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Evaluation of surface treatments for high pressure die casting dies

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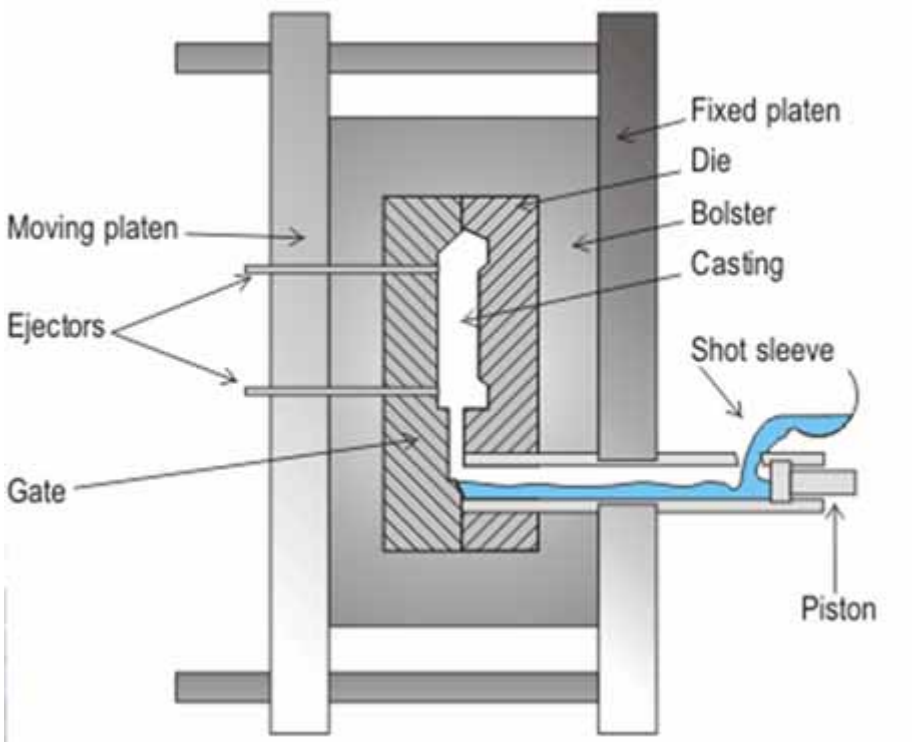
Outline

- Introduction
  - High pressure die casting
  - Wear phenomena
- Experimental
  - Surface treatments
  - Sessile drop test
  - Cross sections: barrier properties
  - Pulling test (Ease-of-release)
- Industrial tests
  - Three cases
- Conclusions

Introduction

- High Pressure Die Casting
  - Aluminium 700 ⌗C
  - Zinc (Zamac) 420 ⌗C

product **die**



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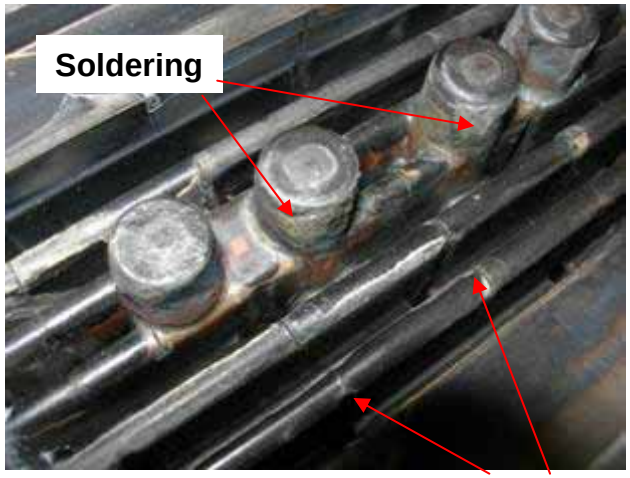
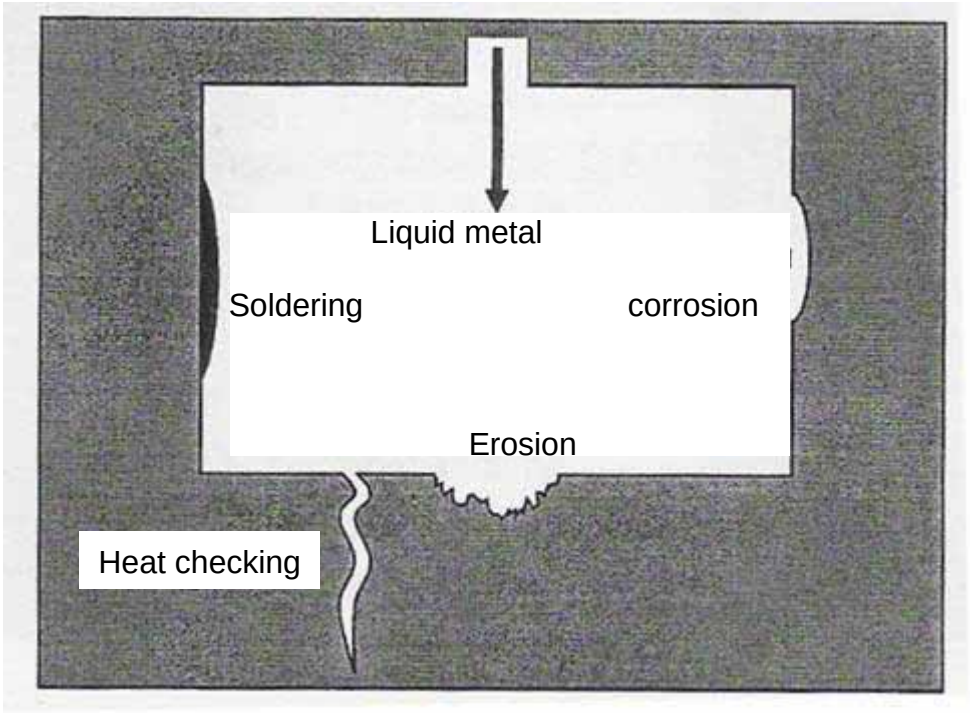
Introduction

Die Wear (Aluminium)

- Different phenomena
- Also release problems
- High tooling costs

  → Wear can represent high costs





Die steel: hot working steel (DIN1.2343)

Introduction

- Start of a project “SURCAST”
  - Sirris
  - Industrial partners
    - Pedeo
    - MGG Antwerpen
    - Umicore/Nyrstar
    - Hayes Lemmerz
  - Objectives
    - Acquiring knowledge on wear and adhesion phenomena
    - How can surface treatments contribute in preventing wear
    - Improvement of the lifetime of dies and core pins to reduce production costs

Experimental

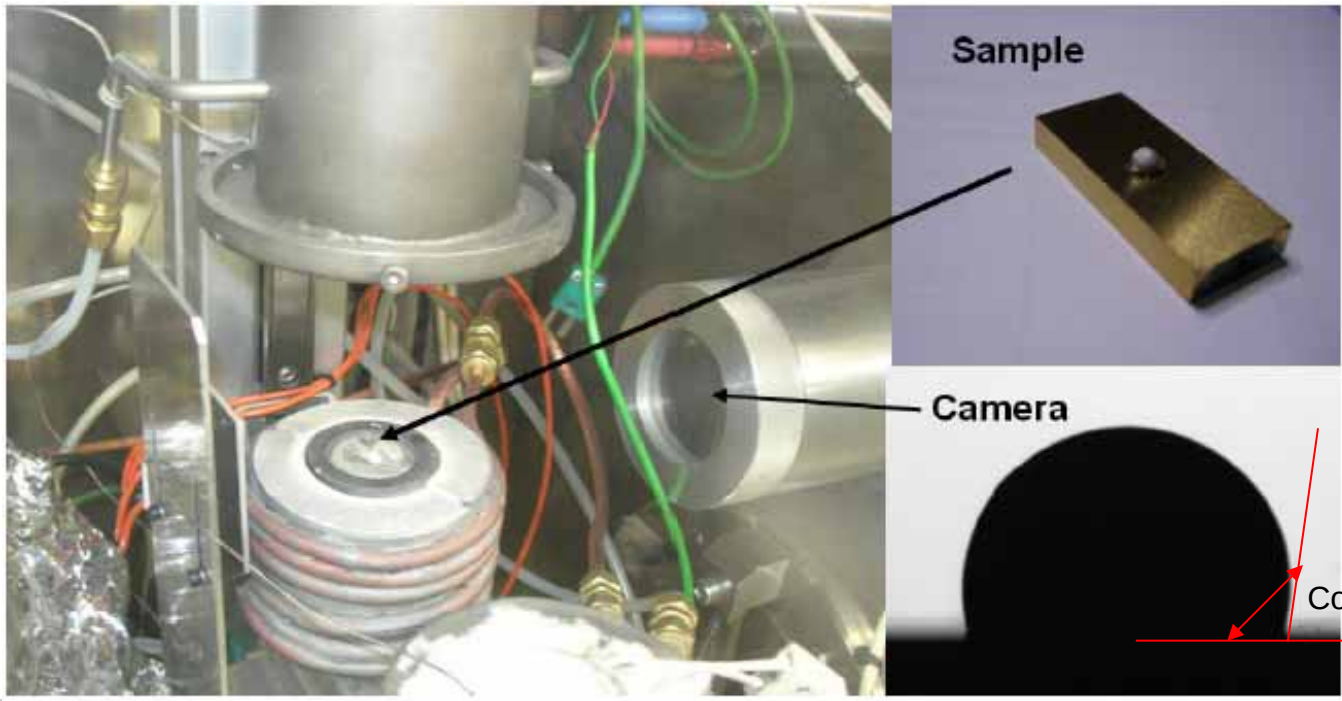
- Selected surface treatments
  - Thermochemical treatments
  - Physical Vapour Deposited coatings
  - Chemical Vapour Deposite coatings
- Examples in literature indicate that these coatings can prevent wear

Treatment	Technology	Roughness (R_a, µm)	Thickness
QPQ	Salt bath nitriding + oxidizing	0.39	25 µm
TiN	PVD ion plating	0.22	3 µm
CrN	PVD ion plating	0.22	5 µm
CrAlN	PVD arc evaporation	0.19	2 µm
TiAlN	PVD arc evaporation	0.31	2 µm
CVD-TiN	Thermal CVD + polishing	0.08	8 µm
CVD-W	Thermal CVD	0.60	10 µm
Reference	uncoated	0.18	/

Experimental

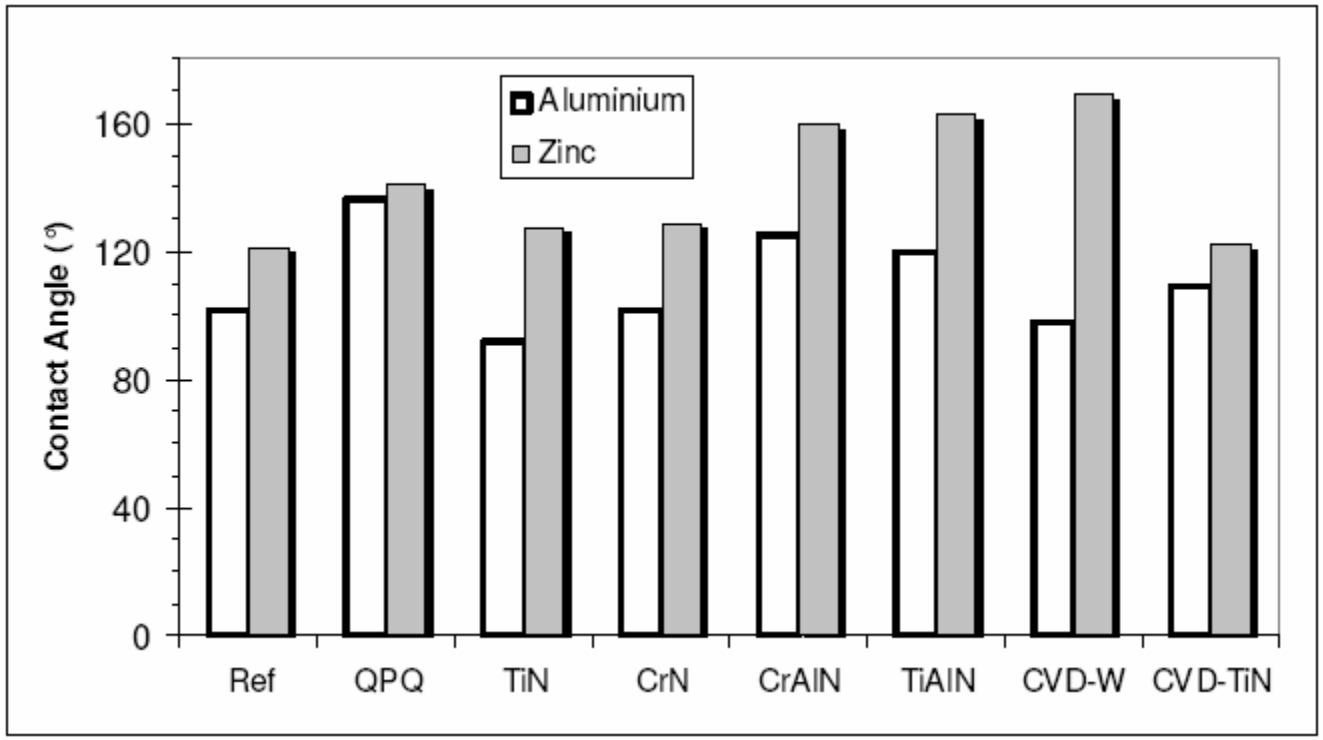
Sessile drop experiment: measuring wettability by contact angle

- Controlled atmosphere
- Al at 700 ⌗C, Zn at 425 ⌗C
- Equilibration time of 30 minutes



Experimental

Sessile drop results (highest contact angle: smallest wettability)



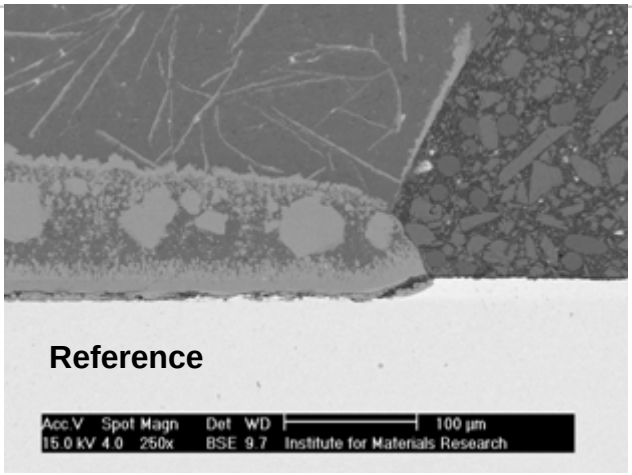
Aluminium
- QPQ
- CrAlN
- TiAlN

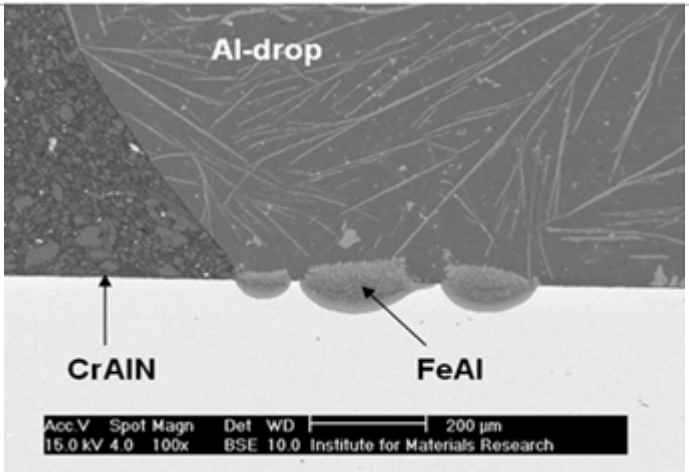
(oxide surface layer)

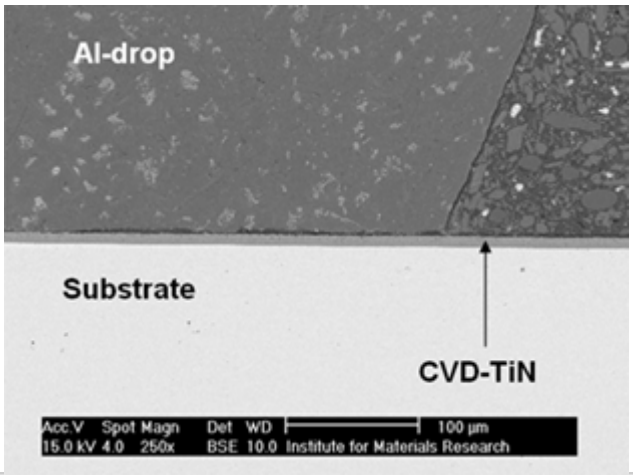
Zinc
- CVD-W
- TiAlN
- CrAlN

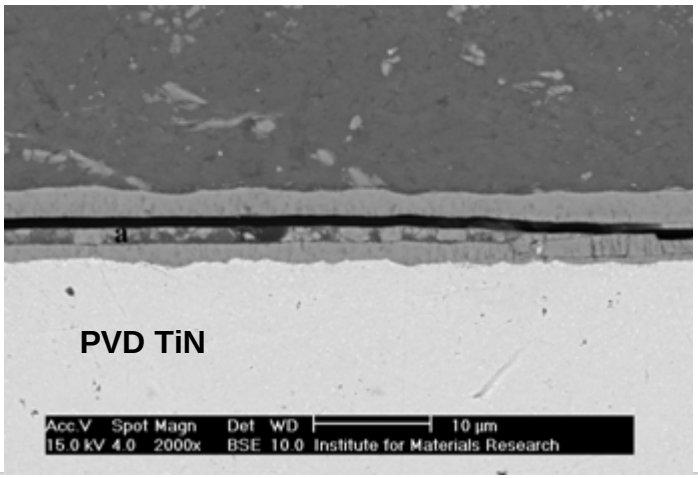
Experimental

Cross sections of samples with Aluminium drop









Excellent barrier
- CVD-TiN
- CVD-W

Good barrier
- QPQ
- CrN

Poor barrier
- CrAlN
- TiAlN
- TiN (horizontal crack)

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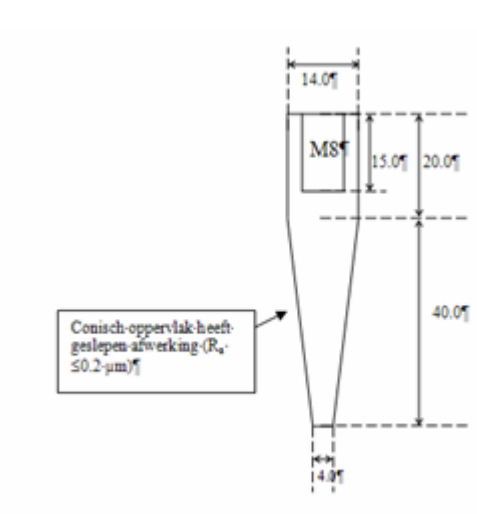
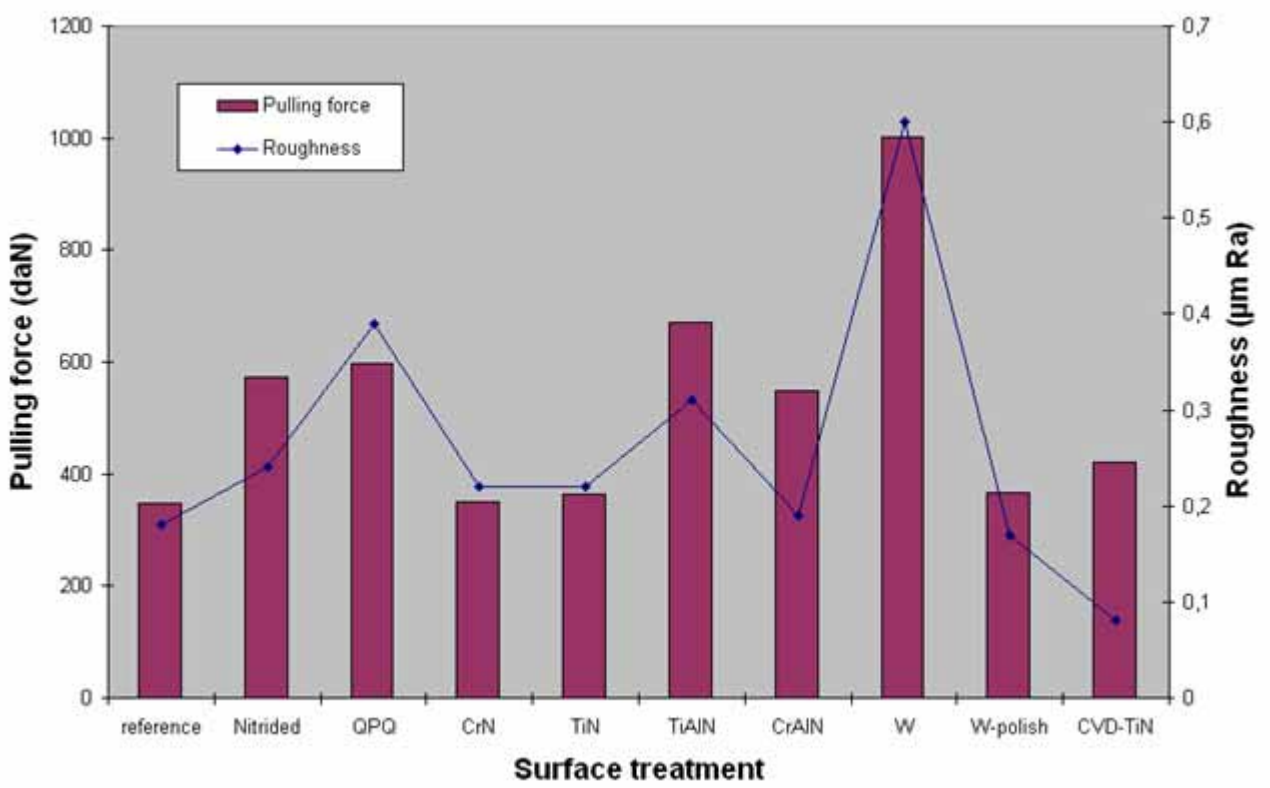
Experimental

- Pulling test: ease of release
  - Conical pins with different substrate treatments
  - Pins are casted (aluminium)
  - Maximum pulling force (just before release) is noted
  - Three pins per surface treatment



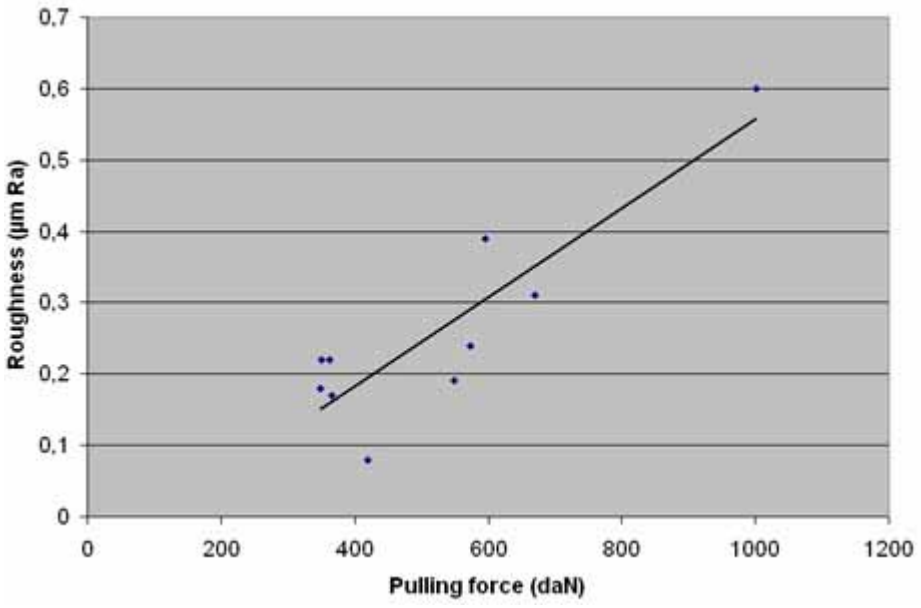
Experimental

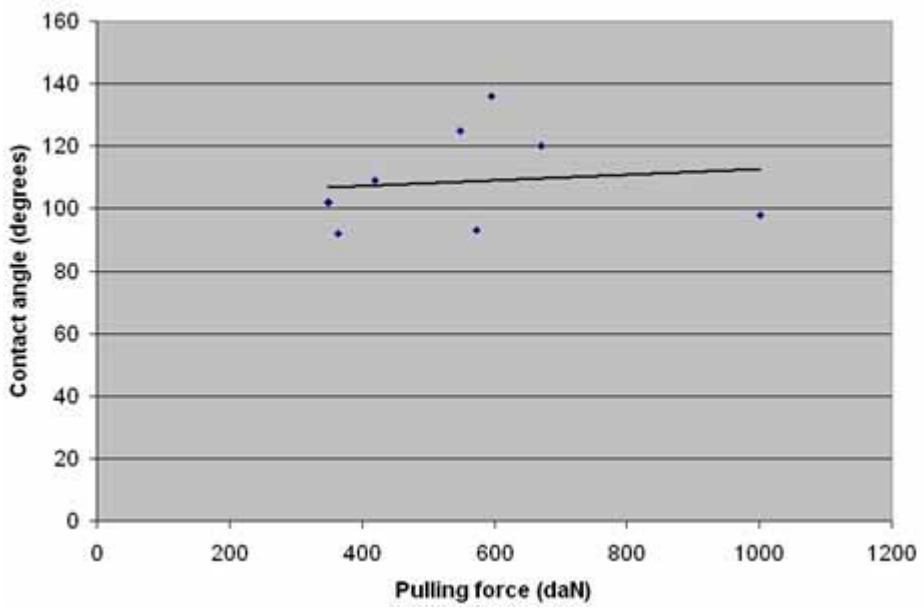
- Results for the pulling force on release
  - Also indicated is roughness



Experimental

- Clear correlation between pulling force and surface roughness
- No correlation between pulling force and contact angle
- Visual ranking based on amount of adhered aluminium correlates with contact angle (and hence wettability)





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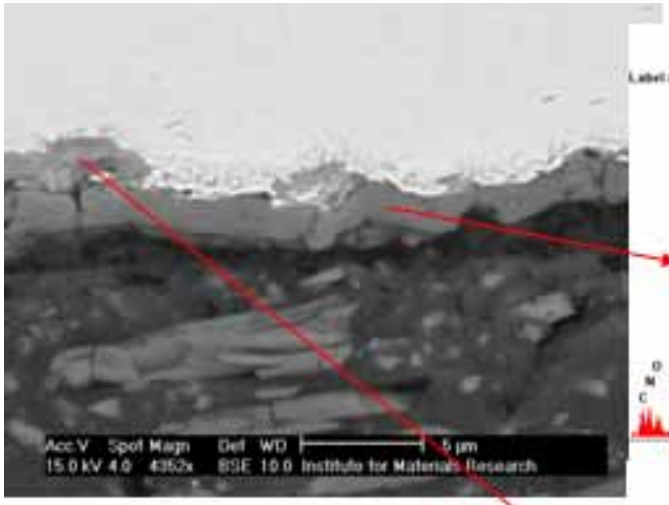
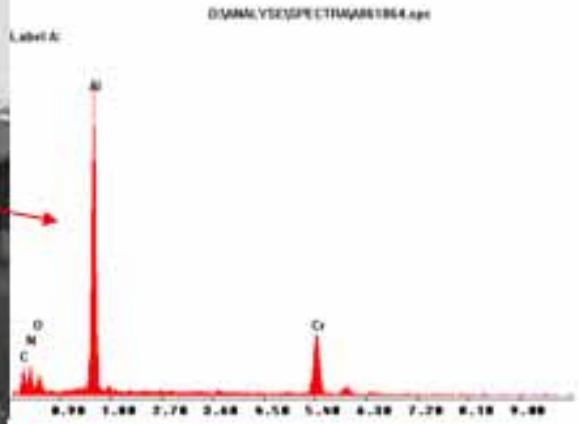
Industrial tests

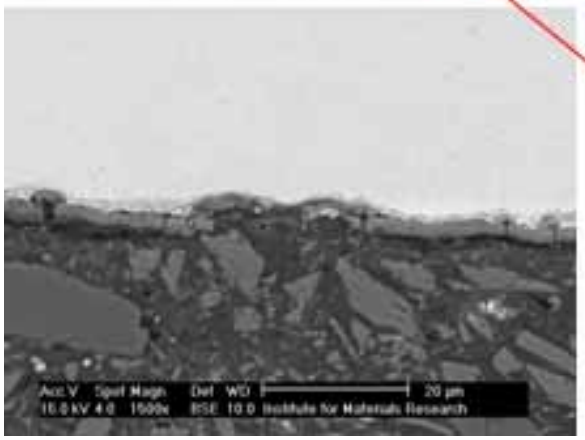
- Core pins
  - Without coating: maximum 16.000 shots
  - With CrAlN coating: between 36.000 and 43.000 shots (to date)
  - Hence significant lifetime increase due to coating

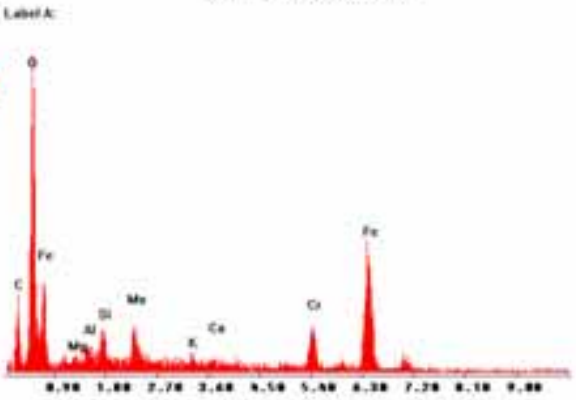
Industrial tests

Wear analysis CrAlN coated core pins









- Coating schows cracks
- The steel substrate under the cracks is corroded
- Corroded steel is porous Fe-oxide
- Corrosion proceeds under the coating

Industrial tests

Powercoupler

- Frequent rupture of the casting
- Treatment with CVD-TiN and CVD-W (both polished)
- No rupture to date

Left: CVD-W
Right: CVD-TiN

Industrial tests

- Die slide
  - Upper face is functional
  - Problem is adhesion of Aluminium
  - Testing
    - First test with PVD CrN: no improvement
    - Second test based on results of sessile drop
      QPQ treatment: significant less adhering

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Conclusions

- In this work the performance of different surface treatments in dedicated laboratory tests and in high pressure die casting field tests was evaluated.
- It was found that the wettability behaviour as measured by the sessile drop test can indeed be used to select a suitable surface treatment to reduce adhesion of aluminium (soldering) on industrial dies.
- The lifetime of core pins is considerably increased by applying a coating, but when treating core pins surface roughness is important and decisive when high release forces are the problem.
- The examination of a cross section of the drop-substrate interface after the sessile drop test, is relevant for evaluating the corrosion protective properties of a coating or surface treatment.

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