離子氮化表面硬化處理重型機械及卡車柴油引擎用球墨鑄鐵活塞之磨耗行為研究

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指 導 教 授：林宏茂 副教授
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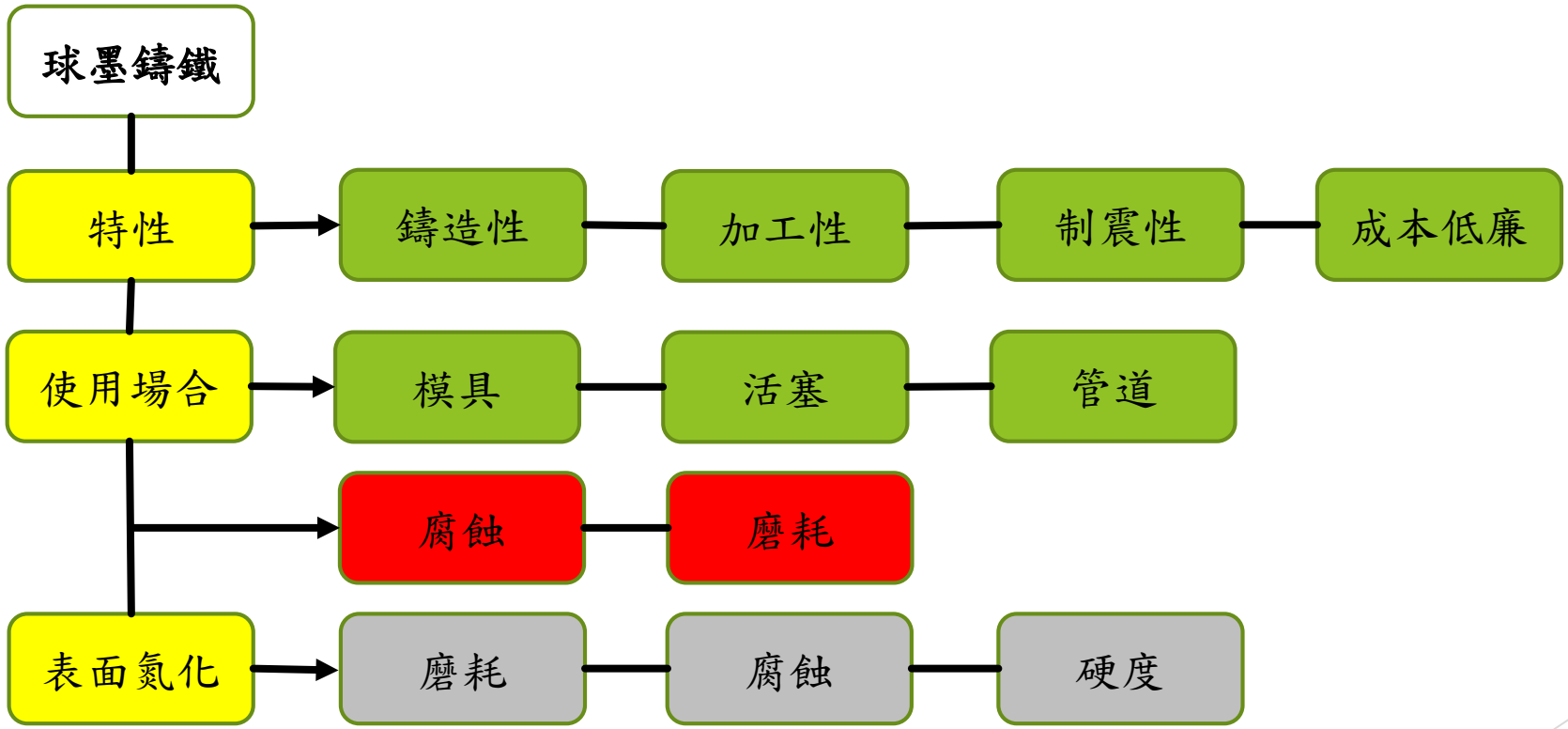
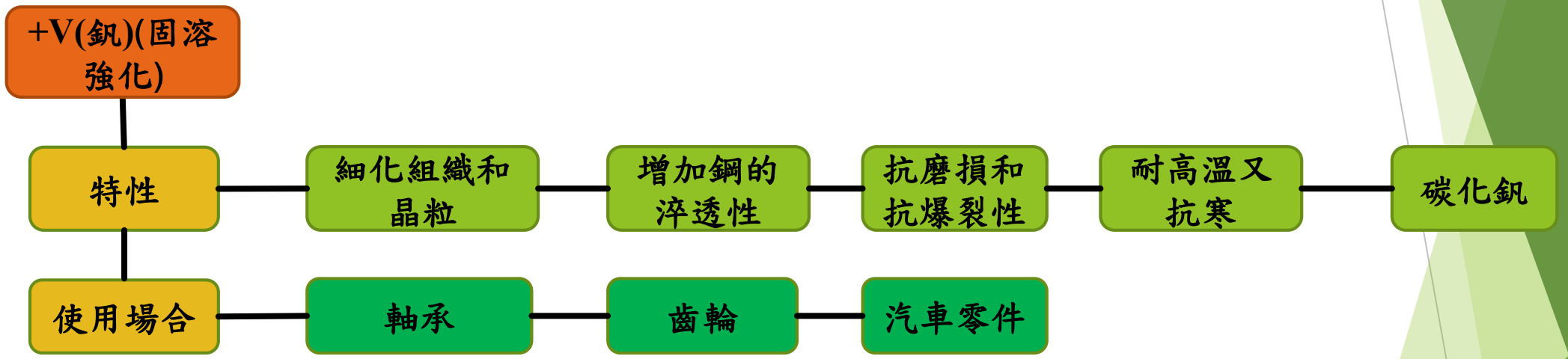
目錄

前　言

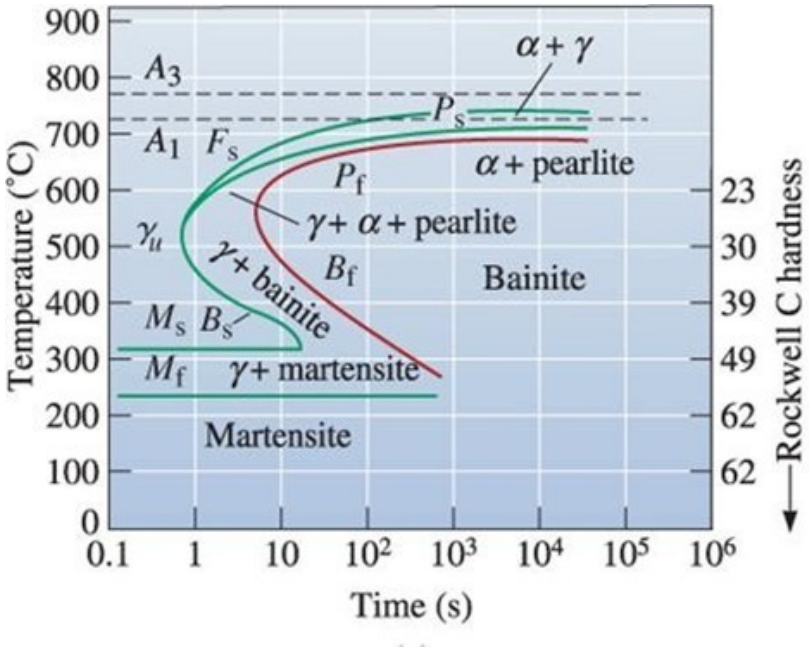
- 球墨鑄鐵(FCD600）



添 加 釩 的 特 性


+V(釩)(固溶強化)
特性
細化組織和晶粒
增加鋼的淬透性
抗磨損和抗爆裂性
耐高溫又抗寒
碳化釩
使用場合
軸承
齒輪
汽車零件

沃斯回火製程



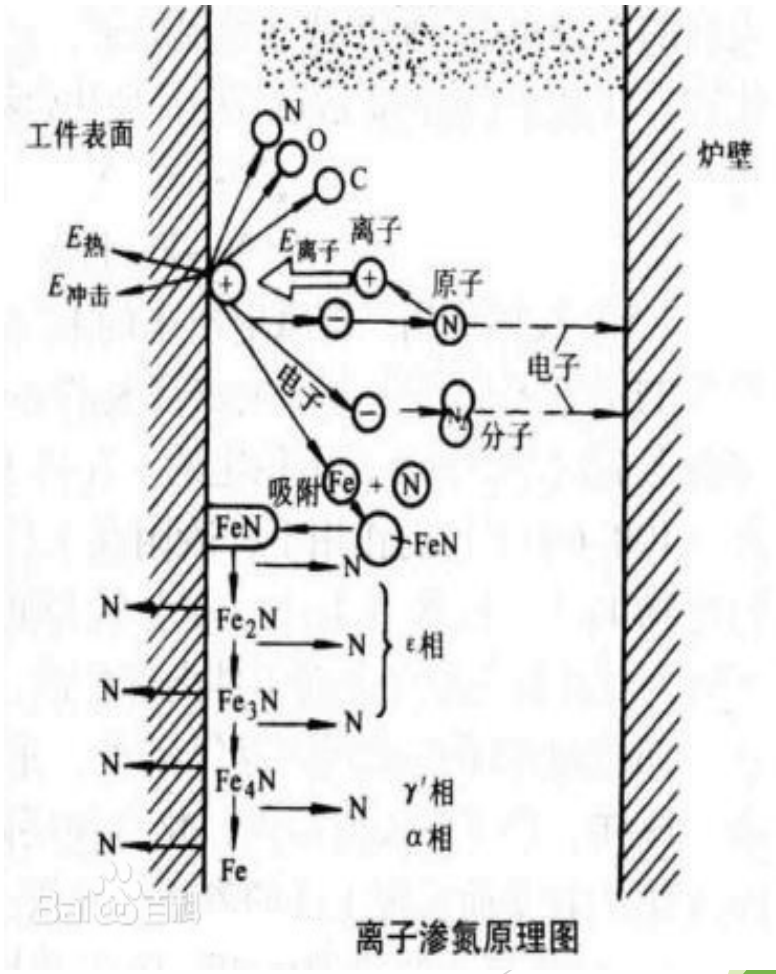
將沃斯回鐵狀態的鋼料淬入溫度介於 S 曲線鼻部與 MS 變態點間的熱浴，直到過冷沃斯回鐵完全變態為變韌鐵才取出空冷的一種熱處理工法，稱為沃斯回火(Austempering)。

沃斯回火特性

- 優點：
  - 高強度
  - 高韌性
  - 變形量極小
  - 不易脆裂
- 缺點：
  - 有牙孔時殘鹽洗淨不易
  - 生產效率低
  - 生產成本高

離子氮化製程原理

- 離子滲氮也稱為電漿滲氮，其離子氮化是利用高電壓，使得氮氣及氫氣在電場作用下碰撞至陰極促使氮原子與氫原子反覆的碰撞下與碰撞產生的鐵原子結合形成FeN。



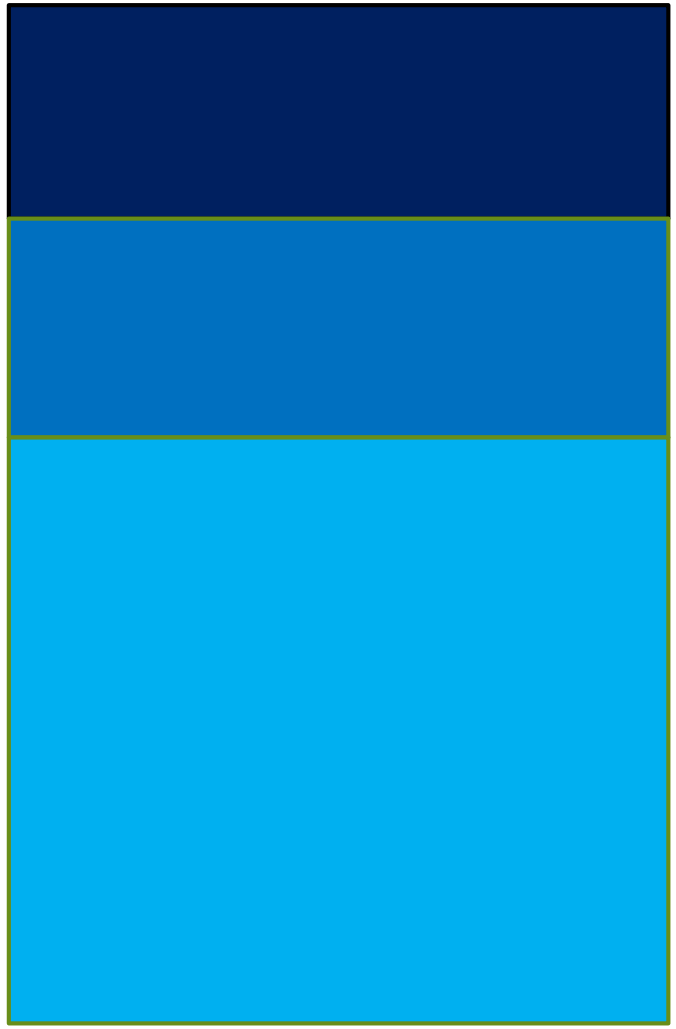
离子滲氮原理图

離子氮化製程特性

白層
(FeN)

擴散層
(合金氮化物)

基材



提升磨耗及腐蝕特性

延長疲勞壽命

離子氮化製程優點

- 氮化層與表面組織緻密較不易發生氮化脆性。
- 離子氮化處理的溫度較低時間較短氮化後工件的變形量較少，減少後精加工成本較優於其他傳統氮化處理。
- 離子氮化對不規則形狀工件也容易加工。
- 離子氮化後提升表面的硬度、耐磨性及腐蝕特性。

實驗動機

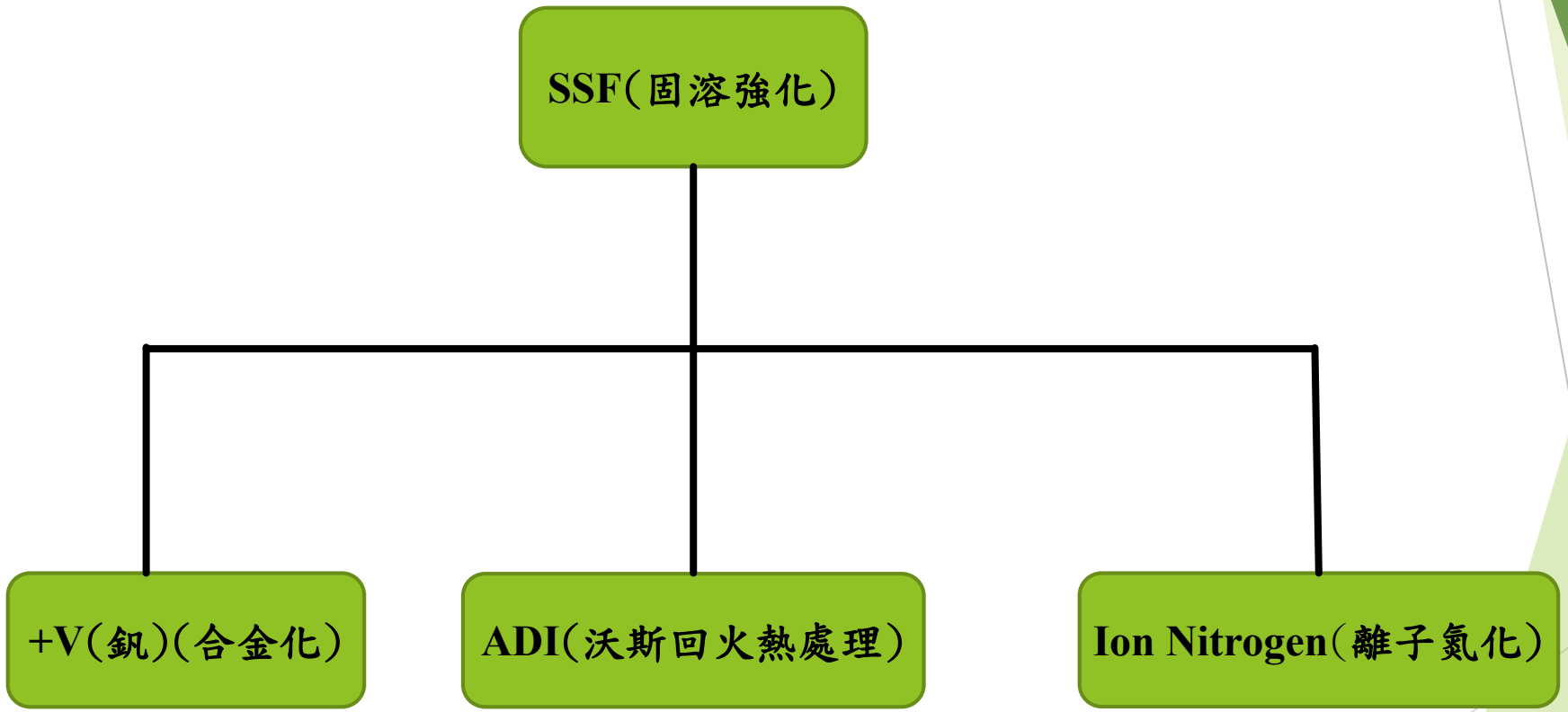
- FCD600經由ADI及離子氮化製程加工，能夠提升基材的表面強度、耐磨性質、抗腐蝕性。

實 驗 目 的

1. 探討FCD600經沃斯回火後表面硬度、耐磨耗性及耐腐蝕性之影響

2. 藉由離子氮化製程經沃斯回火之FCD600耐磨耗性及耐腐蝕性之差異

實 驗 目 的



課程相關知識

材料科學與工程(一)(二)	材料技術實習(二)	物理冶金
擴散(離子氮化) 恆溫變態曲線 合金化及固溶強化製程	熱處理金相製作硬度量測 磨耗試驗 XRD,SEM/EDS	沃斯回火製程(ADI) 離子氮化原理與製程

實驗結果與討論

進度(一):金相(未ADI)

金相(未腐蝕)		
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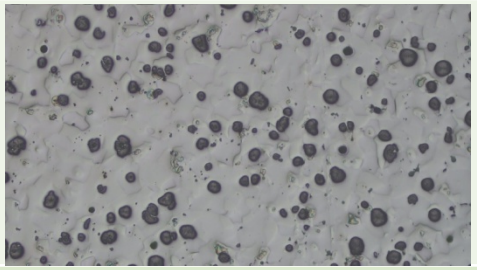	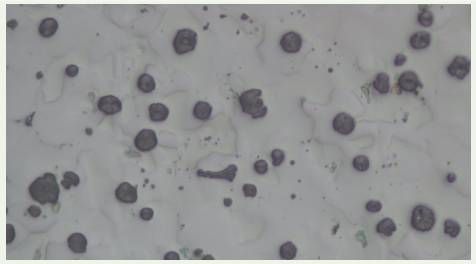	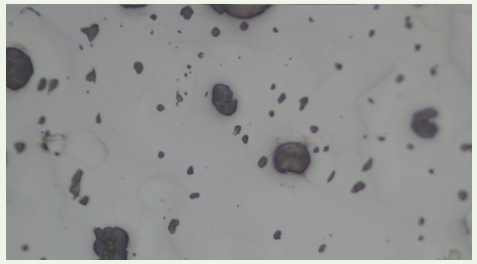
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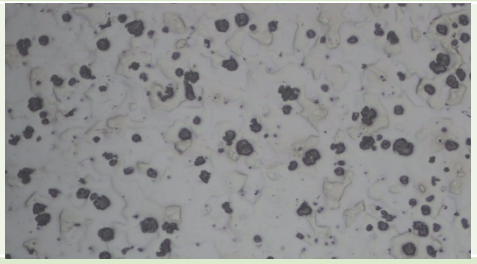	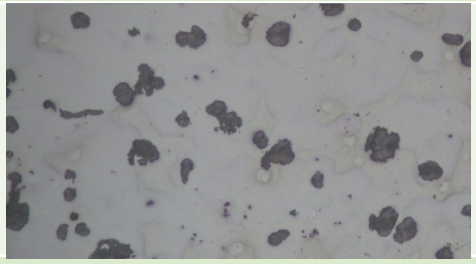	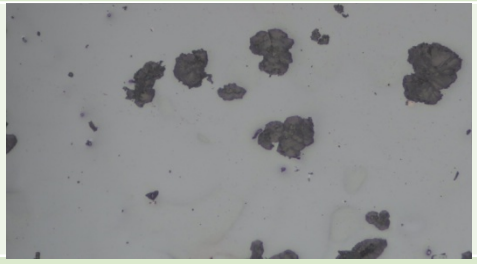
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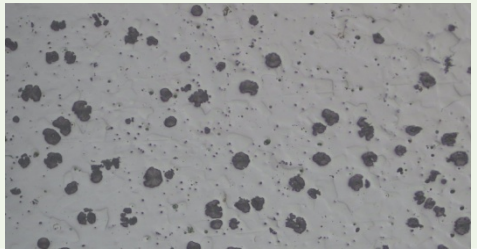	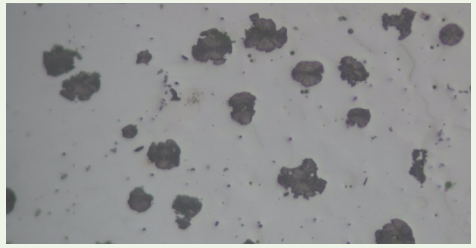	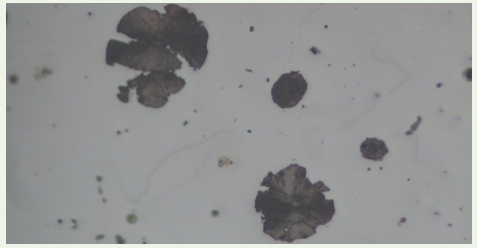

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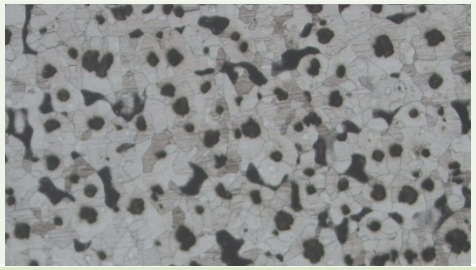	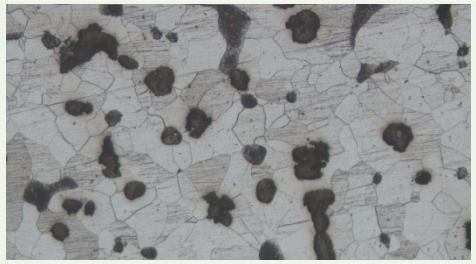	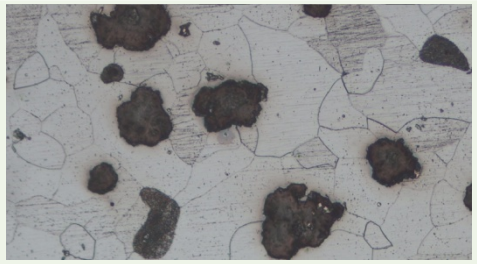
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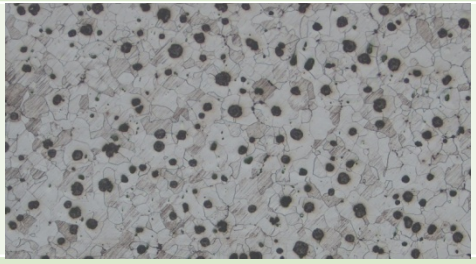	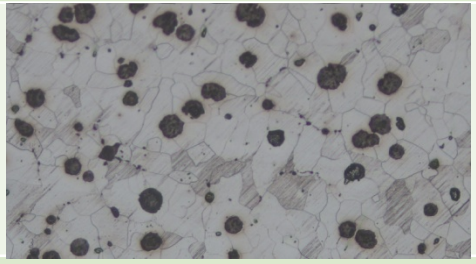	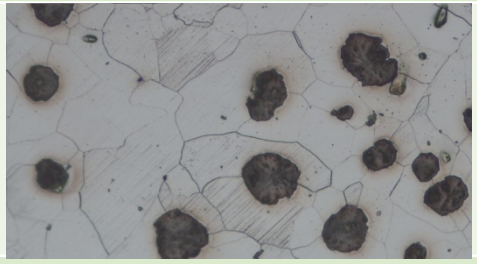
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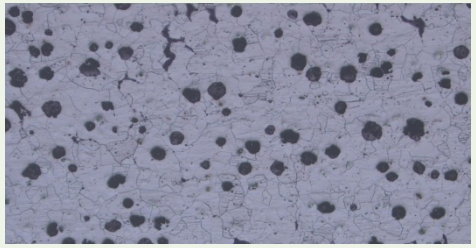	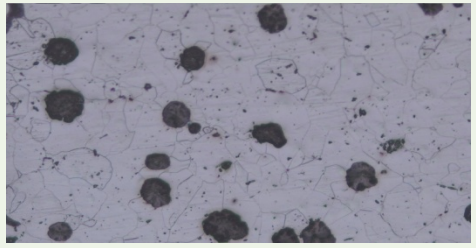	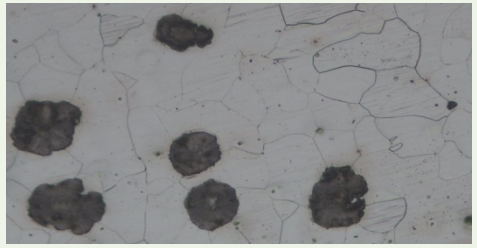

金相(ADI)

金相(未腐蝕)		
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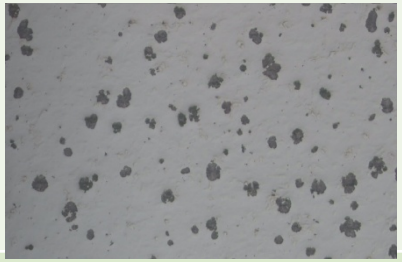	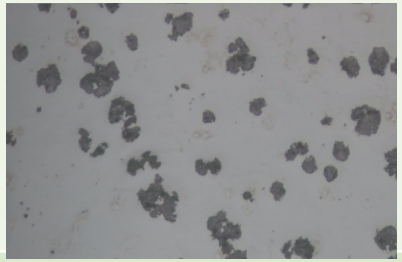	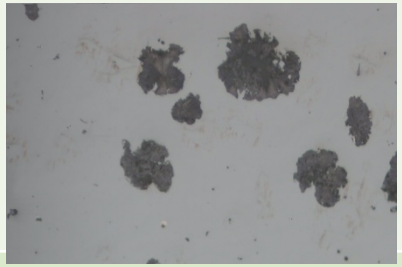
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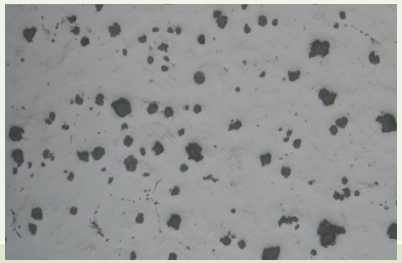	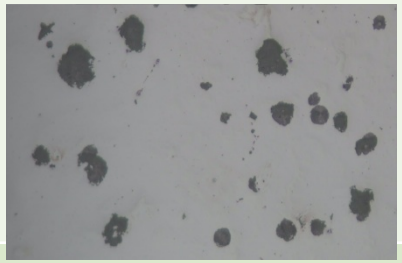	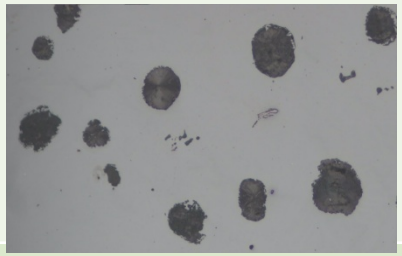
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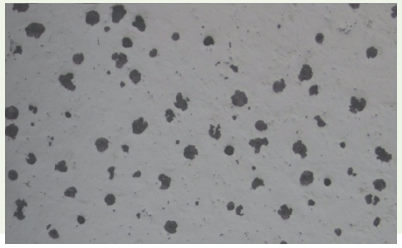	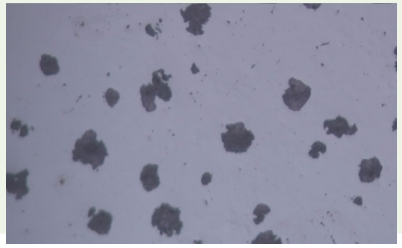	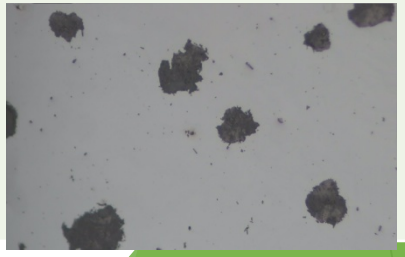

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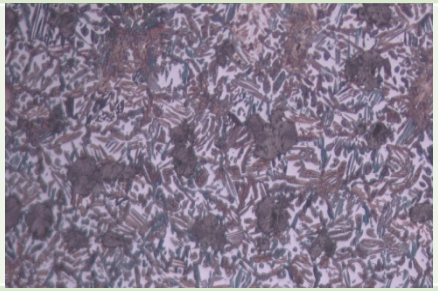	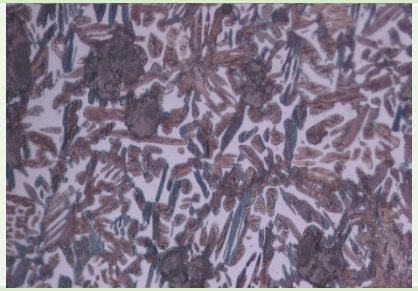	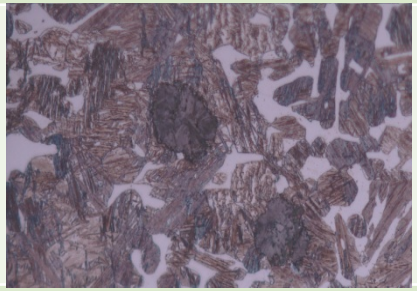
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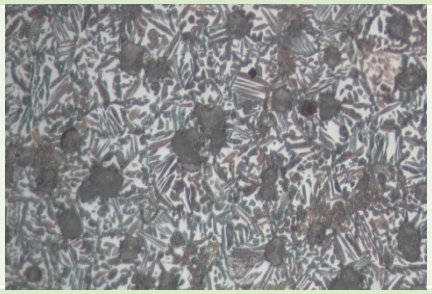	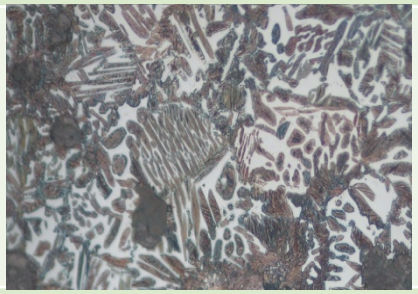	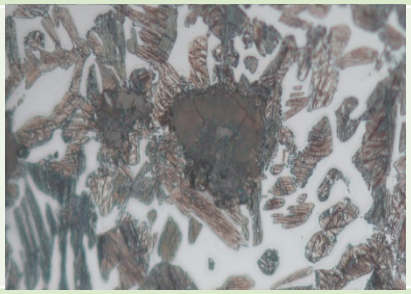
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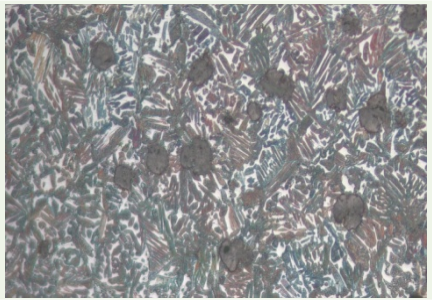
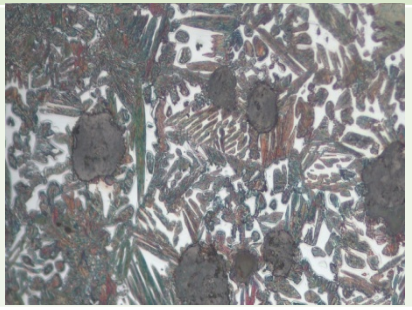
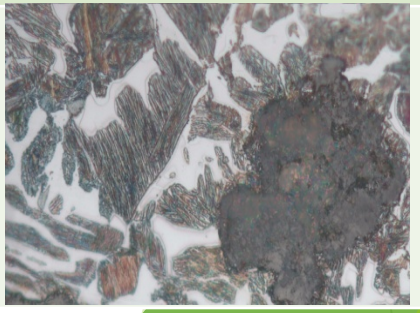
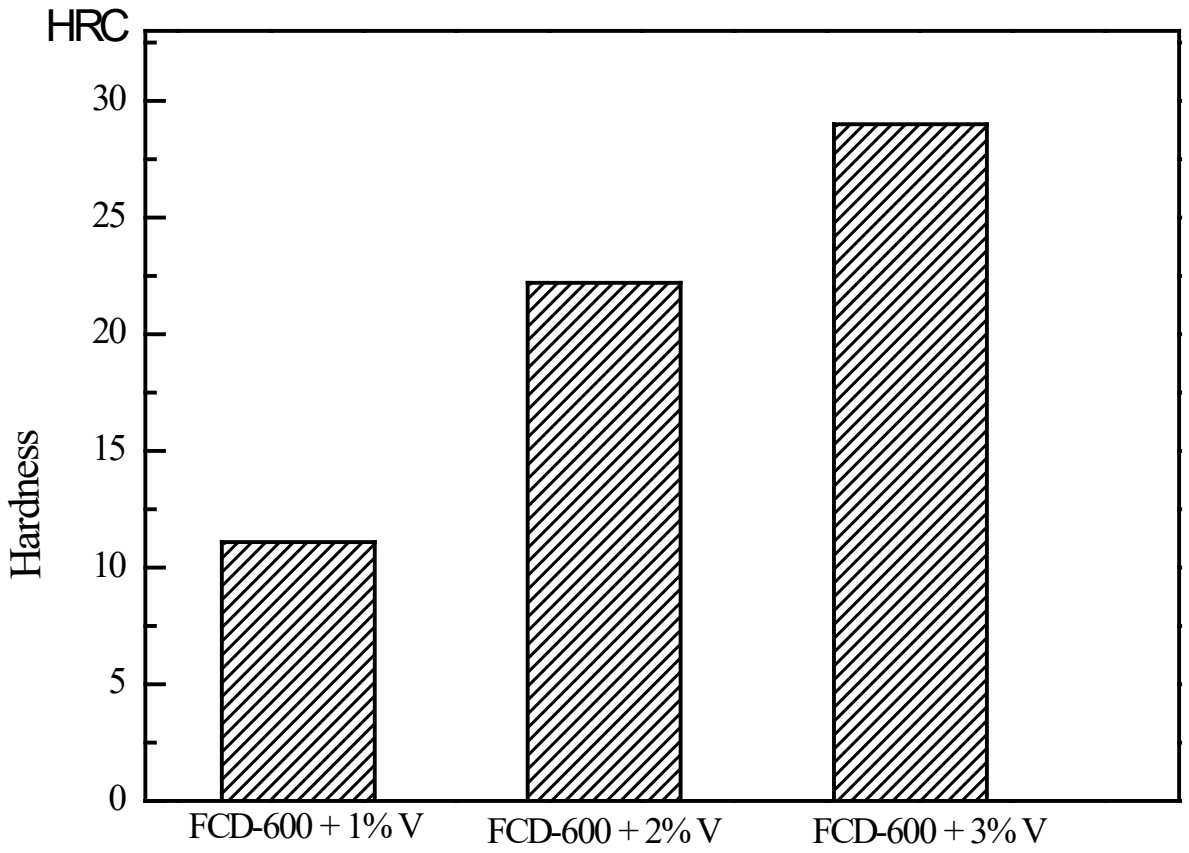
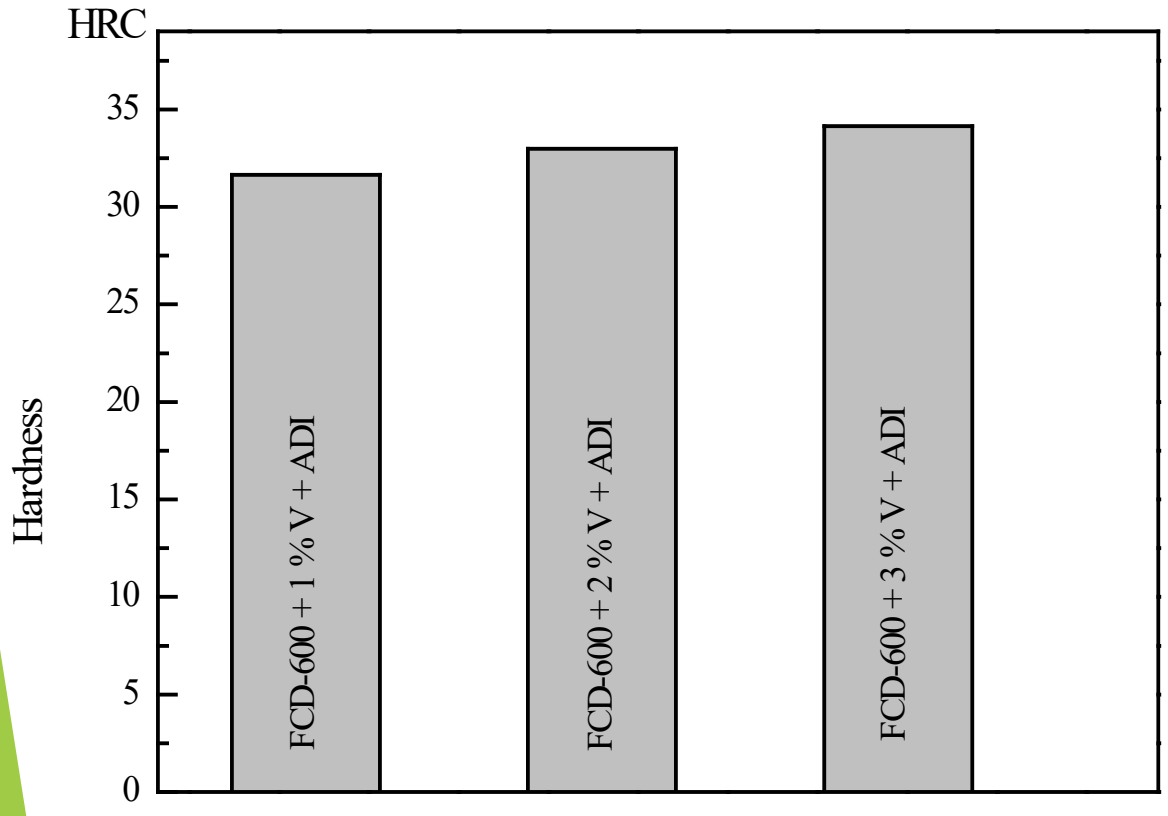
		

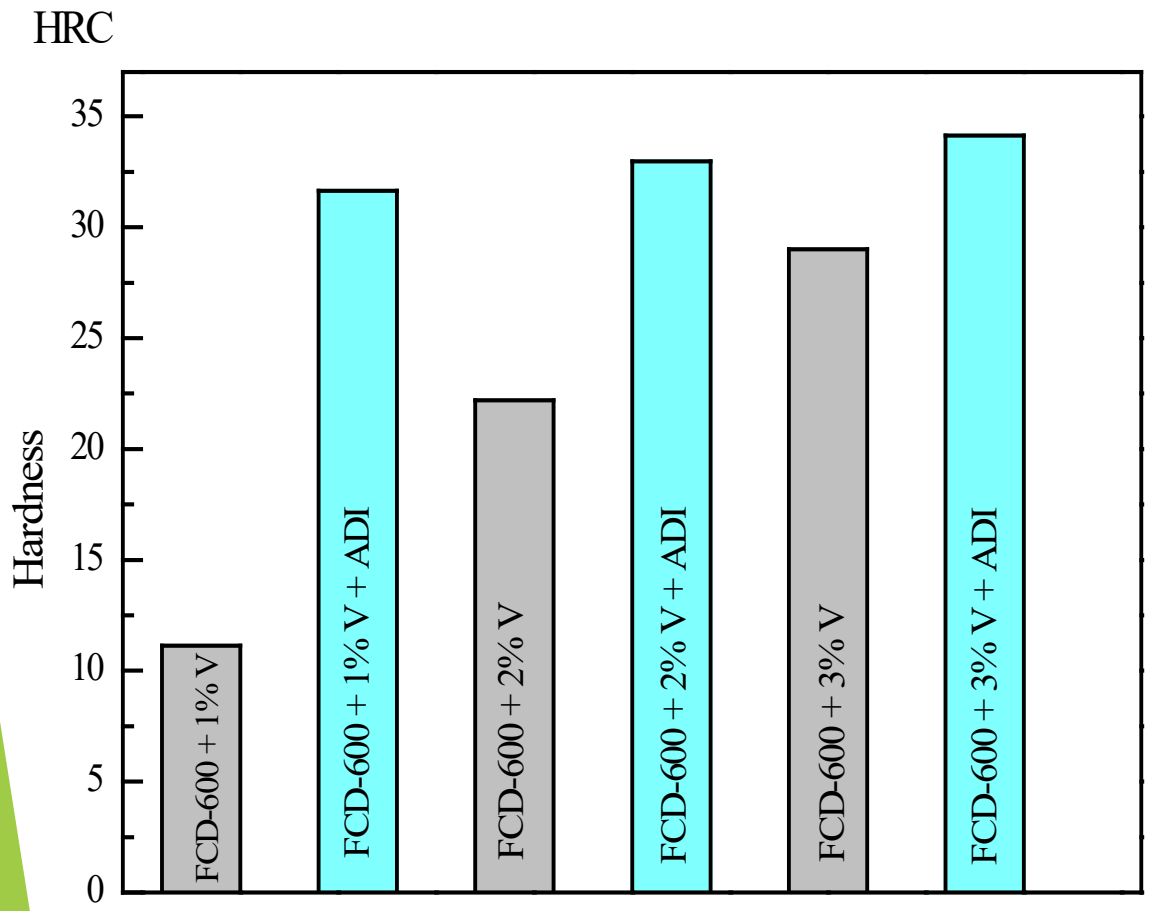
進度二. 硬度



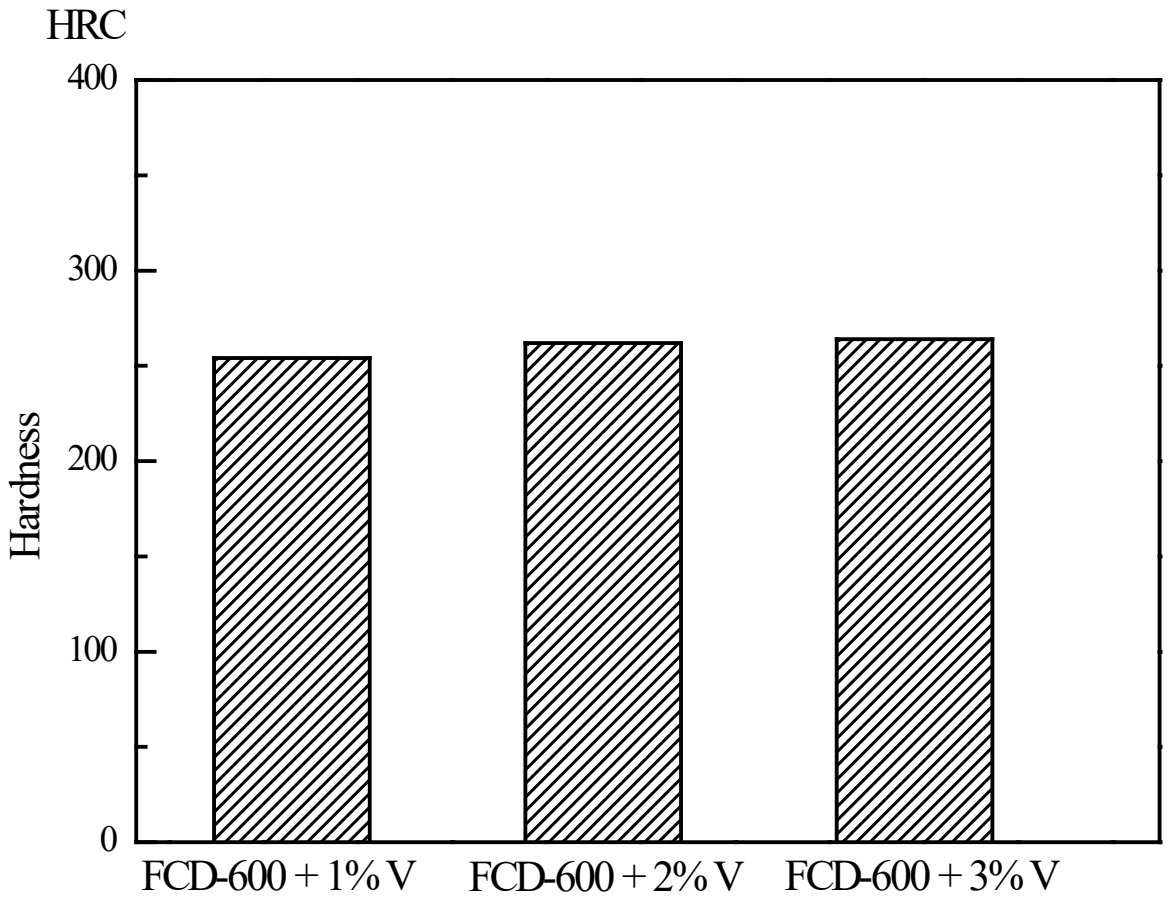
經由此數據得知FCD600+3%V的HRC硬度測試結果較硬而FCD600+1%V較軟，硬度比較為3%V>2%V>1%V



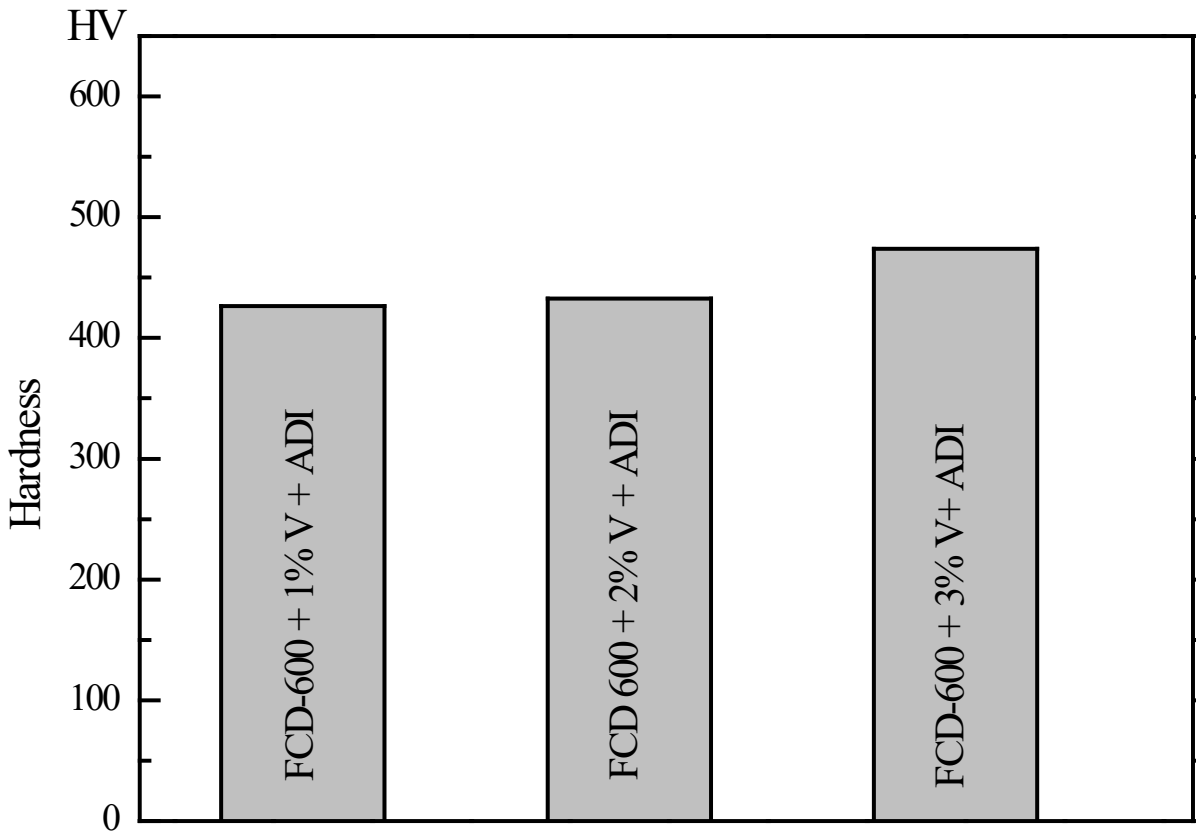
經由此數據得知FCD600+3%V(ADI)的HRC硬度測試結果較硬而FCD600+1%V(ADI)較軟，硬度比較為3%V>2%V>1%V



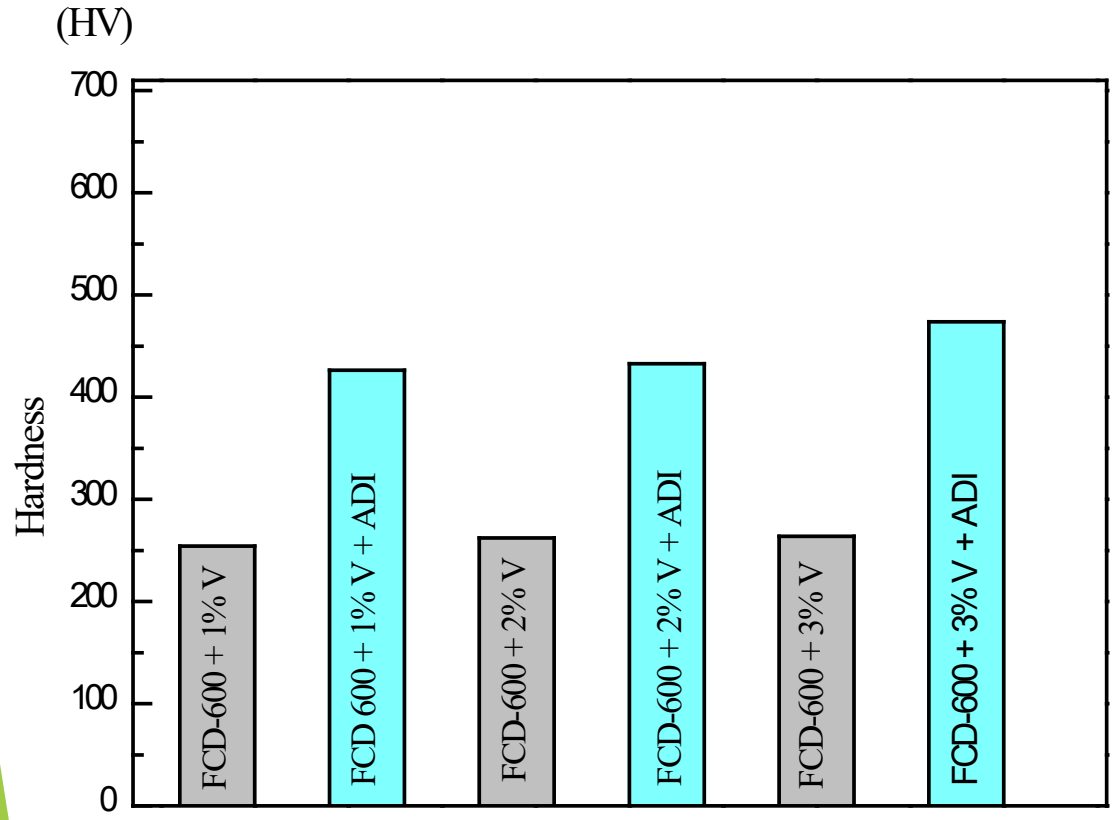
經由此數據得知FCD600+3%V的HRC硬度測試結果較硬而FCD600+1%V較軟，硬度比較為3%V>2%V>1%V，從圖表發現FCD600經ADI後的硬度有明顯提升



經由此數據得知FCD600+3%V的Hv硬度測試結果較軟而FCD600+1%V較硬，硬度比較為3%V>2%V>1%V



經由此數據得知FCD600+3%V(ADI)的Hv硬度測試結果較硬而FCD600+1%V(ADI)較軟，硬度比較為3%V>2%V>1%V



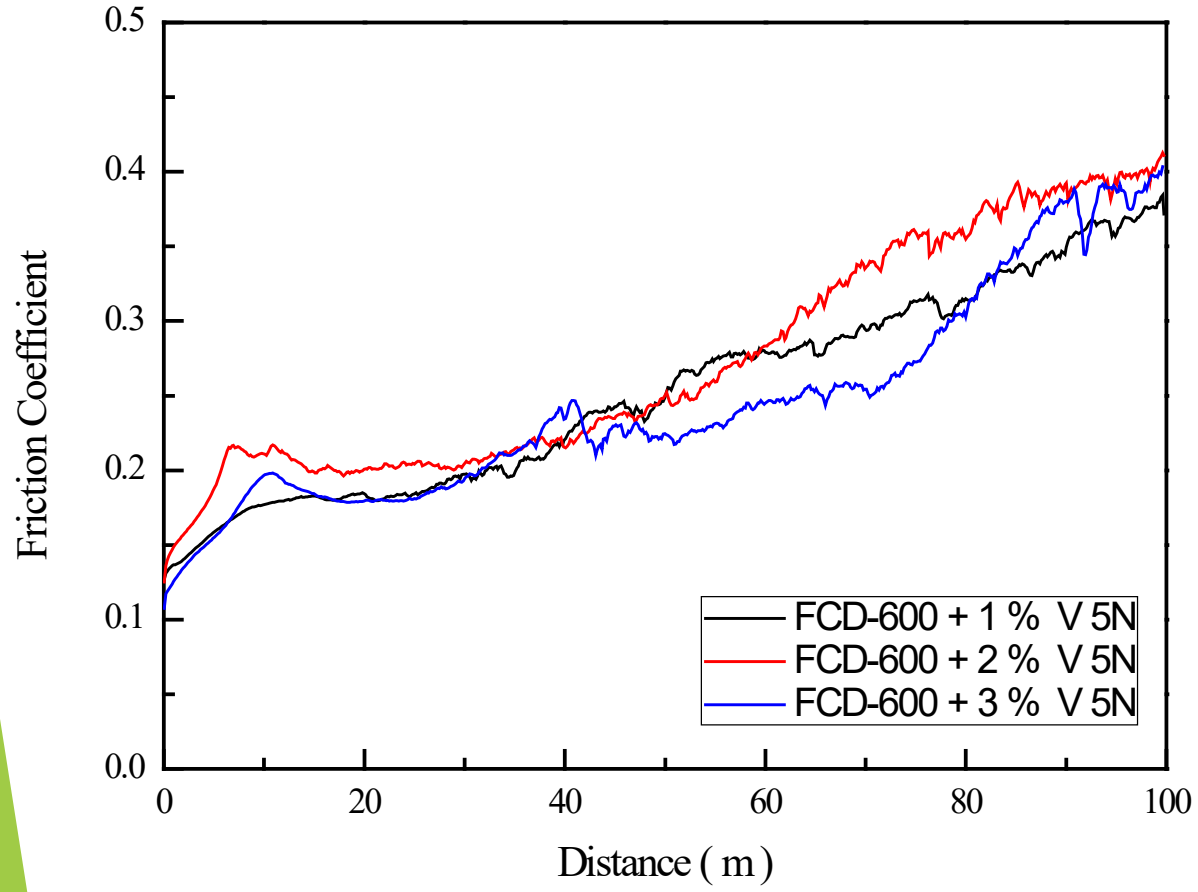
經由此數據得知FCD600+3%V的Hv硬度測試結果較硬而FCD600+1%V較軟，硬度比較為3%V>2%V>1%V，從圖表發現FCD600經ADI後的硬度有明顯提升。

進度三. 磨耗

FCD600添加釩(ADI)之循環式磨耗參數:

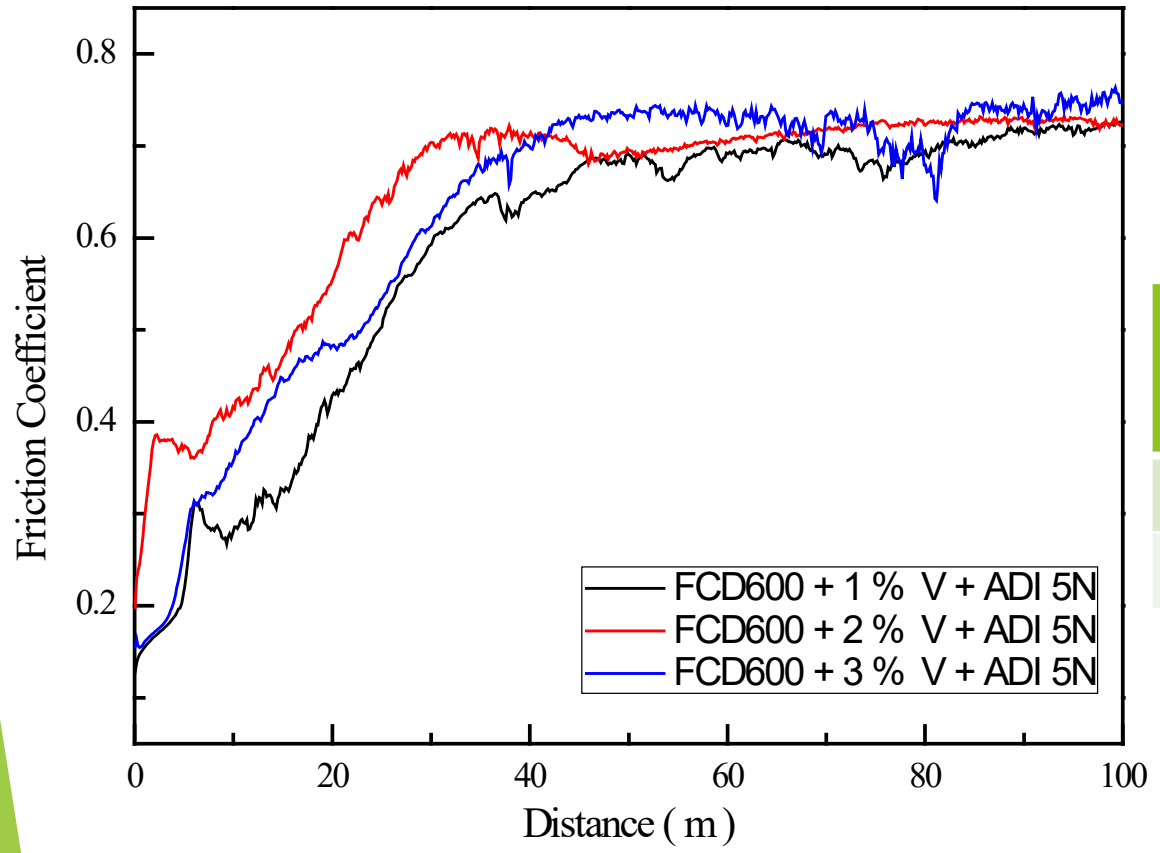
參數	條件
荷重	5 N、6 N、7 N
滑動速度	10.4 cm/s
轉速	300 rpm
行走直徑	5 mm
滑度距離	100 m
對耗材	Al_2O_3

FCD600添加釩之磨耗曲線 荷重5N 比較圖



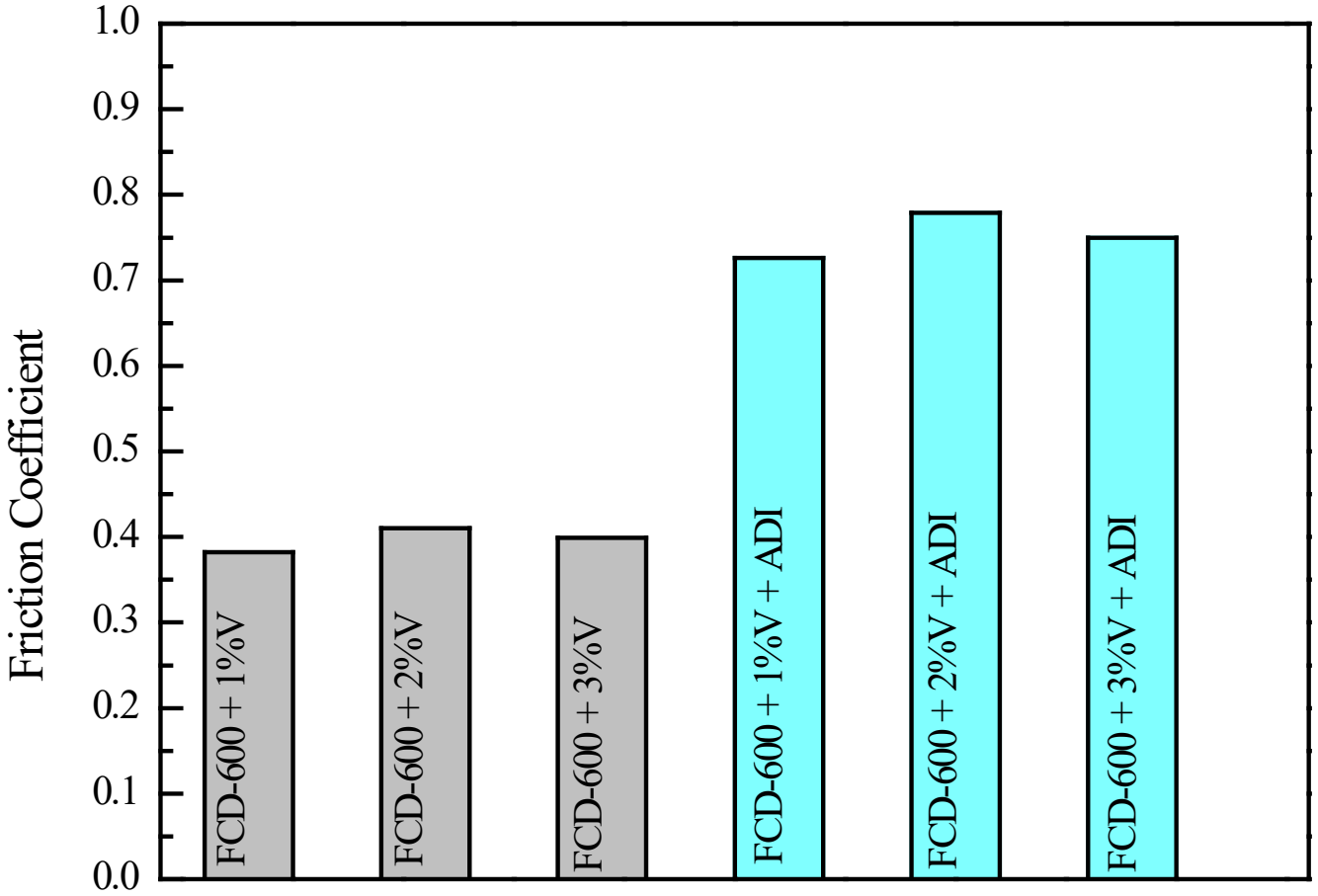
	FCD-600 + 1% V	FCD-600 + 2% V	FCD-600 + 3% V
磨耗係數	0.382	0.410	0.399
磨耗損失率	6.33×10^{-6}	3.58×10^{-6}	3.02×10^{-6}

FCD600添加釩+ADI之磨耗曲線 荷重5N 比較圖

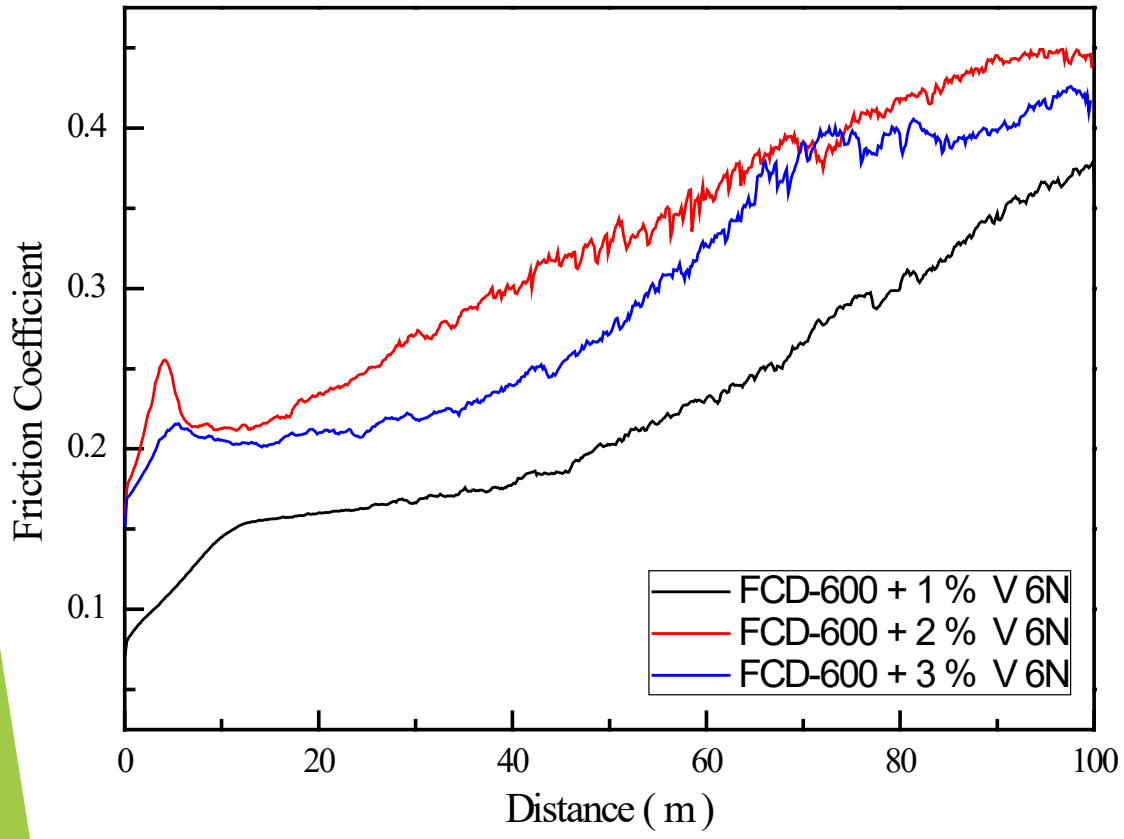


	FCD-600 + 1% V (ADI)	FCD-600 + 2% V (ADI)	FCD-600 + 3% V (ADI)
磨耗係數	0.726	0.730	0.759
磨耗損失率	4.04×10^{-6}	3.09×10^{-6}	2.6×10^{-6}

5N摩擦係數

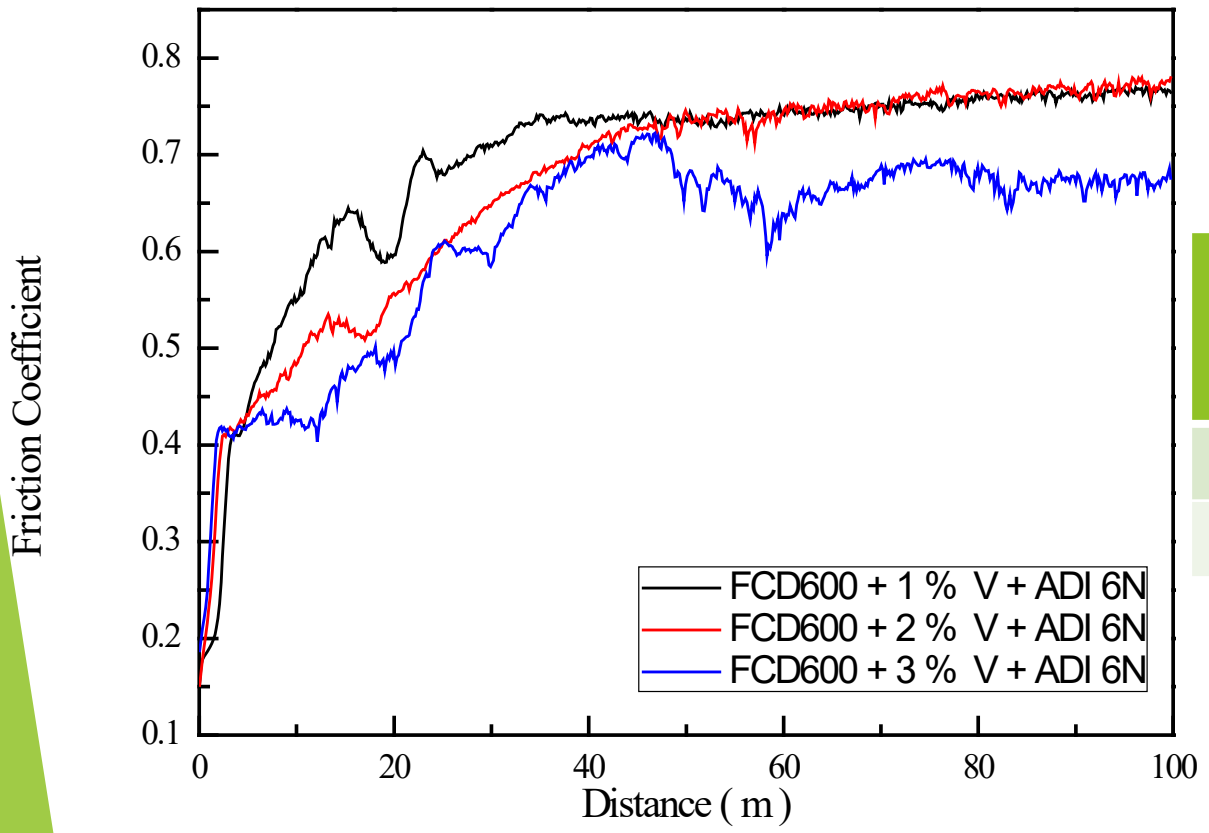

Friction Coefficient
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
FCD-600 + 1%V
FCD-600 + 2%V
FCD-600 + 3%V
FCD-600 + 1%V + ADI
FCD-600 + 2%V + ADI
FCD-600 + 3%V + ADI

FCD600添加釩之磨耗曲線 荷重6N 比較圖



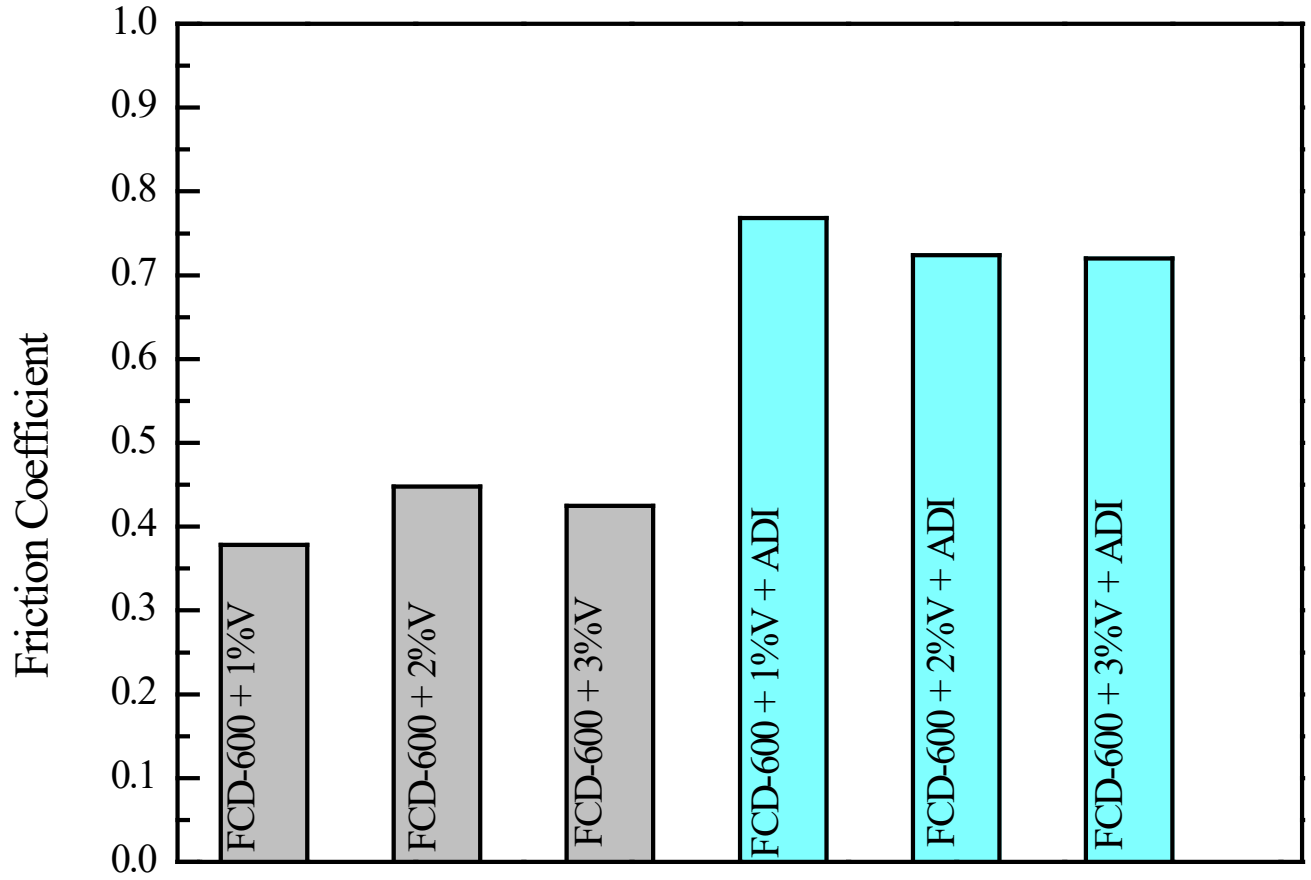
	FCD-600 + 1% V	FCD-600 + 2% V	FCD-600 + 3% V
磨耗係數	0.378	0.448	0.425
磨耗損失率	5.6×10^{-6}	4.06×10^{-6}	3.53×10^{-6}

FCD600添加釩+ADI之磨耗曲線 荷重6N 比較圖

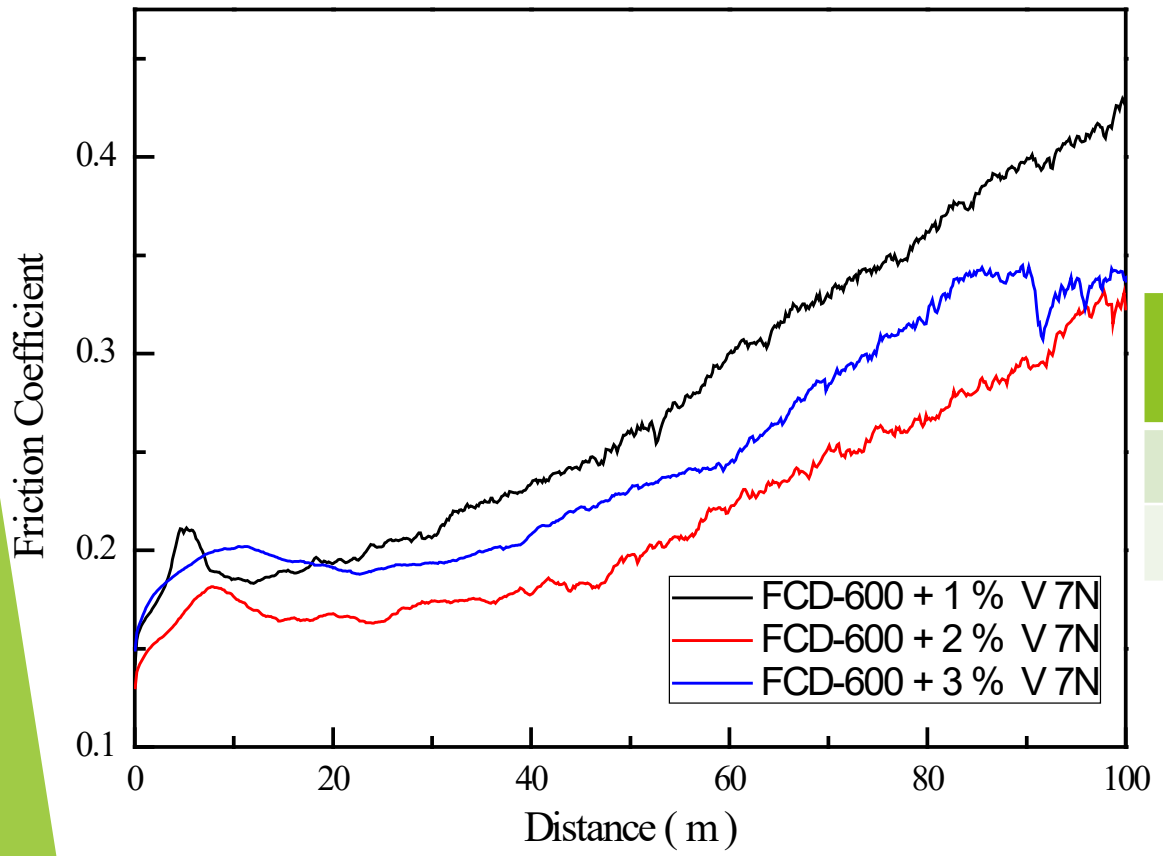


	FCD-600 + 1% V (ADI)	FCD-600 + 2% V (ADI)	FCD-600 + 3% V (ADI)
磨耗係數	0.768	0.777	0.720
磨耗損失率	5.24×10^{-6}	3.41×10^{-6}	2.58×10^{-5}

6N摩擦係數

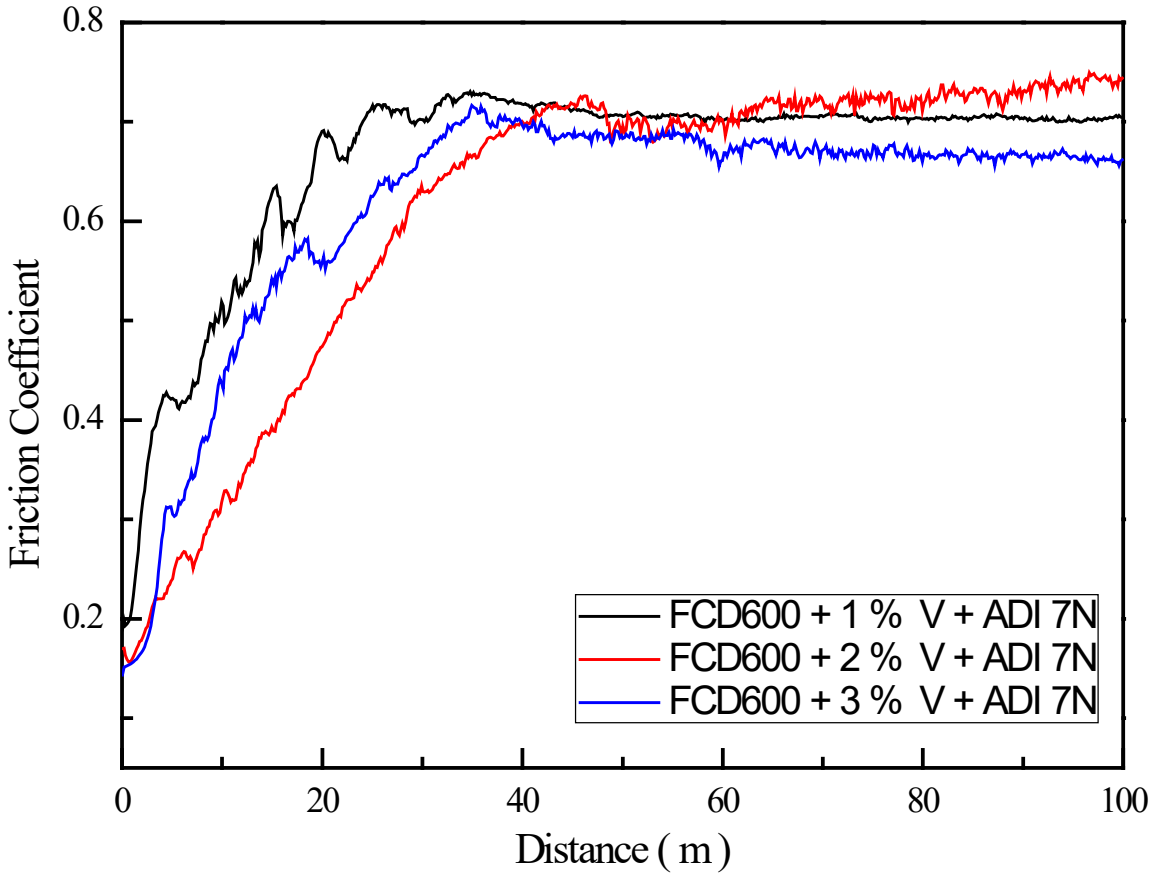

Friction Coefficient
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
FCD-600 + 1%V
FCD-600 + 2%V
FCD-600 + 3%V
FCD-600 + 1%V + ADI
FCD-600 + 2%V + ADI
FCD-600 + 3%V + ADI

FCD600添加釩之磨耗曲線 荷重7N 比較圖



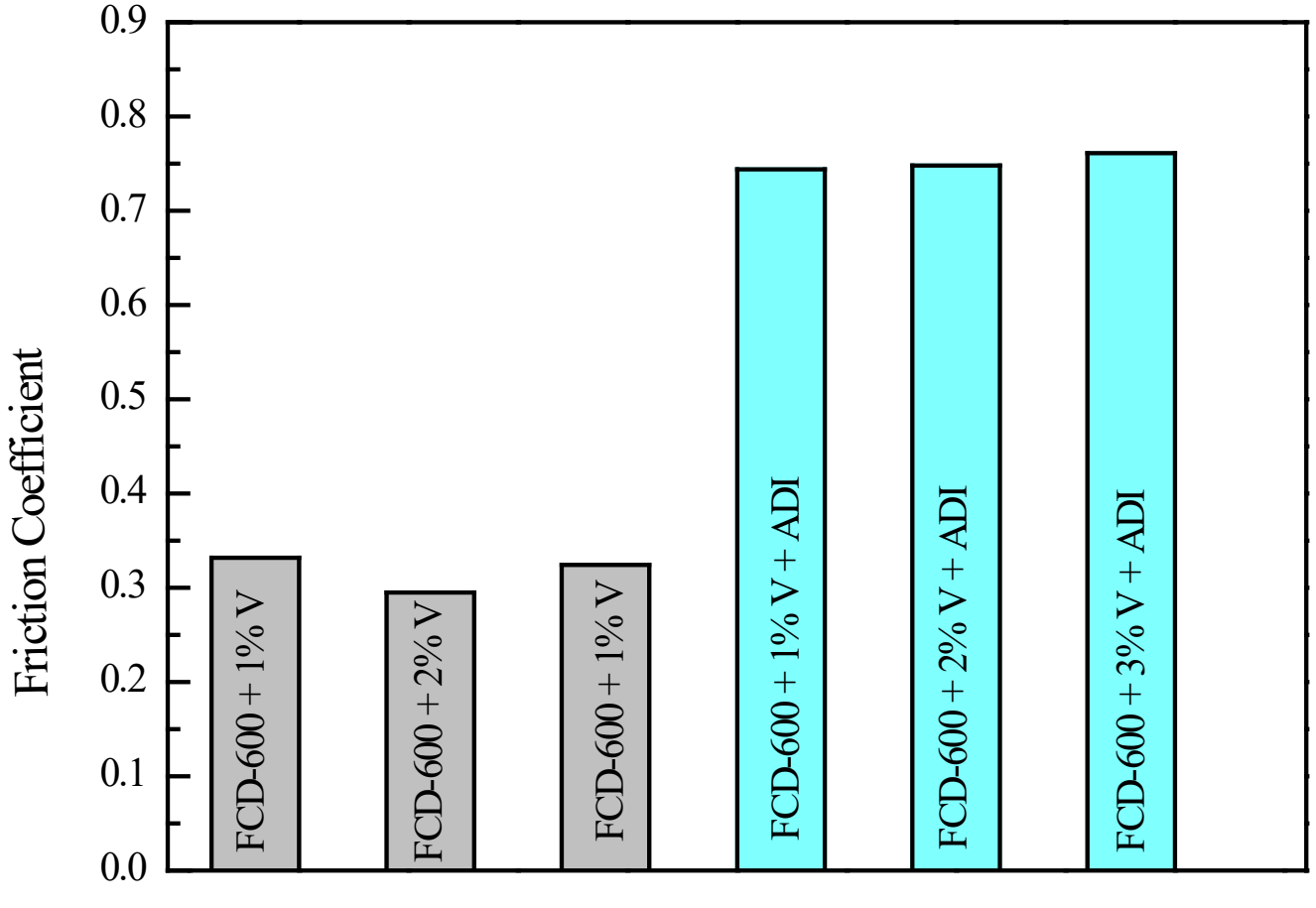
	FCD-600 + 1% V	FCD-600 + 2% V	FCD-600 + 3% V
磨耗係數	0.428	0.329	0.343
磨耗損失率	5.79×10^{-6}	4.37×10^{-6}	4.02×10^{-6}

FCD600添加釩+ADI之磨耗曲線 荷重7N 比較圖

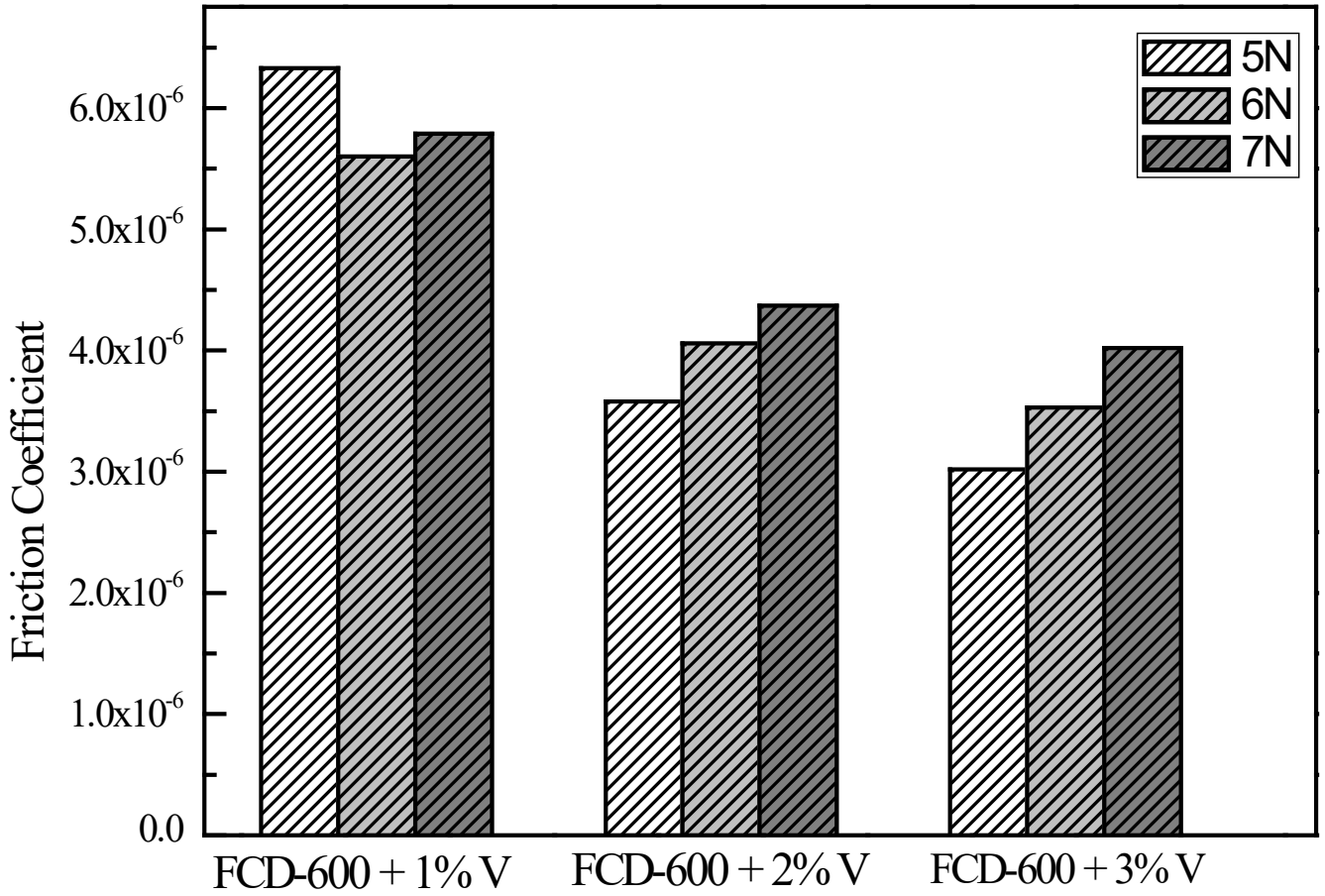


	FCD-600 + 1% V (ADI)	FCD-600 + 2% V (ADI)	FCD-600 + 3% V (ADI)
磨耗係數	0.729	0.748	0.714
磨耗損失率	4.63×10^{-6}	3.8×10^{-6}	2.77×10^{-6}

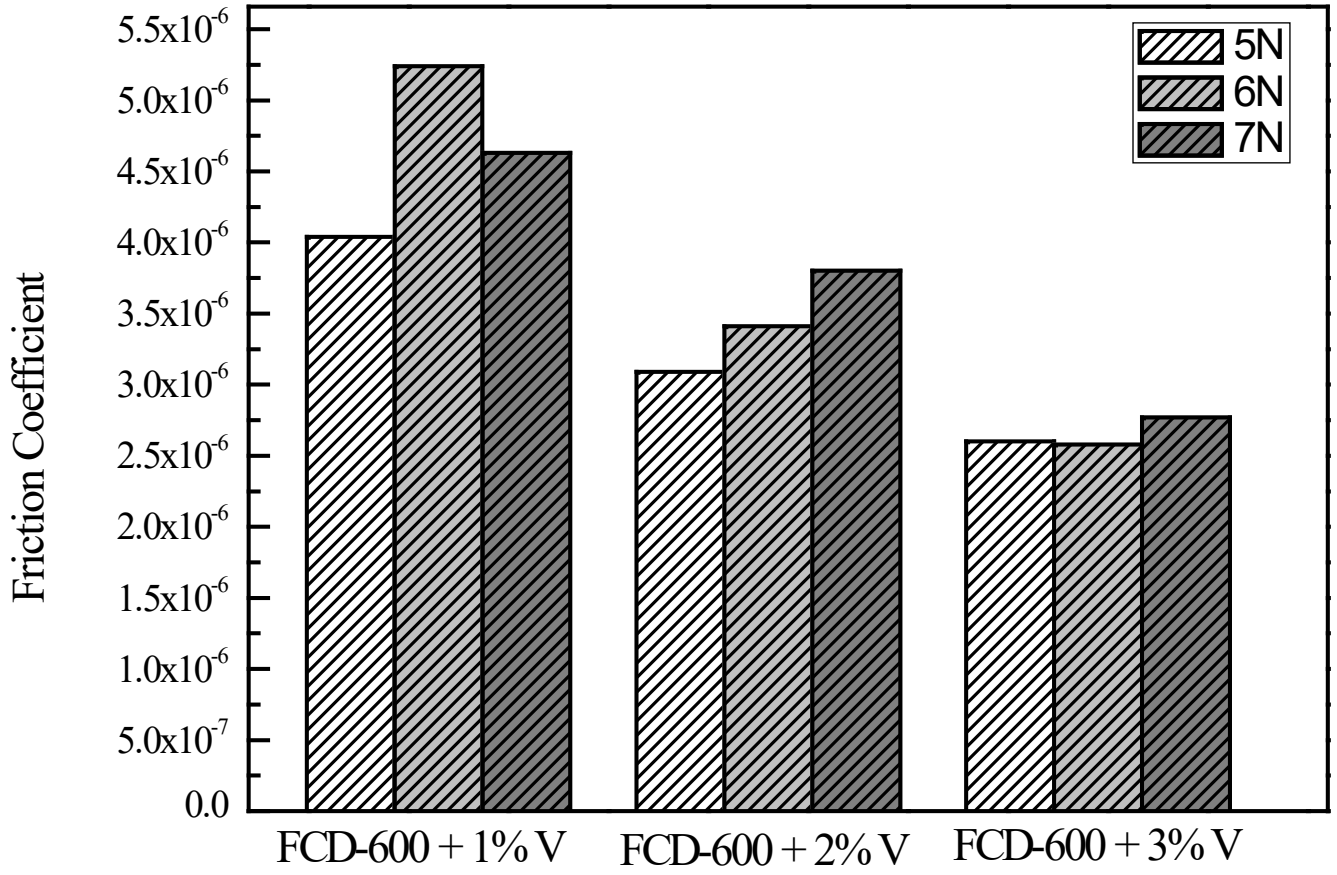
7N磨耗係數


Friction Coefficient
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
FCD-600 + 1% V
FCD-600 + 2% V
FCD-600 + 1% V
FCD-600 + 1% V + ADI
FCD-600 + 2% V + ADI
FCD-600 + 3% V + ADI

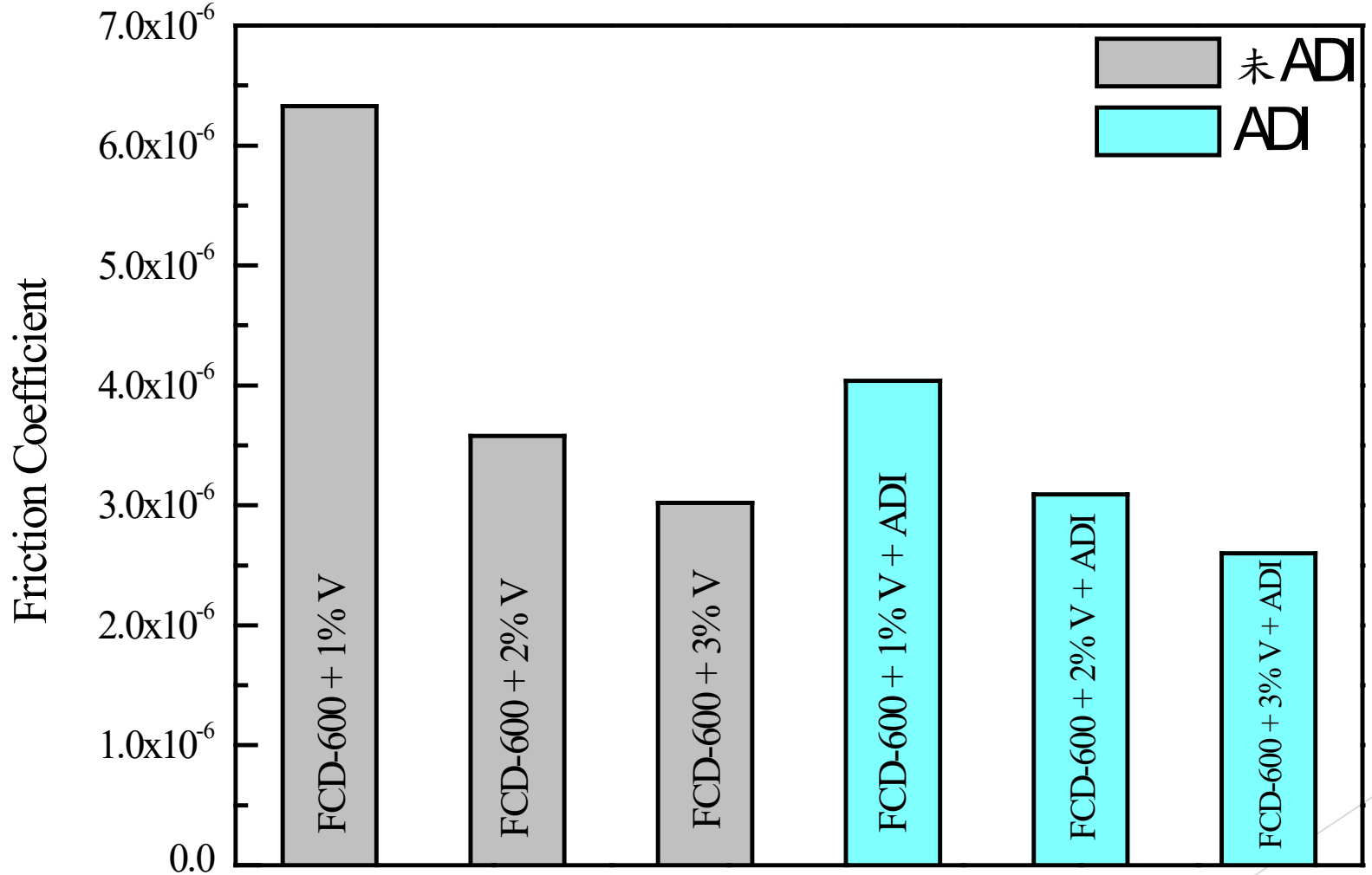
FCD600+V 磨耗損失率 比較圖



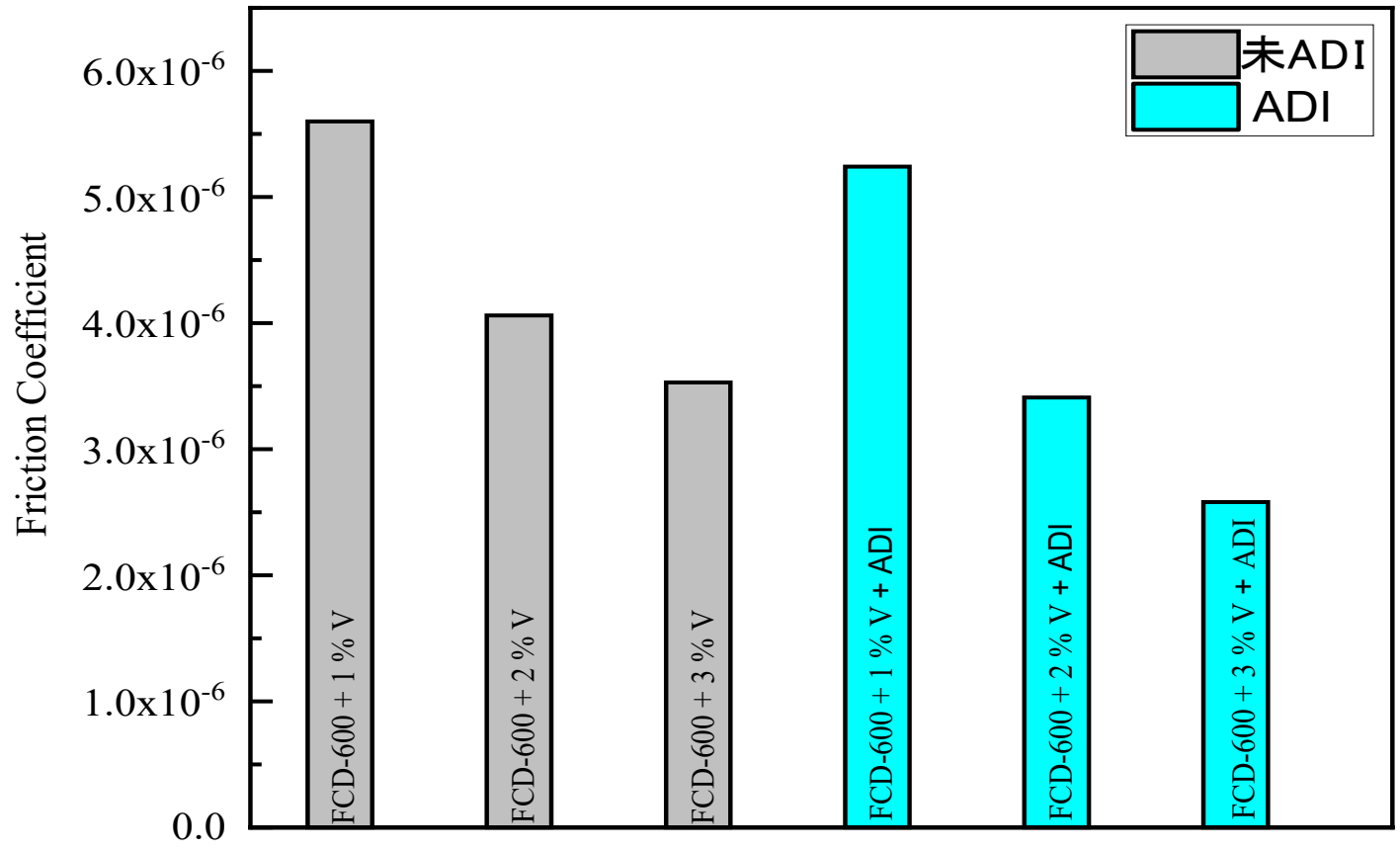
FCD600 + V + ADI 磨耗損失率 比較圖



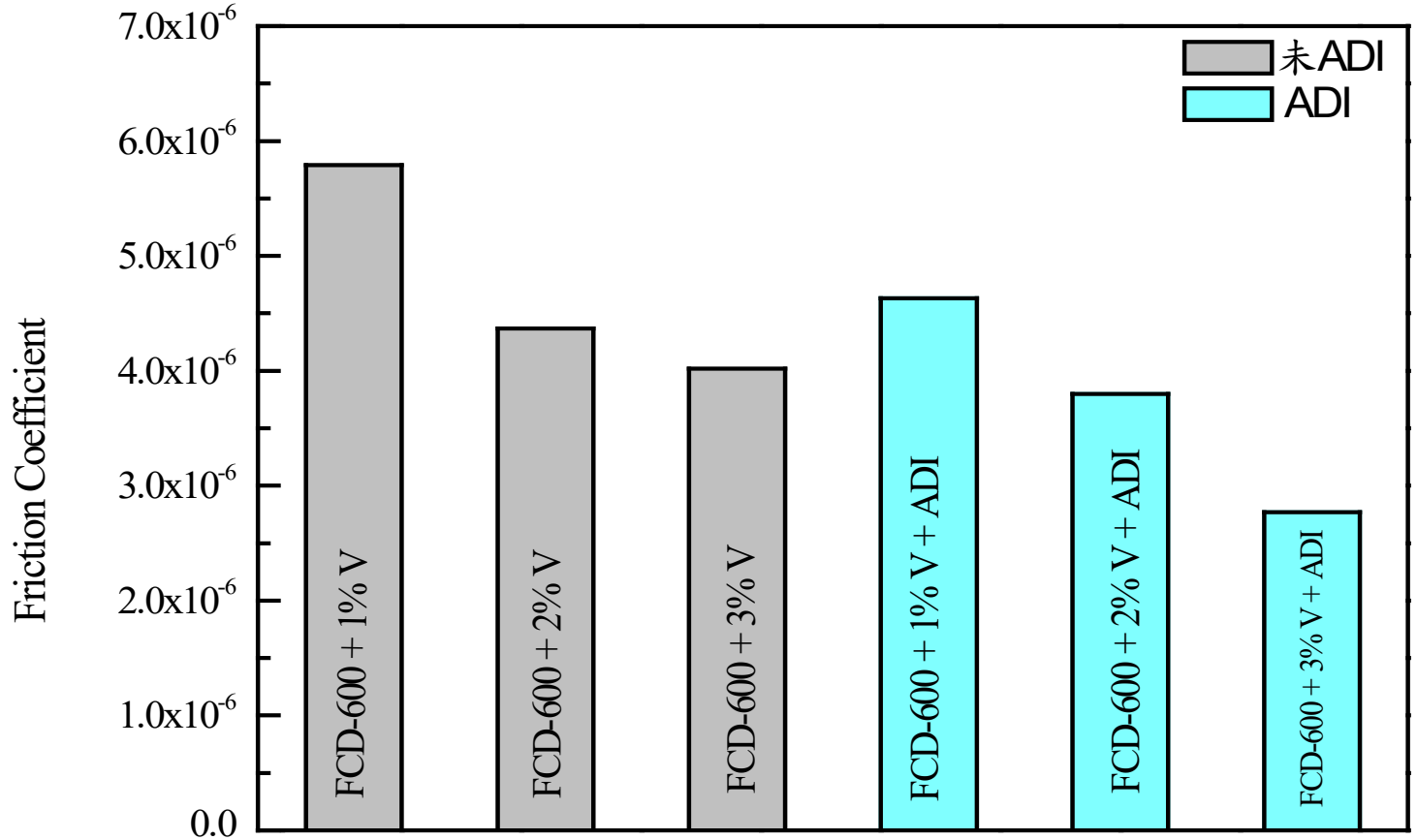
FCD600+V 5N 磨耗損失率



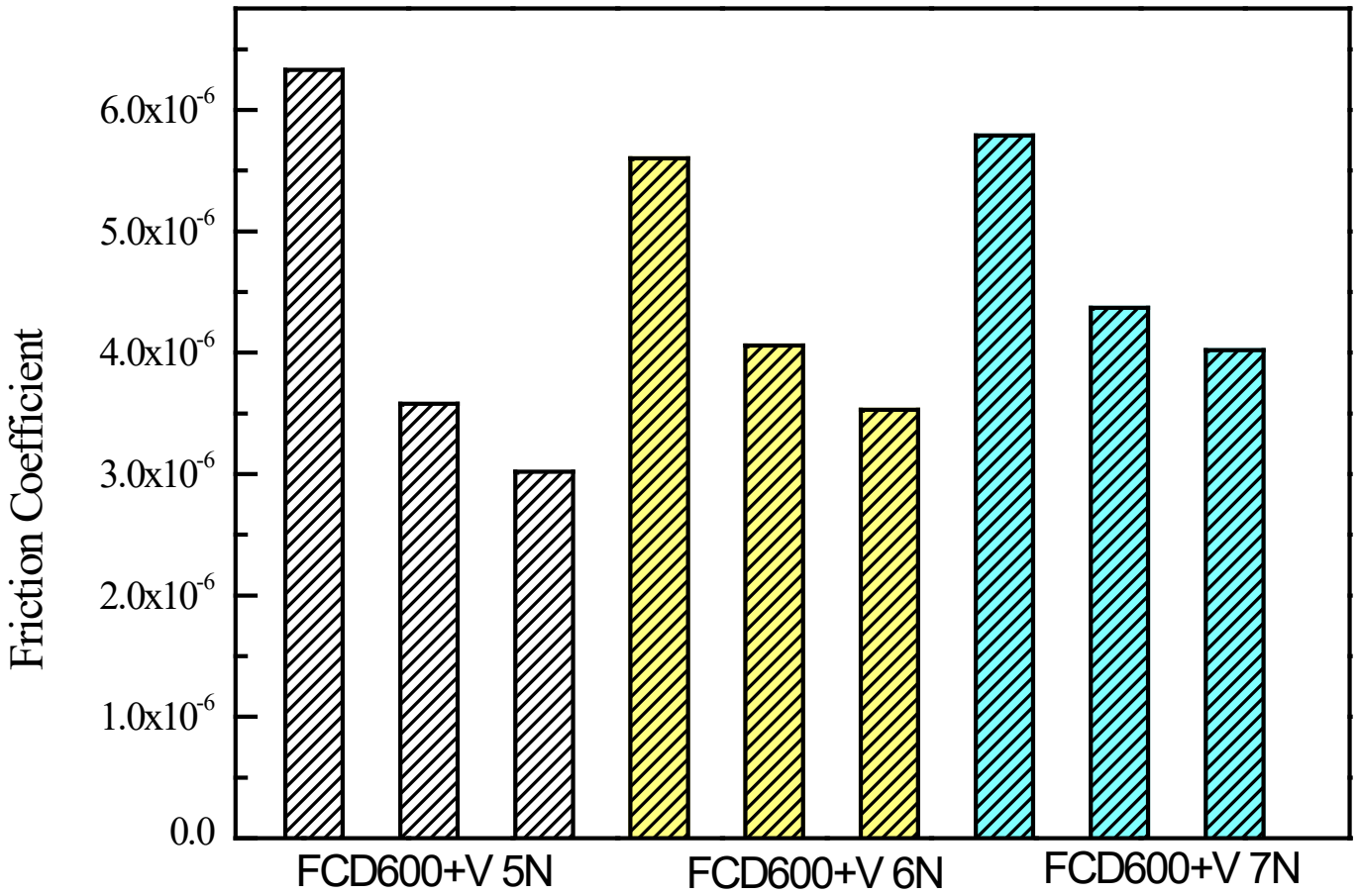
FCD600+V 6N 磨耗損失率



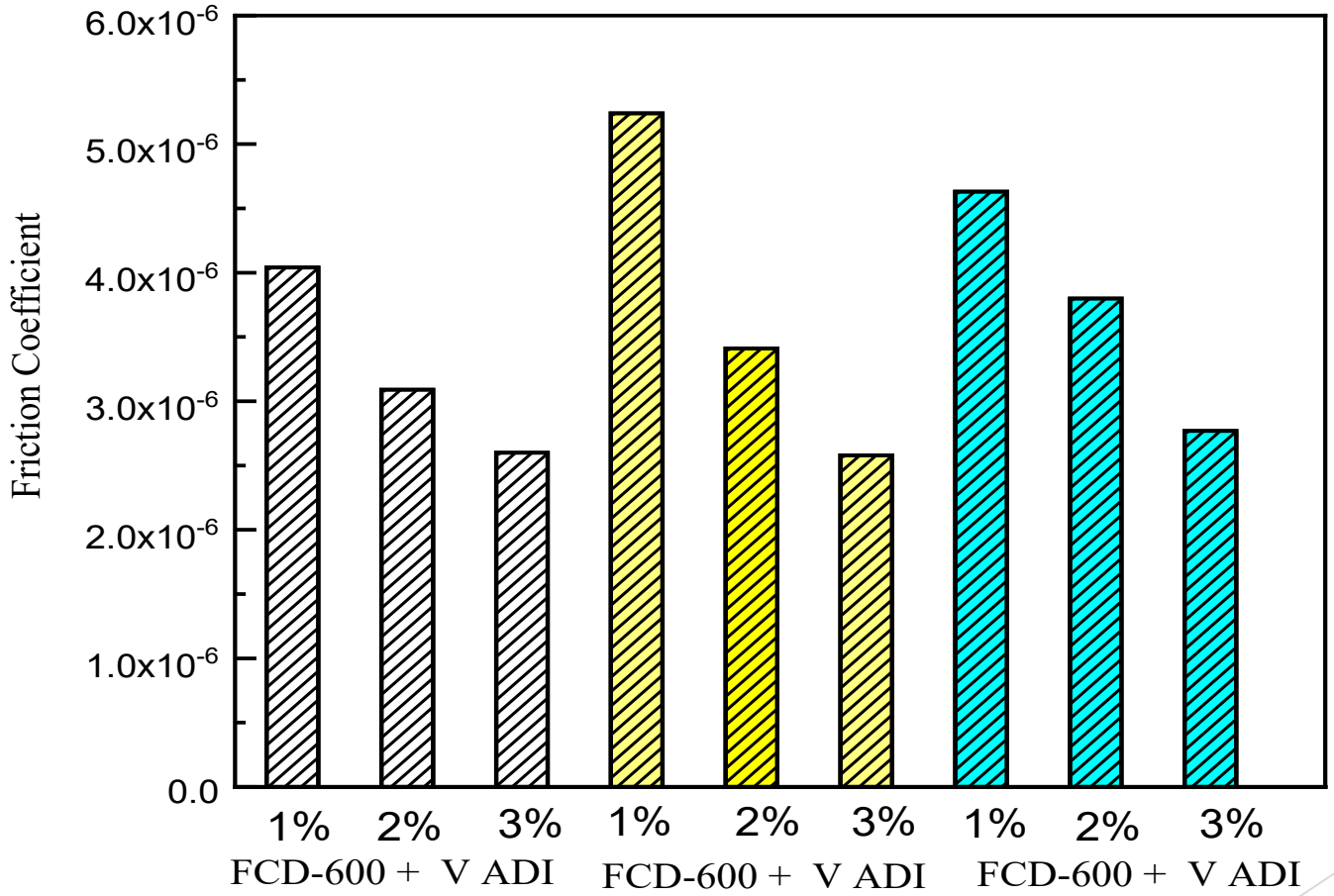
FCD600+V 7N 磨耗損失率



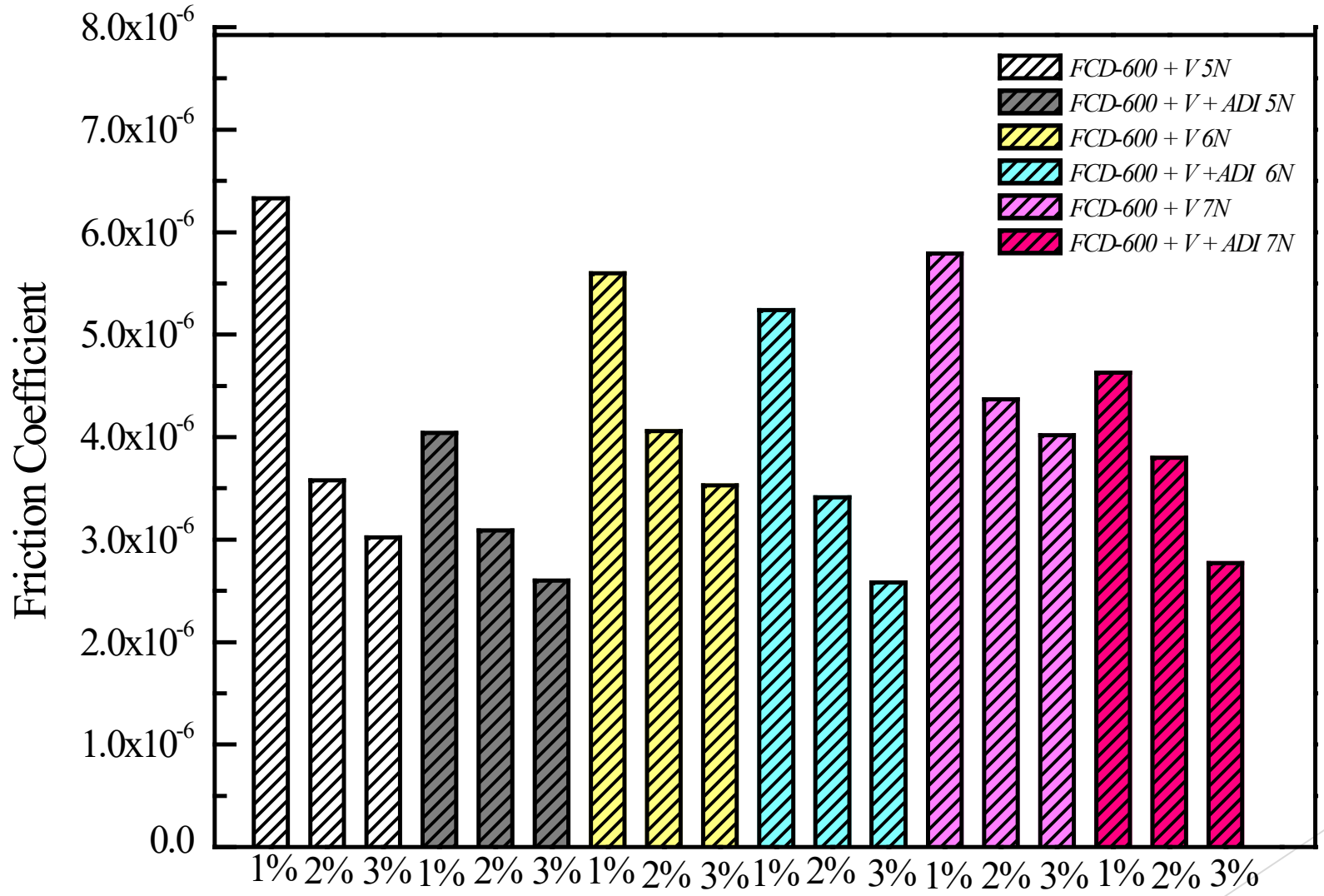
FCD600+V 未ADI 磨耗損失率



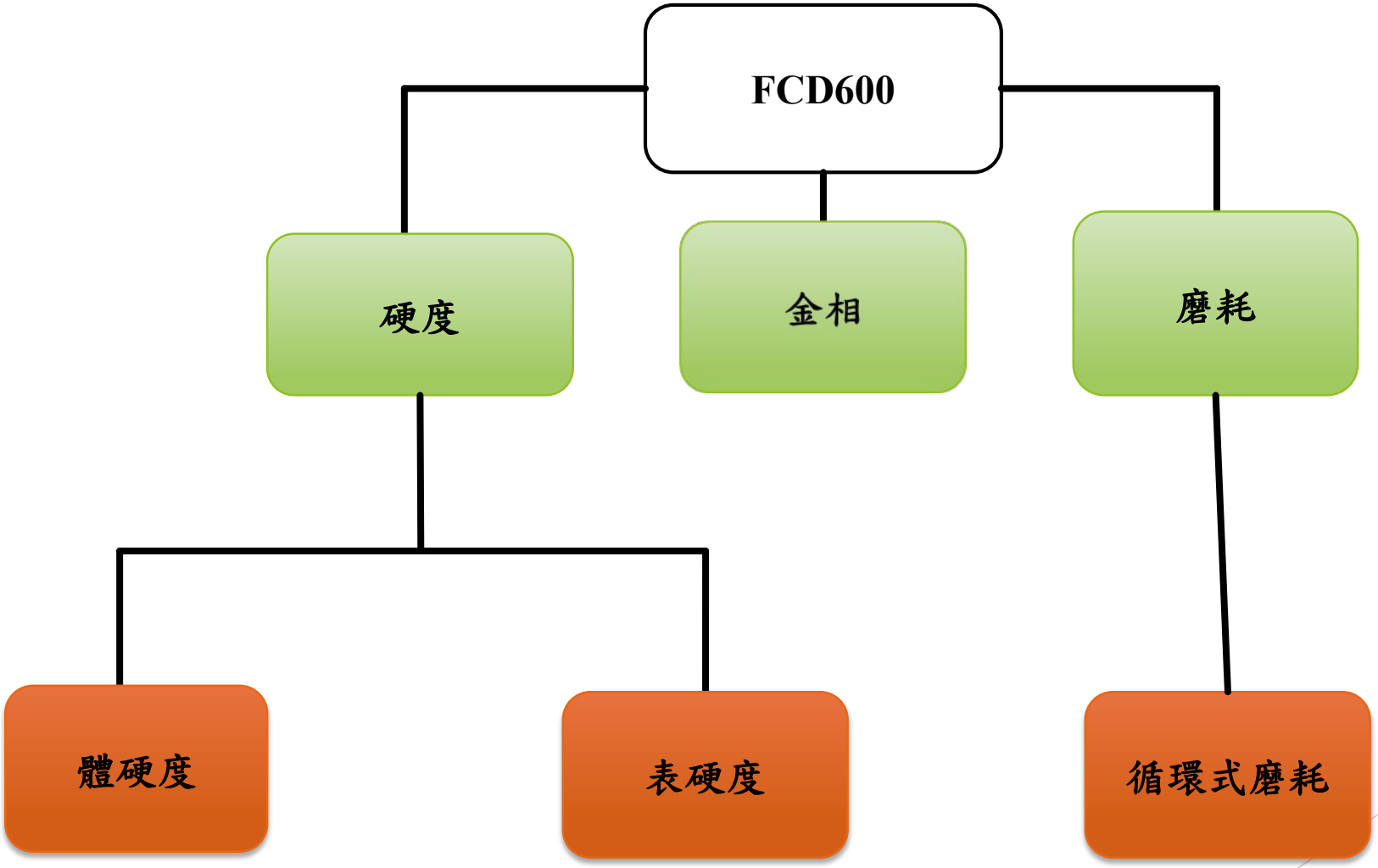
FCD600+V ADI 磨耗損失率



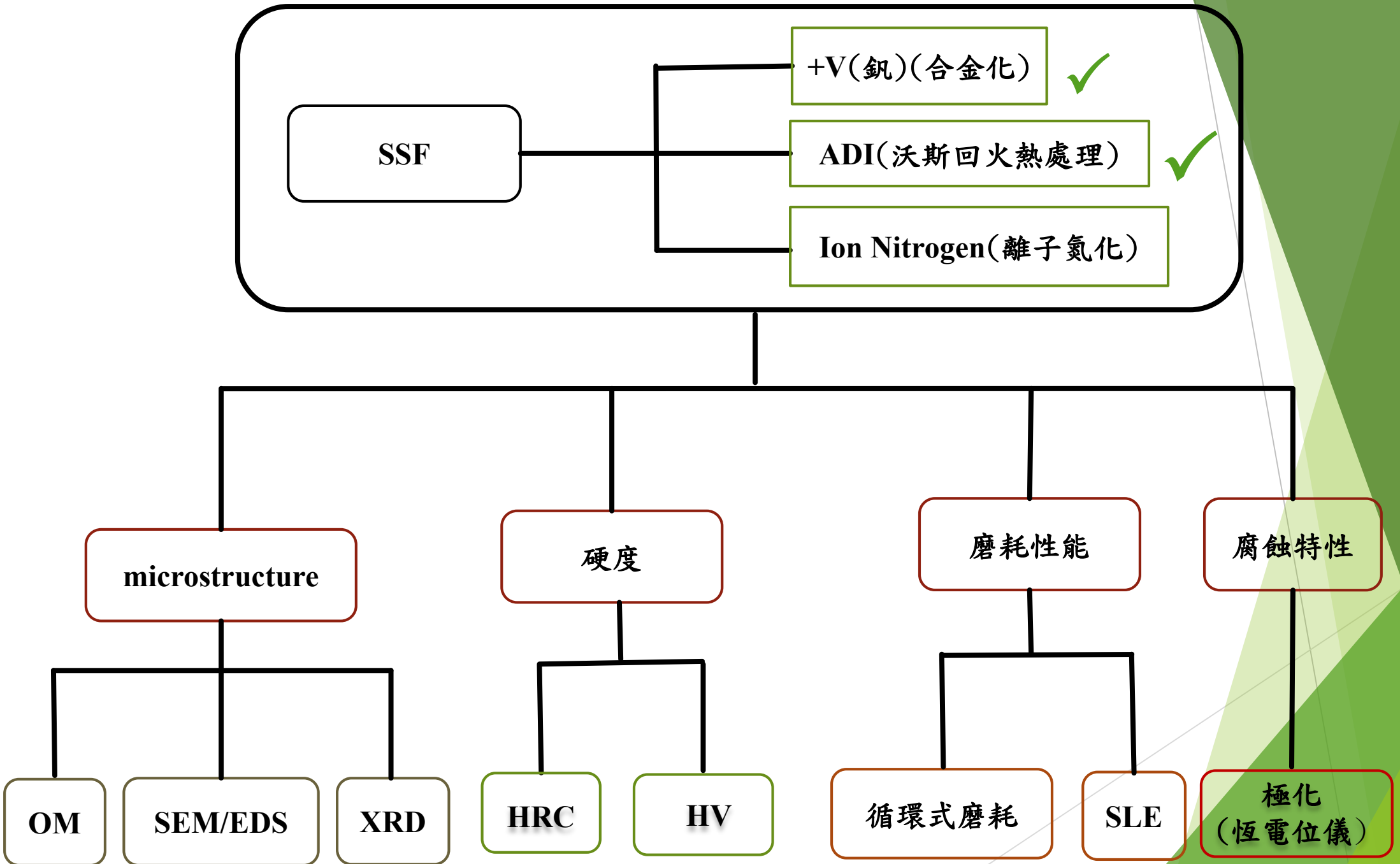
摩擦損失率總表


Friction Coefficient
8.0x10-6
7.0x10-6
6.0x10-6
5.0x10-6
4.0x10-6
3.0x10-6
2.0x10-6
1.0x10-6
0.0
1% 2% 3% 1% 2% 3% 1% 2% 3% 1% 2% 3% 1% 2% 3% 1% 2% 3%
FCD-600 + V 5N
FCD-600 + V + ADI 5N
FCD-600 + V 6N
FCD-600 + V +ADI 6N
FCD-600 + V 7N
FCD-600 + V + ADI 7N

目前進度



未來進度


SSF
+V(釩)(合金化)
ADI(沃斯回火熱處理)
Ion Nitrogen(離子氮化)
microstructure
硬度
磨耗性能
腐蝕特性
OM
SEM/EDS
XRD
HRC
HV
循環式磨耗
SLE
極化
(恆電位儀)

工作進度甘特圖

月次 / 工作項目	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Mar-21	Apr-21	May-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21
資料收集/練習	★	★	★	★	★	★	★	★	★	★	★	★	
ADI製程						★	★	★					
離子氮化													
金相試驗				★	★	★	★	★	★	★			
磨耗試驗										★	★	★	
撰寫報告						★	★	★	★	★	★	★	
海報製作								★					
預定累積進度百分比	5%	10%	10%	10%	13%	15%	15%	16%	20%	23%	25%	30%	

謝謝指教