POZNAN UNIVERSITY OF TECHNOLOGY

Faculty of Mechanical Engineering,
Institute of Materials Technology, Piotrowo 3, 60-965 Poznan, POLAND

EPF European Polymer Congress
22 -27 June 2025 GRONINGEN

Assesment of polymer flowability on laser microstructured metal inserts with profilometric studies

Karol Bula, Bartosz Korzeniewski, Paweł Brzęk and Wiktor Woźniak

karol.bula@put.poznan.pl

INTRODUCTION

For increase of micromechanical adhesion between polymer and metal in direct joining realised by overmolding, metal surface structuring is often most desired. The purpose of this study was to evaluate the infiltration efficiency of the microstructure of laser-engraved steel by molten polymer material as a function of melt flow length on structured metallic surface. Polymer-metal joints were made from austenitic steel (316) and polyamide 6 GF30.

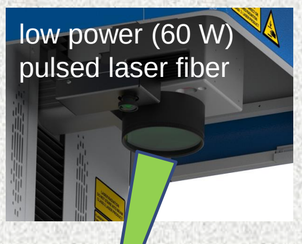
MATERIALS,PRETREATMENT OF INSERTS

The main experimental procedure focused on the sample preparation. Surfaces of metal inserts were microstructured by laser engraving by use of a low power (60 W) pulsed (nanosecond) fiber laser device. Four different microstructures were produced on steel plates. The process of injection molding (overmolding) of 316 steel inserts was carried out with use of surface preheating by an external infrared radiator, attached to a gripper of an installed manipulator, therefore radiator moved in relation to inserts.

Metallic inserts: austenitic steel 316 2mm of thickness

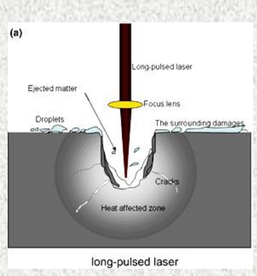
Thermoplastic: polyamide 6 with 30% of glass fibers (MVR 45 cm³/10min)

Austenitic steel engraving with fiber laser



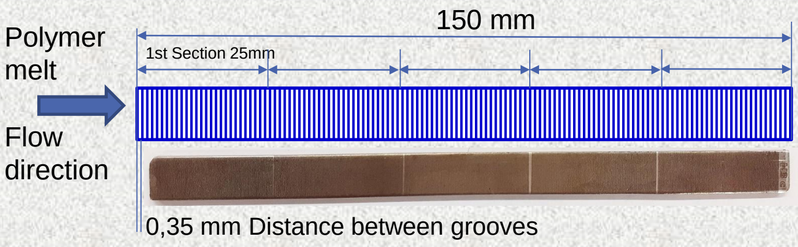
Laser working parameters:
- Diode power – 60 [W]
- Pulse Energy – 2 [mj]
- Pulse width – 100 [ns]
- Frequency – 40 – 120 [kHz]
- Scanning speed – 800 [mm/s]

Laser beam



long-pulsed laser

Set of microstructured samples



Laser microstructurisation parameters

	Beam intensity	Frequency	Pulse width	Repetitions	Scanning speed
Series A	75 [%]	40 [kHz]	100 [ns]	10	800 [mm/s]
Series B	100 [%]	40 [kHz]	100[ns]	10	800 [mm/s]
Series D	75 [%]	80 [kHz]	100 [ns]	10	800 [mm/s]
Series F	75 [%]	40 [kHz]	200 [ns]	10	800 [mm/s]

INJECTION OVERMOLDING

Overmolding parameters/ Engel Victory 50 kN clamping force/Viper robot

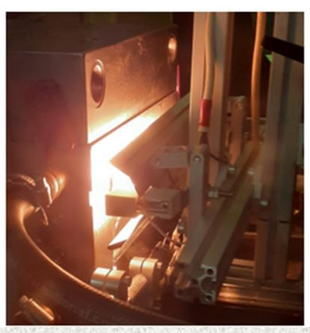
Injection			Holding		
Injection speed (maximal)	130	mm/s	Holding pressure	60	bar
Injection speed (real)	90	mm/s	Holding pressure time Z4	5	s
Injection pressure	100	bar	Cooling time	25	s
Plasticizing			**Temperature set up**		
Screw rotation speed	75	rpm	Nozzle (first zone)	275	ºC
Screw back(feed) position	57	mm	Barrel (second zone)	260	ºC
Plastification pressure	1.0	bar	Barrel (third zone)	260	ºC
Plasticizing time	14	s	Barrel (fourth zone)	250	ºC
Screw diameter	25	mm	Mold	80	ºC

Mold heated by extermal chiller temp. 80 C

Injection overmolding steps

Insert emplaced in the cavity

Quartz radiator mounted on cartesian robot gripper (stand by)



Infrared rapid surface heating by Quartz Tungsten

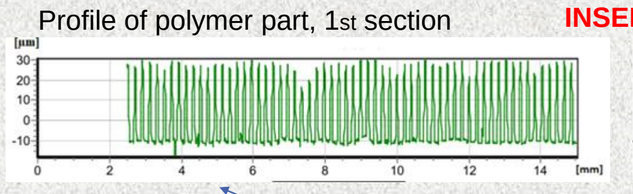
cartesian robot rides outside of mold space, injection overmolding starts

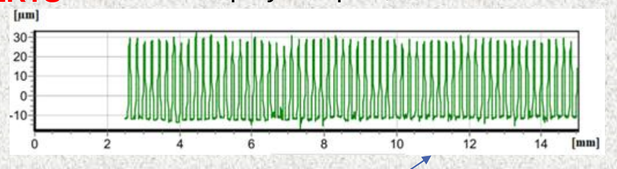
CONTACT PROFILOMETRY ROUGHNESS PROFILES

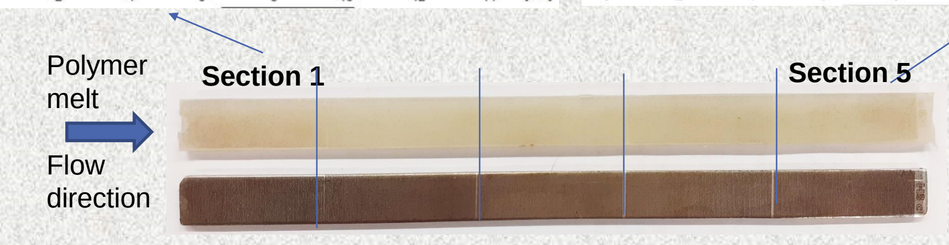
Profile of polymer part, 1st section — **Cold INSERTS** — Profile of polymer part, 5th section

Preheated INSERTS

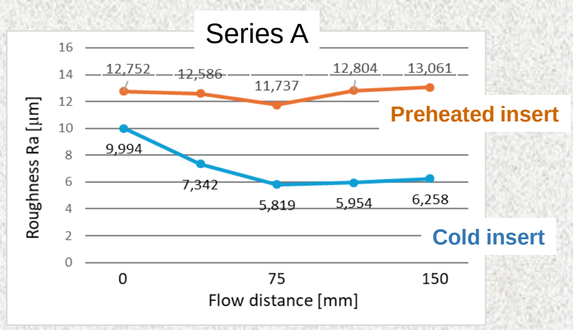
Profile of polymer part, 1st section — Profile of polymer part, 5th section

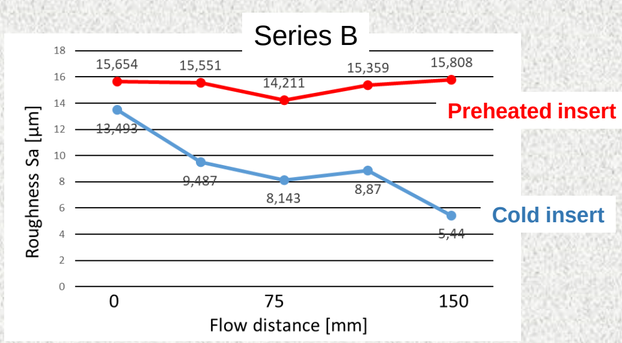


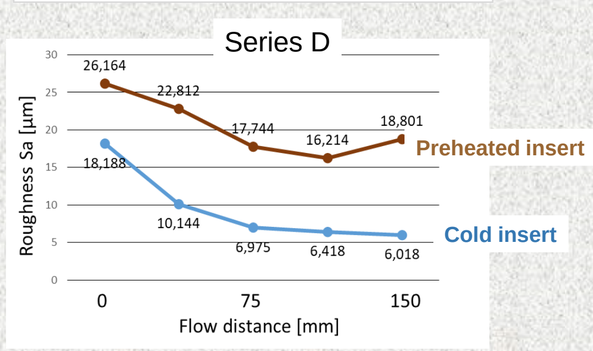


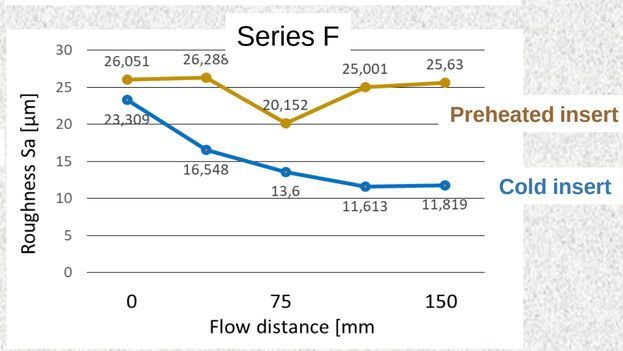


Roughness distribution on flow length of polymer part

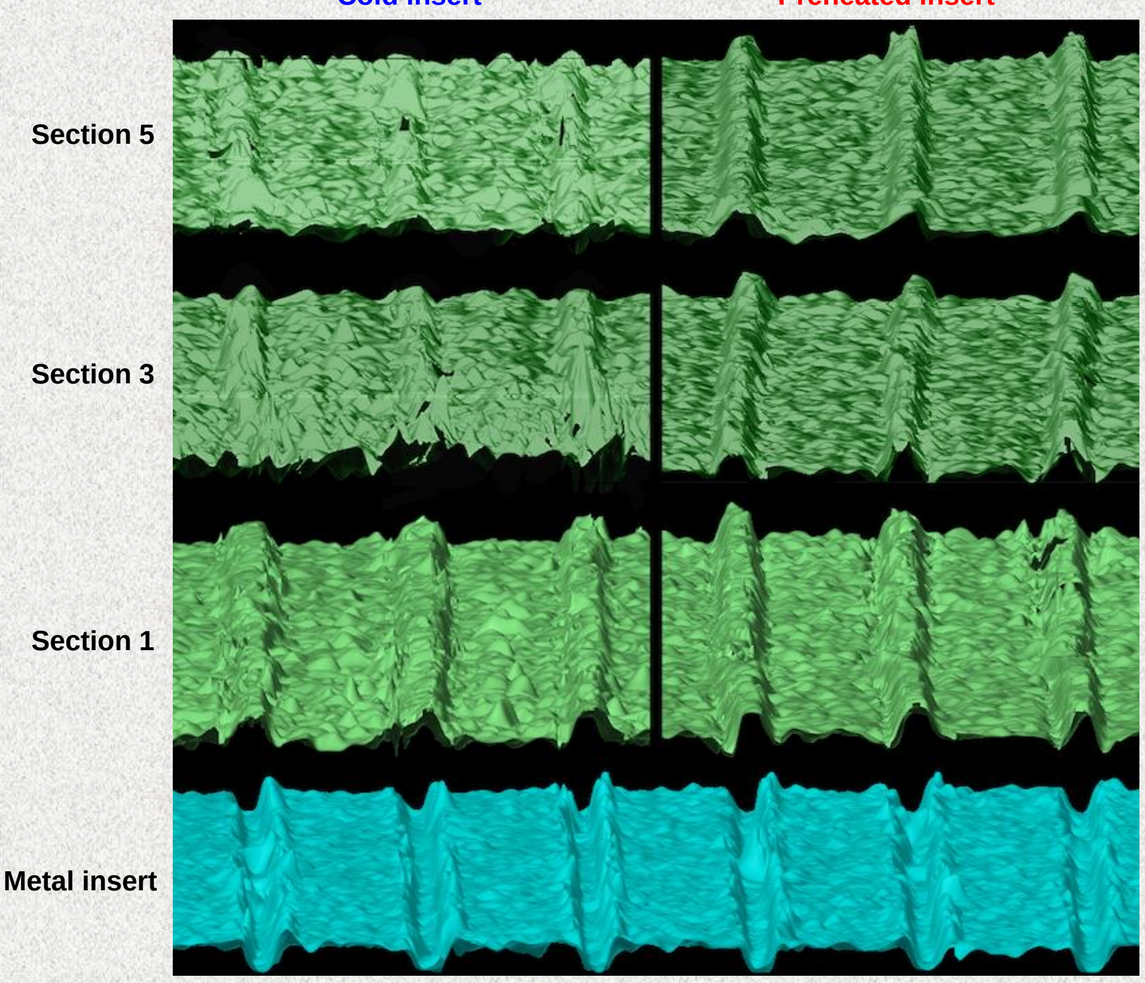








NON-CONTACT PROFILOMETRY



3D scans of metal and polymer parts; cold and preheated inserts compared.
Note: Preheated inserts retained same surface properties in all sections, at full flow length

Acknowledgments

The research was financially supported by the Poznan University of Technology PUT, internal subsidy, 0613/SIGR/2403