Effect of Burnishing Force on Surface Roughness and Hardness of Low Carbon Steel Spur Gear by using Diamond Gear Burnishing

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Abstract

Gear Burnishing is a cold working surface finishing process in which the work gear is rolled in tight mesh with hardened and highly accurate smooth gears. When contact stress between gear teeth increases the yield point stress of the material, plastic deformation occurs that reduces surface irregularities improving surface finish and induces useful residual compressive stresses. Gear burnishing if carried out properly results in improvement in metallic surface properties such as surface finish, surface hardness, wear resistance, corrosion resistance and fatigue life. The involute spur gears of AISI 1018 and AISI 1020 are burnished by diamond gear burnishing tool for fixed values of cycle time and speed without coolant. The burnishing force is varied to investigate its impact on surface roughness and surface hardness of gears. The spur gear is rolled in mesh with hard diamond coated gear at 300 rpm for 30 seconds in clockwise direction and then for another 30 sec in anticlockwise direction on standard diamond gear burnishing machine. Considerable effect of burnishing force on surface finish and micro hardness of spur gear of is observed due to burnishing.

Keywords: Burnishing, Surface Roughness, Surface Hardness, Burnishing Force, Diamond Gear

I. INTRODUCTION

In burnishing, the contact stress or pressure between the work piece and the burnishing tool must exceed the yield point stress of the material. Good burnishing occurs when the burnishing pressure is 1.8 to 2.1 times the yield point stress of the material. Material yields when contact stress exceeds yield point stress of the material, plastic deformation occurs beyond yielding. The yield strength(S_{yt}) of AISI 1018 is 370MPa and that of AISI 1020 is 295MPa. In the present work, the involute spur gears of AISI 1018 & AISI 1020 are burnished by diamond gear burnishing tool for fixed values of cycle time and speed without coolant. The burnishing force is varied to investigate its impact on surface roughness and surface hardness of gears. The spur gear is rolled in mesh with hard diamond coated gear at 300 rpm for 30 seconds in clockwise direction and then for another 30 sec in anticlockwise direction on standard diamond gear burnishing machine. The surface roughness is examined by using Hommel Tester T1000 and hardness tested by portable hardness tester model PHT – 1840.

II. MATERIAL AND EQUIPMENT

The material of work gear specimen, its dimensions and the diamond gear machine setup specifications are as follows:

A. *Material Chemical Composition*

Table – 1
Material Chemical Composition

Element	*Carbon, C*	*Iron, Fe*	*Manganese, Mn*	*Phosphorous, P*	*Sulfur, S*
AISI 1018 (EN32B)	*0.14 - 0.20 %*	*98.81 – 99.26 %*	*0.60 – 0.90 %*	*≤ 0.040 %*	*≤ 0.050%*
AISI 1020 (EN3A)	*0.17 - 0.23 %*	*99.08 – 99.53 %*	*0.30 – 0.60 %*	*≤ 0.040 %*	*≤ 0.050%*

B. *Spur Gear Specification*

1) *Work Gear*

Module, m = 2 mm, Pitch Circle Diameter, d = 40 mm, Number of Teeth, T = 20, Face width, b = 10 mm

Fig. 1: Work Gear

2) *Diamond Gear*

Module, m = 2 mm, Pitch Circle Diameter, d = 220 mm, Number of Teeth, T = 110, Face width, b = 24 mm

Fig. 2: Diamond Gear

3) *Diamond Gear Burnishing Machine Set up Specification:*

Spindle Speed: 300 to 1100 rpm (Inverter Controlled)
Spindle Power: 2 HP, 950 rpm
Maximum force on gear: 300 kgf at 5 bar pneumatic line pressure
Electrical controller: PLC Siemens S7 – 200 – TD – 200 Display
Pneumatic System – Festo
Maximum work diameter: 200 mm
Minimum work diameter: 20 mm
Tilt angle: ± 15^0

Fig. 3: Gear Burnishing Set up

III. EFFECT OF BURNISHING FORCE ON SURFACE ROUGHNESS AND HARDNESS

Specified spur gears are burnished using diamond gear burnishing tool for different values of burnishing forces. The surface roughness and hardness of burnished gear are recorded precisely. Following tables and graphs shows that there is considerable variation in surface roughness and hardness with burnishing force.

Table – 1
Variation of surface roughness with burnishing force for AISI 1018

Sr. No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Burnishing Force (kgf)	*20*	*25*	*30*	*35*	*40*	*45*	*50*	*55*
Surface Roughness (µm)	*1.829*	*1.816*	*1.516*	*1.050*	*0.886*	*1.129*	*1.229*	*1.334*

Table – 2
Variation of surface hardness with burnishing force for AISI 1018

Sr. No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Burnishing Force (kgf)	*20*	*25*	*30*	*35*	*40*	*45*	*50*	*55*
Surface Hardness (HRB)	*68*	*70*	*71*	*73*	*75*	*74*	*72*	*71*

Table – 3
Variation of surface roughness with burnishing force for AISI 1020

Sr. No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Burnishing Force (kgf)	*20*	*25*	*30*	*35*	*40*	*45*	*50*	*55*
Surface Roughness (µm)	*1.952*	*1.821*	*1.609*	*0.906*	*0.996*	*1.139*	*1.474*	*1.501*

Table – 4
Variation of surface hardness with burnishing force for AISI 1020

Sr. No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Burnishing Force (kgf)	*20*	*25*	*30*	*35*	*40*	*45*	*50*	*55*
Surface Hardness (HRB)	*63*	*64*	*67*	*72*	*71*	*69*	*69*	*68*

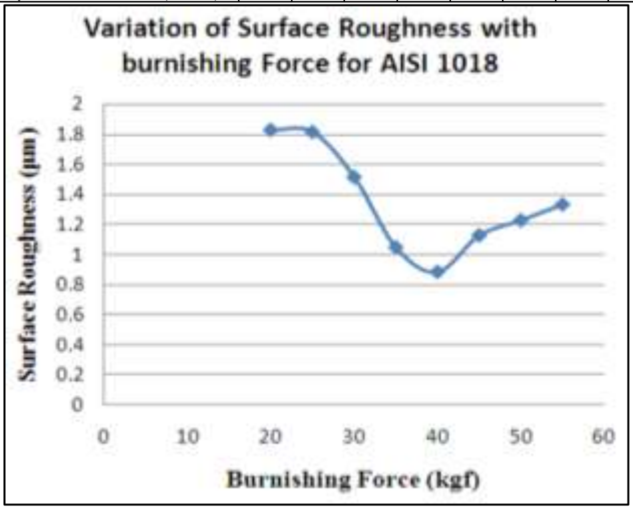

Fig. 4: Effect of Burnishing Force on Surface Roughness for AISI 1018

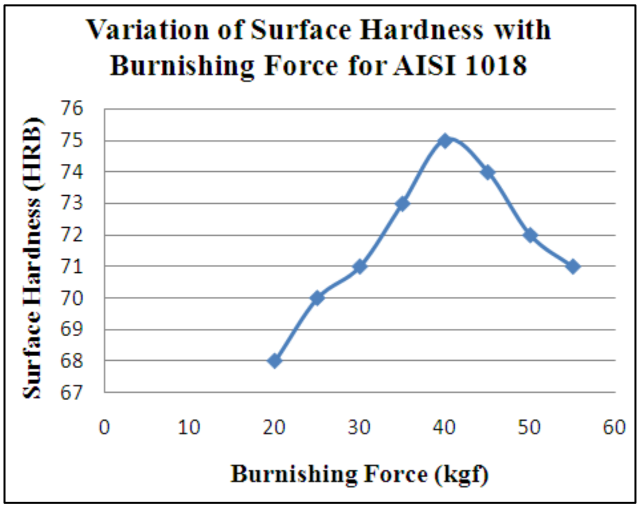

Fig. 5: Effect of Burnishing Force on Surface Hardness for AISI 1018

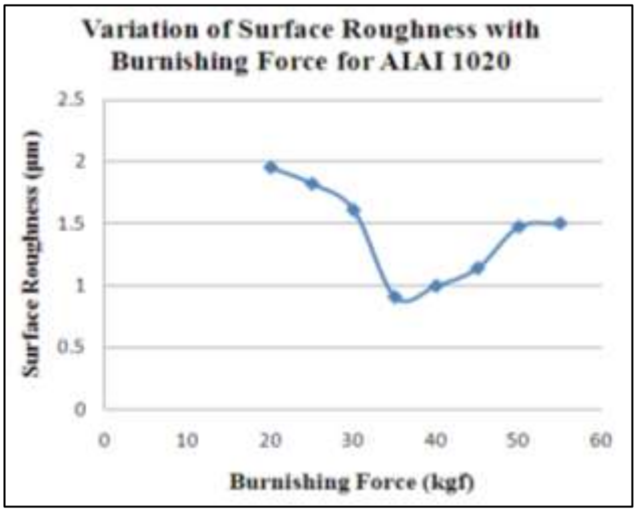

Fig. 6: Effect of Burnishing Force on Surface Roughness for AISI 1020

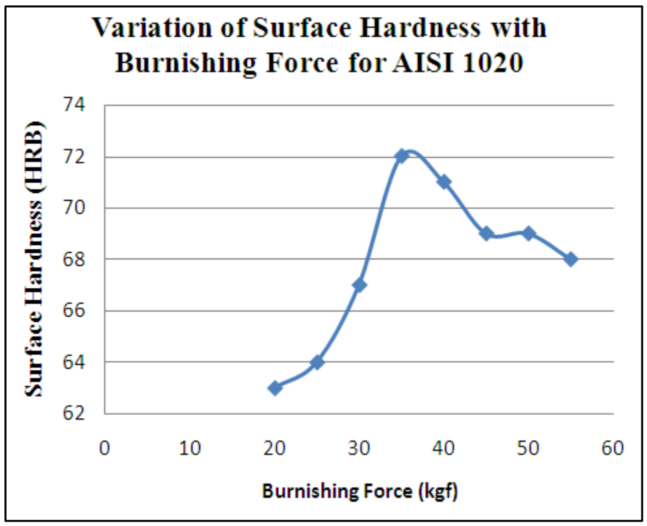

Fig. 7: Effect of Burnishing Force on Surface Hardness for AISI 1020

IV. Conclusion

The impact of burnishing force on surface roughness and hardness of spur gears of materials AISI 1018 and AISI 1020 are investigated. The burnishing force greatly affects the roughness and hardness of gears. The hardness increases and roughness decreases with burnishing force up to certain value (40Kgf for AISI 1018, 35Kgf for AISI 1020). Beyond this value of force decrease in hardness and increase in roughness is observed. It is found that the roughness value (Ra) reduces maximum by 51.55% for AISI 1018 and 53.59% for AISI 1020. The surface hardness is increased maximum by 10.29% for AISI 1018 and 14.28% for AISI 1020 material.

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