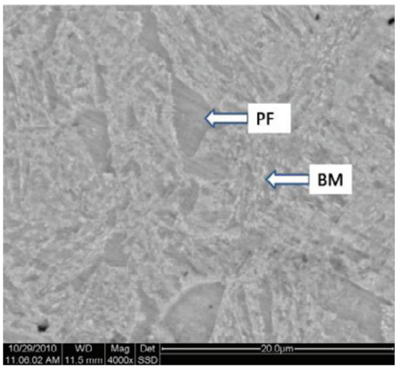
http://dx.doi.org/10.1016/j.procir.2012.05.039

1.2. Microstructure of the multiphase steel

The micrograph obtained through optical and scanning electron microscope (SEM) of the work material is shown in Figure 1. The samples were etched with 2% Nital to see the microstructure of the steel. Polygonal ferrite (PF) and bainite-martensite (BM) colonies are seen in the microstructure.



(a)



(b)

Fig. 1. Micrograph of multiphase microalloyed steel (a) Optical (b) SEM

Table 2. Experimental results for Cutting Force and Surface Roughness

Cutting Condition	Cutting Speed (m/min)	Feed Rate (mm/rev)	Depth of Cut (mm)	Cutting Force (N)	Surface Roughness (μm)
1	60	0.1	0.2	127	1.20
2	60	0.2	0.4	210	1.70
3	60	0.3	0.6	627	3.10
4	80	0.1	0.4	213	0.80
5	80	0.2	0.6	415	1.20
6	80	0.3	0.2	298	3.50
7	100	0.1	0.6	259	0.61
8	100	0.2	0.2	212	1.44
9	100	0.3	0.4	456	3.10

2. Result and Discussion

2.1 Optimal cutting conditions

The optimal cutting conditions for getting minimum cutting force are shown in the Fig. 2 and the optimal parameters are found to be 60 m/min, 0.1 mm/rev, 0.2 mm. Similarly for minimum surface roughness the optimal parameter are 100 m/min, 0.1 mm/rev, 0.6 mm and is shown in Fig. 3.

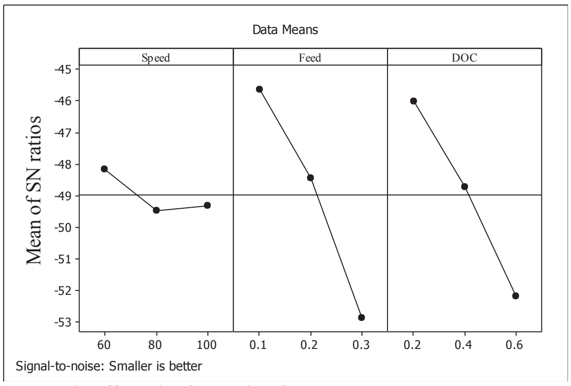


Fig. 2. Main effect plot for cutting force

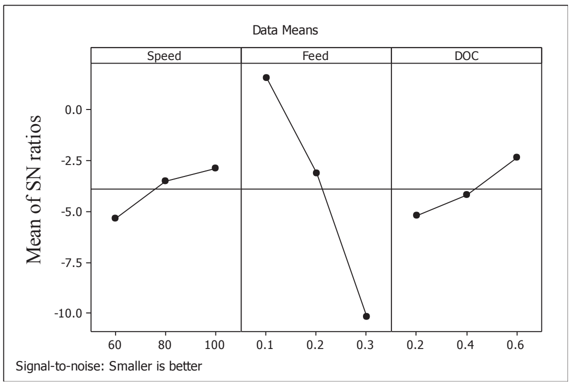


Fig. 3. Main effect plot for Surface Roughness

2.2 Effect of Cutting Parameters

Analysis of variance (ANOVA) for cutting force shows that the feed rate (55.29 %) influences more than depth of cut (39.66 %) and cutting speed (2.15%). Similar trend is observed while machining quenched and tempered steels [5, 6] and also the cutting force acquired is almost half of the cutting force recorded while machining high strength low alloy (HSLA) steel [5]. Similarly for surface roughness the only influencing factor is feed rate (90.16%) than other two parameters namely depth of cut (5.32%) and cutting speed (4.16%). The ANOVA results obtained for cutting force and surface roughness are shown in Table 3 and Table 4.

Table 3 ANOVA for cutting force

Symbol	Cutting Parameter	Degree of freedom	Sum of squares	Means square	Contribution (%)
A	Cutting Speed	2	3.11	1.55	2.15
B	Feed rate	2	79.78	39.89	55.29
C	Depth of cut	2	57.23	28.61	39.66
	Error	2	4.13	2.06	2.86
	Total	8	144.27		100