SCALE-UP DEVULCANIZATION OF RECYCLED TIRE RUBBER WITH SUPERCRITICAL CO_2

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Background

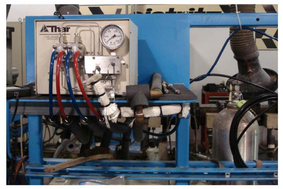
- Devulcanization of waste rubber with $scCO_2$ in an extruder is an environmentally friendly continuous process;
- Materials engineering of devulcanized rubbers offers new types of thermoplastic vulcanizates (TPV);
- Lab-scale devulcanization process of rubber crumbs using a twin-screw extruder has been established;
- In scale-up trial, volatiles generated during devulcanization can blast out of the exit of extruder periodically.

Objectives

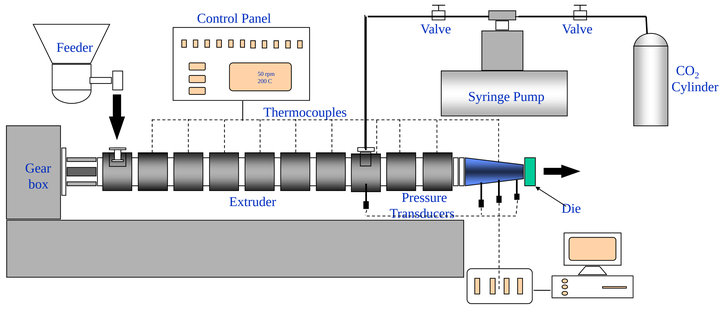
- To achieve a higher throughput of the devulcanized rubber for cost- reduction ;
- To maintain the degree of devulcanization in the scale-up devulcanization ;
- To optimize the process and find out the processing window to avoid the volatil blast-off .

Devulcanization

1. Twin screw extrusion, CO_2 injection, and data acquisition

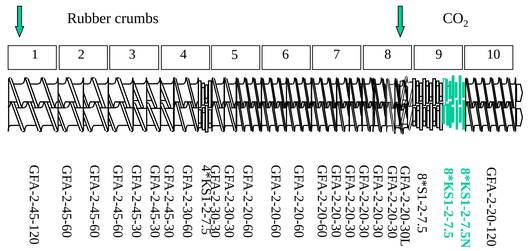


Sc Co2 injection system

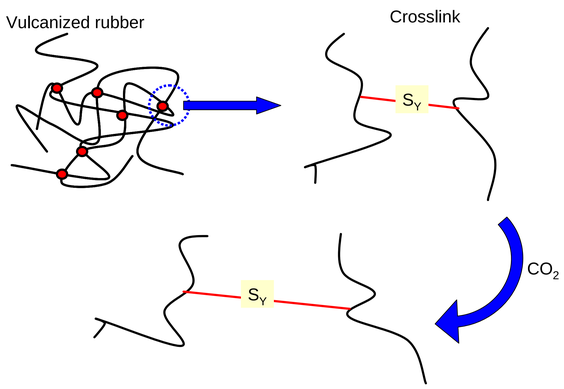


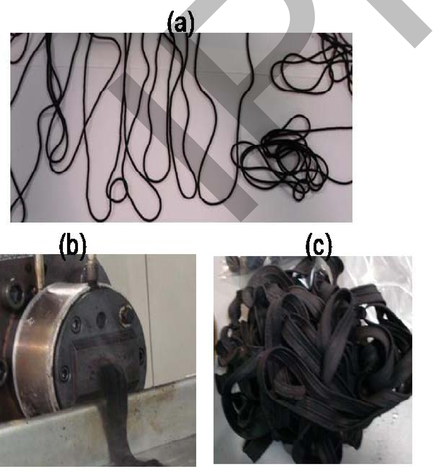
50 mm twin screw extruder (Leistritz Inc. Nj)

2. Configurations of screw



3. Devulcanization mechanism





Typical devulcanized samples :

a) Samples of devulcanized rubber in strand shape
b) Devulcanized rubber ribbons exiting the die;
c) Samples of devulcanized rubber in ribbon shape

Scale up of rubber devulcanization process

1. Specific energy consumption calculation

Kw (applied) = Kw(motor rating)×(%torque)×(rpm running/max rpm)×0.97

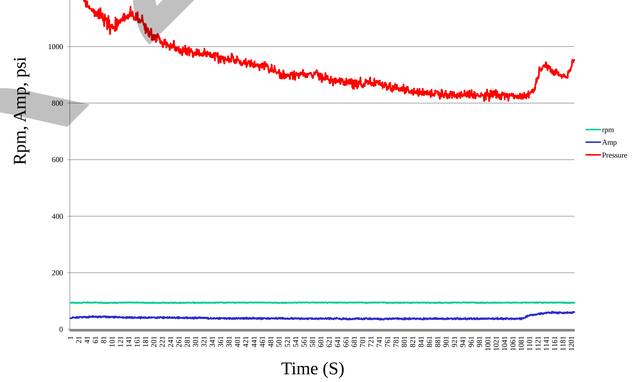
Specific Energy consumption = Kw(applied)/Kg per hour

2. Process variables and conditions

Screw Configurations	Screw Speed (rpm)	Feeding Rate (lb/hr)
Screw #1	50	20
Screw #2	100	50
Screw #3	200	100
Screw #4	220	
Screw #5		
Screw #6		
Screw #7		

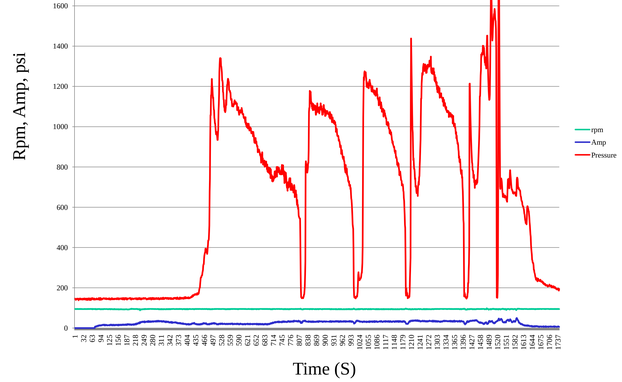
Material	Extruder/Screw configuration	Feeding rate (lb/hr)	Screw speed (rpm)	$ScCo_2$ Rate (gr/min)	Process condition
10 mesh CR	50mm / #2	50	111	No gas	Unstable
30 mesh CR	50mm / #3	10	40	5	Stable
30 mesh CR	50mm / #3	10	50	5	Stable
30 mesh CR	50mm / #3	20	50	5	Stable
30 mesh CR	50mm / #3	20	100	No gas	Unstable
30 mesh CR	50mm / #4	50	200	10	Stable
30 mesh CR	50mm / #4	20	50	5	Stable
30 mesh CR	50mm / #4	50	200	10	Stable
30 mesh CR	50mm / #4	60	200	5	Stable
30 mesh CR	50mm / #4	100	50	5	Stable
10 mesh CR	50mm / #4	50	100	5	Stable

3. Process Stability (Pressure fluctuations)



Stable Process

Process condition:
Temperature: 220 °C
Screw Speed: 100 rpm
Flow Rate: 50 lb/hr.
Screw #6



Unstable Process

Process condition:
Temperature: 220 °C
Screw Speed: 100 rpm
Flow Rate: 50 lb/hr.
Screw #4

Concluding Remarks

- **Devulcanization of ground tire rubber crumbs under stress in the twin screw extruder with supercritical CO_2 is a continuous, cost-effective, and environmentally friendly process;**
- **A reasonably high throughput of devulcanized rubber has been obtained in the scale-up devulcanization process in a twin screw extruder, which is stable;**
- **The volatiles generated during extrusion can be controlled and screw configuration, feeding rate and the screw speed are the key parameters to control the process stability.**

ACKNOWLEDGEMENTS