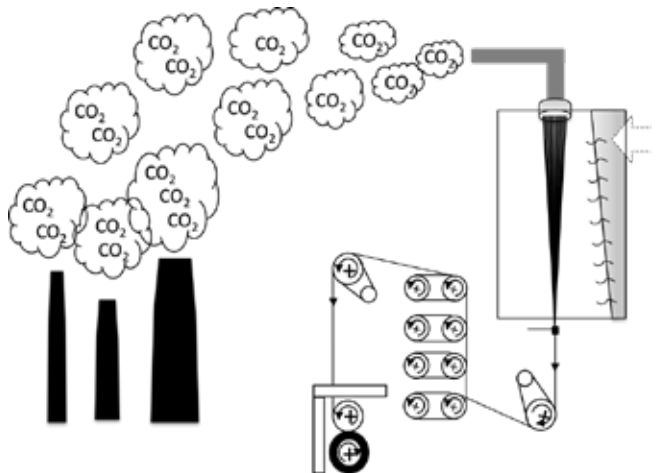


Melt spinning of carbon dioxide based thermoplastic polyurethane

Pavan Kumar Manvi



**„Melt Spinning of Carbon Dioxide Based Thermoplastic
Polyurethane“**

**„Schmelzspinnen von thermoplastischem Polyurethan auf
Kohlendioxid-Basis“**

Von der Fakultät für Maschinenwesen
der Rheinisch-Westfälischen Technischen Hochschule Aachen
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Pavan Kumar Manvi

Abstract

Developing sustainable processes and products that create “sustainable growth” and “low carbon footprint” are the future concerns of the European industry. Thermoplastic polyurethanes from carbon dioxide based raw materials are recently developed by the company Covestro AG, Leverkusen, Germany. This is an innovative solution to support sustainable production with the potential to be established as an alternative to conventional polyurethanes. Therefore, this PhD thesis is aimed at developing a melt spinning process for carbon dioxide (CO₂) based thermoplastic polyurethane (TPU) to identify textile applications. The melt spinning process is successfully developed at technical scale at a winding speed of 2500 m/min, which is the highest ever winding speed known for polyurethane filaments in any spinning process. Filament spinnability is tested for a fineness range from 156 dtex to 1240 dtex, which is successfully completed. Melt spun elastic filaments are evaluated regarding their technical and economic aspects. The filaments have a tensile strength equivalent to the industrial benchmarks. Elongation is lower than the benchmark and therefore a scope analysis is made to analyse the feasibility for implementation in industrial products. Melt spun elastic filaments can be used in the majority of elastic textile products. However the whole range of applications cannot be covered. From an economical point of view, melt spun carbon dioxide based thermoplastic polyurethane filaments are 50 – 60 % cheaper than conventional solution polyurethane filaments. The much lower price shows the high potential of melt spun carbon dioxide based thermoplastic polyurethane filaments in the textile market. Further efforts are required to improve the filament elongation to cover the whole range of elastic textile applications.

Kurzfassung

Die Entwicklung nachhaltiger Prozesse und Produkte für ein "nachhaltiges Wachstum" und einen "geringen CO₂-Fußabdruck" ist ein zentrales Zukunftsanliegen der europäischen Industrie. Thermoplastische Polyurethane aus kohlenstoffdioxidbasierten Rohstoffen wurden von der Covestro AG, Leverkusen, Deutschland entwickelt und sind ein innovativer Lösungsansatz zur Unterstützung der nachhaltigen Produktion mit dem Potential zur Etablierung als Alternative zu konventionellen Polyurethanen. Die vorliegende Promotionsarbeit ist gezielt auf die Entwicklung eines Schmelzspinnverfahrens für thermoplastisches Polyurethan (TPU) auf Basis von Kohlenstoffdioxid (CO₂) zur Identifizierung des Potentials für Textilanwendungen ausgerichtet. Der Schmelzspinnprozess wurde erfolgreich im technischen Maßstab mit einer Wickelgeschwindigkeit von 2500 m/min entwickelt. Dies ist die höchste bekannte Wickelgeschwindigkeit für Polyurethanfilamente bei Betrachtung sämtlicher Spinnverfahren. Der Prozess wurde auf einem Feinheitsbereich von 156 dtex bis 1240 dtex erfolgreich getestet. Schmelzgesponnene elastische Filamente wurden hinsichtlich ihrer technischen und wirtschaftlichen Aspekte bewertet. Die Filamente zeigen eine mit den Benchmark-Werten vergleichbare Zugfestigkeit. Da die Dehnung im Vergleich zum Benchmark geringer ausfällt, wird eine Machbarkeitsstudie für schmelzgesponnene Filamente zur Untersuchung der Einsetzbarkeit in industriellen Produkten durchgeführt. Schmelzgesponnene elastische Filamente können im Großteil der elastischen Textilprodukte verwendet werden, die gesamte Bandbreite an Anwendungen kann jedoch nicht abgedeckt werden. Aus ökonomischer Sicht sind die TPU-Filamente auf Kohlenstoffdioxid-Basis um 50 – 60 % preiswerter als herkömmliche Polyurethanfilamente. Der niedrige Preis deutet auf das große Potential der schmelzgesponnenen elastischen Filamente auf dem Textilmarkt hin. Weitere Forschungen sind erforderlich, um die Filamentdehnung zu verbessern und um den gesamten Bereich der elastischen Textilanwendungen abzudecken.

Content

1	Introduction and objective	1
1.1	Current status and motivation	2
1.2	Research questions and aim of the research work	4
1.3	Approach and methods to achieve the objectives	4
2	Structure of the research work	7
3	Polyurethane polymer technology	9
3.1	Polymer, homopolymer and copolymer	9
3.2	Polyurethane, a block copolymer	12
3.3	Basic components of polyurethane	12
3.4	Developments in polyurethanes – sustainability aspects in raw materials	15
3.5	Developments in polyurethanes – improvement in thermoplasticity	16
3.6	Two-phase morphology of polyurethane	18
3.7	Carbon-dioxide as raw material in thermoplastic polyurethane	21
3.8	Overview of experimental polymers	23
4	Polyurethane spinning technology	26
4.1	Dry spinning process	26
4.2	Solution wet spinning process	28
4.3	Reactive melt spinning process	28
4.4	Melt spinning process	30
4.5	Qualitative evaluation of polyurethane spinning processes	31
5	Methodology for melt spinning process development	33
5.1	Development models in manmade fibre industry	33
5.1.1	Iterative model for process optimization	33
5.1.2	Stage-gate model for development of new fibres	34
5.1.3	Waterfall model for development of a process chain	36
5.1.4	Spiral model for process development	37

5.2	Evaluation of fitness of development models into development process of a melt spinning process for carbon dioxide based thermoplastic polyurethane	38
5.3	Model for the development of melt spinning process for carbon-dioxide based thermoplastic polyurethane	41
5.4	Benchmark definition	44
5.5	Concept for thermoplastic polyurethane melt spinning	47
5.5.1	Concept development	47
5.5.2	Concept implementation	48
5.6	Melt spinning process development	48
5.6.1	Process establishment	48
5.6.2	Properties optimization and evaluation	49
5.7	Evaluation of commercial potential	52
6	Process and machine technology	57
6.1	Criteria of melt spinning machine selection	57
6.2	Lab scale melt spinning machine	61
6.3	Pilot scale melt spinning machine	63
6.4	Technical scale melt spinning machine	65
7	Analytical and testing instruments	73
7.1	Karl Fischer moisture content tester	74
7.2	Differential scanning calorimetry	75
7.3	Thermogravimetric analysis	76
7.4	Gel permeation chromatography	77
7.5	Wide angle X-ray diffraction analysis	78
7.6	Capillary rheometer	79
7.7	Parallel plate rheometer	80
7.8	Zwick tensile tester	81
7.9	Summary of the analytical methods	81
8	Benchmarks	83
9	Melt spinning concept development	84
9.1	Stage 1: Changes in the polymer structure in the molten phase	88

9.1.1 Thermal transitions in thermoplastic polyurethane	89
9.1.2 Effect of melt processing temperature on crystallization	94
9.1.3 Rheological behaviour as function of temperature and shear	96
9.1.4 Rheological behaviour as function of processing time	100
9.1.5 Analysis of change in molecular weight in melt spinning process	103
9.2 Stage 2: Changes in the polymer morphology in filaments	106
9.2.1 Effect of polymer dwell time in extrusion line on polymer morphology in filaments	108
9.2.2 Effect of melt draw ratio on filament structure and properties	114
9.2.3 Effect of draw ratio on filament structure and properties	120
9.3 Melt spinning concept implementation in filament spinning	128
10 Melt spinning process development	134
10.1 Melt spinning at lab scale	135
10.1.1 Process establishment	135
10.1.2 Optimization of filament properties	140
10.1.3 Feasibility analysis and scope of upscaling	141
10.2 Melt spinning at pilot scale	143
10.2.1 Process establishment	143
10.2.2 Optimization of filament properties	154
10.2.3 Feasibility analysis and scope of upscaling	158
10.3 Melt spinning process development at technical scale	159
10.3.1 Process establishment	160
10.3.2 Optimization of filament properties	179
11 Evaluation of commercial potential	191
11.1 Process evaluation	191
11.2 Technical evaluation	194
11.2.1 Comparative study of experimental filament properties with benchmark filaments	194
11.2.2 Analysis of filament processability in textile process chain	195
11.3 Economic evaluation	204
11.3.1 Benchmark price analysis	204
11.3.2 Cost calculation of melt spun TPU filaments in production	205

11.4 Market evaluation	212
11.5 Perception evaluation	212
11.6 Regulation and policy education	213
11.7 Study of technology readiness level	214
11.8 Evaluation of commercial potential using scoring model	214
11.9 Comparison of mechanical properties of fabric	216
11.10 Scope analysis of application of experimental filaments	222
12 Summary	231
13 Zusammenfassung	234
14 Outlook	238
14.1 Polymer modification	238
14.2 Spin finishes	240
15 List of figures and tables	241
15.1 List of figures	241
15.2 List of tables	248
16 Literature	252
17 Student theses	278
18 Appendix A: Abbreviations, symbols	280