Reviewed by Michael Overcash 9-7-10
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EMAC sheet [UIDouterbagEMAC]

Primary packaging for reusable gowns-covers

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Products	outerbagEMAC
Standard inputs	ethylene - methyl acrylate copolymer 92 moleP E

Methodology: Environmental Clarity gtg lci reports are based on industrial practice information, standard methods of engineering process design, and technical reviews. These reports are intended to be representative of industrial production based on the stated route.

Users of this report should cite: E. Griffing and M. Overcash, Chemical Life Cycle Database, www.environmentalclarity.com, 1999 - present.

Chemistry

Primary reaction: No. reaction extrusion into sheet.		
	reactants → products	(1)
	reactants → products	
	reactants → products	
	reactants → products	(2)
	reactants → products	
	reactants → products	
	reactants → products	(3)
	reactants → products	
	reactants → products	
Net reaction:	reactants → products	(4)
	reactants → products	
	reactants → products	
Side reactions: (type of side rxns)		
	reactants → products	(5)
	reactants → products	(6)
	reactants → products	(7)
Notes:		
Side reactions: (type of side rxns)		
	reactants → products	(9)
	reactants → products	(10)
	reactants → products	(11)
Notes:		

Process Summary

Literature

Polyethylene(92mol%)-methyl acrylate copolymer is extruded into a sheet.

The polymer is first dried, melted in an extruder, passed through a slot die, referred to as the casting step.

We use the physical properties of polyethylene for the extruder estimate.

Extruder energy estimate

The extruder energy is calculated below.[1]

The heat capacity of LDPE is 2.3 J/(g*oC), the input temperature is 25 oC and the extruder temperature is 225 oC. From the heuristic we have,

E=1.7301*1000*1000*2.3*(225-25)= $795*10^6$ J/hr = 795.5 MJ/hr.

This value is increased by 10% due to an assumed value of 10% loss from trimming:

795.5 MJ/hr/1000 kg= x/1010.10 kg, x=803.5 MJ

The extrusion through the slot die is vitrified on a chill roll at 25 C. The enthalpy fusion at Tfusion of PE is is 7.758 kJ/gmol= 7758 J/gmol / 28.05 g/gmol = 276.6 J/g. Thus, -7.76 kJ/mol was used at the cooling roller calculation (HX1) for the return to solid phase. The amount of recoverable energy is stipulated as zero for this cooling since the temperature is likely at or near refrigeration.

LCI design

1010.1 kg of EMAC copolymer is extruded at 225C into a sheet and cooled to 25 C. 1% is trimmed before winding. This results in a sheet of Polyethylene(92mol%)-methyl acrylate copolymer. Winding energy is then added at 0.149 MJ/kg.

References

Critical parameters

Product purity		
	EMAC sheet for outer bag	Comments
Used here		
LiteratureSource		

[1] extruder heuristic2.doc by M. Overcash & Yong Li

Summary of LCI Information

Standard inputs					
UID	Name	Flow	Purity	Units	Comments
UIDEMAC	ethylene - methyl acrylate copolymer 92 moleP E	1010	-	[kg/hr]	
	Total	1010		[kg/hr]	
Non-reacting inputs					
UID	Name	Flow	Purity	Units	Comments
	Total	0		[kg/hr]	
Ancillary inputs					
UID	Name	Flow	Purity	Units	Comments
	Total	0		[kg/hr]	
Products					
UID	Name	Flow	Purity	Units	Comments
UIDouterbagEMAC	outerbagEMAC	1000	100	[kg/hr]	
	Total	1000		[kg/hr]	
Benign outflows					
UID	Name	Flow	Purity	Units	Comments
	Total	0		[kg/hr]	

Process emissions							
UID	Name	Gas	Liquid	Solid	Solvent	Units	Comments
UIDEMAC	ethylene - methyl acrylate copolymer 92 moleP E	0	0	10.1	0	[kg/hr]	
	Total	0	0	10.1	0		

Mass balance	
Total inputs	1010
Total outflows	1010
Net input	-1.02E-03

Energy use			
Energy type	Amount	Units	Comments
electricity	953	[MJ/hr]	Net electricity use at plant
Net input requirement	953	[MJ/hr]	Net of energies input to system
cooling water	-744	[MJ/hr]	net cooling by cooling water
Net energy	953	[MJ/hr]	Net input requirement - potential recovery

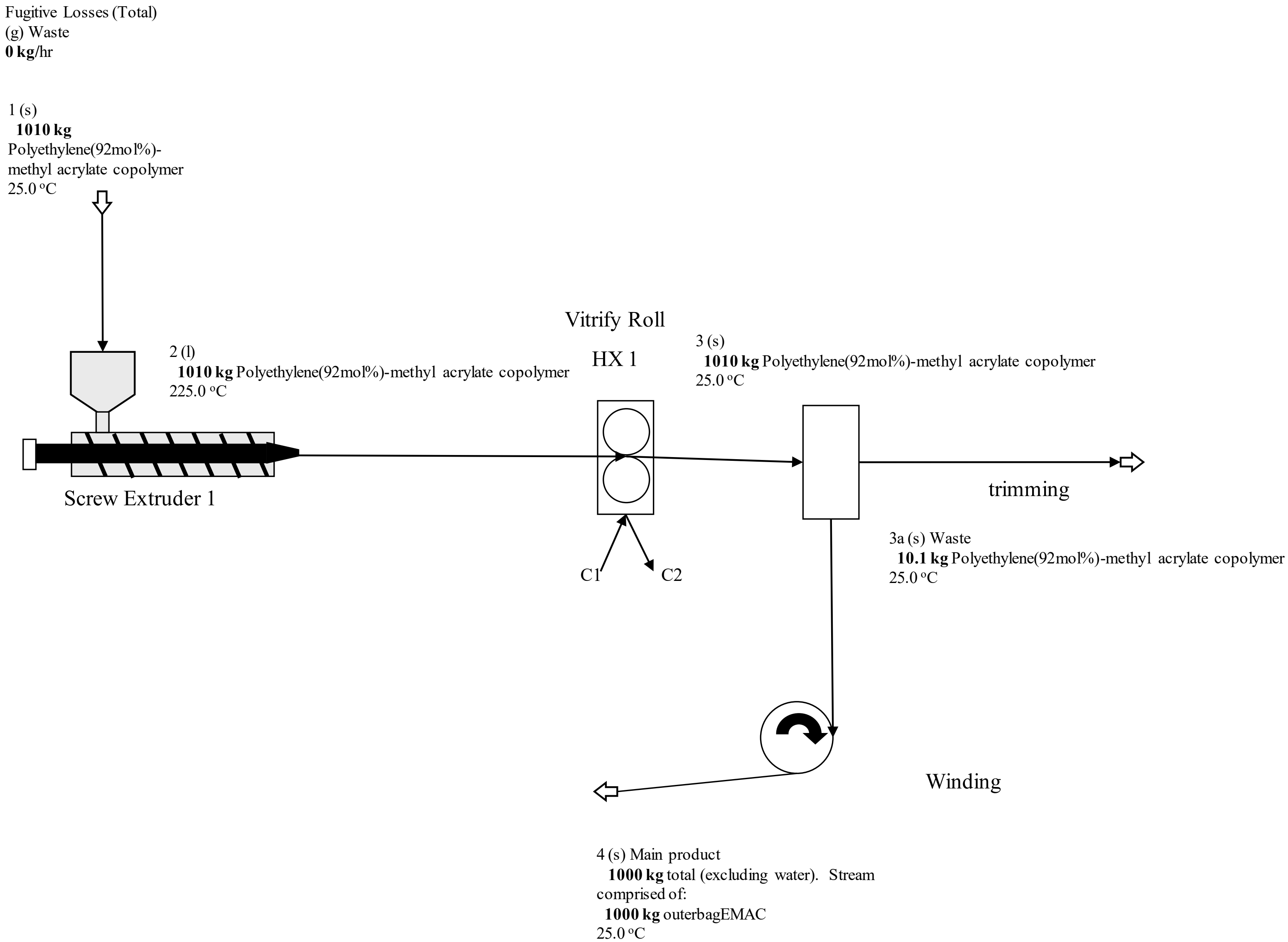
Process Diagram Interpretation Sheet

1) As much as possible, standard symbols are used for all unit processes.
2) Only overall input and output chemicals are labeled on these diagrams. All intermediate information is given on the attached Process Mass Balance sheet
3) The physical state of most streams is shown (gas, g; liquid, l; solid, s)
4) The process numbering is as follows,
   - generally numbers progress from the start to the end of the process
   - numbers are used for process streams
   - C i , i = 1,..n are used for all cooling non-contact streams
   - S j, j = 1,...n are used for all steam heating non-contact streams
5) Recycle streams are shown with dotted lines

For most streams, the temperature and pressure are shown, if the pressures are greater than 1 atm

Process Diagram or Boundary of LCI

Steam enters the process as a gas at 207 ºC and leaves as a liquid at 207 ºC. Cooling water enters at 20 ºC and leaves at 50 ºC.
Unless otherwise indicated, all processes are at 1 atm and 25ºC.



Mass Balance of Chemicals in Each Process Stream

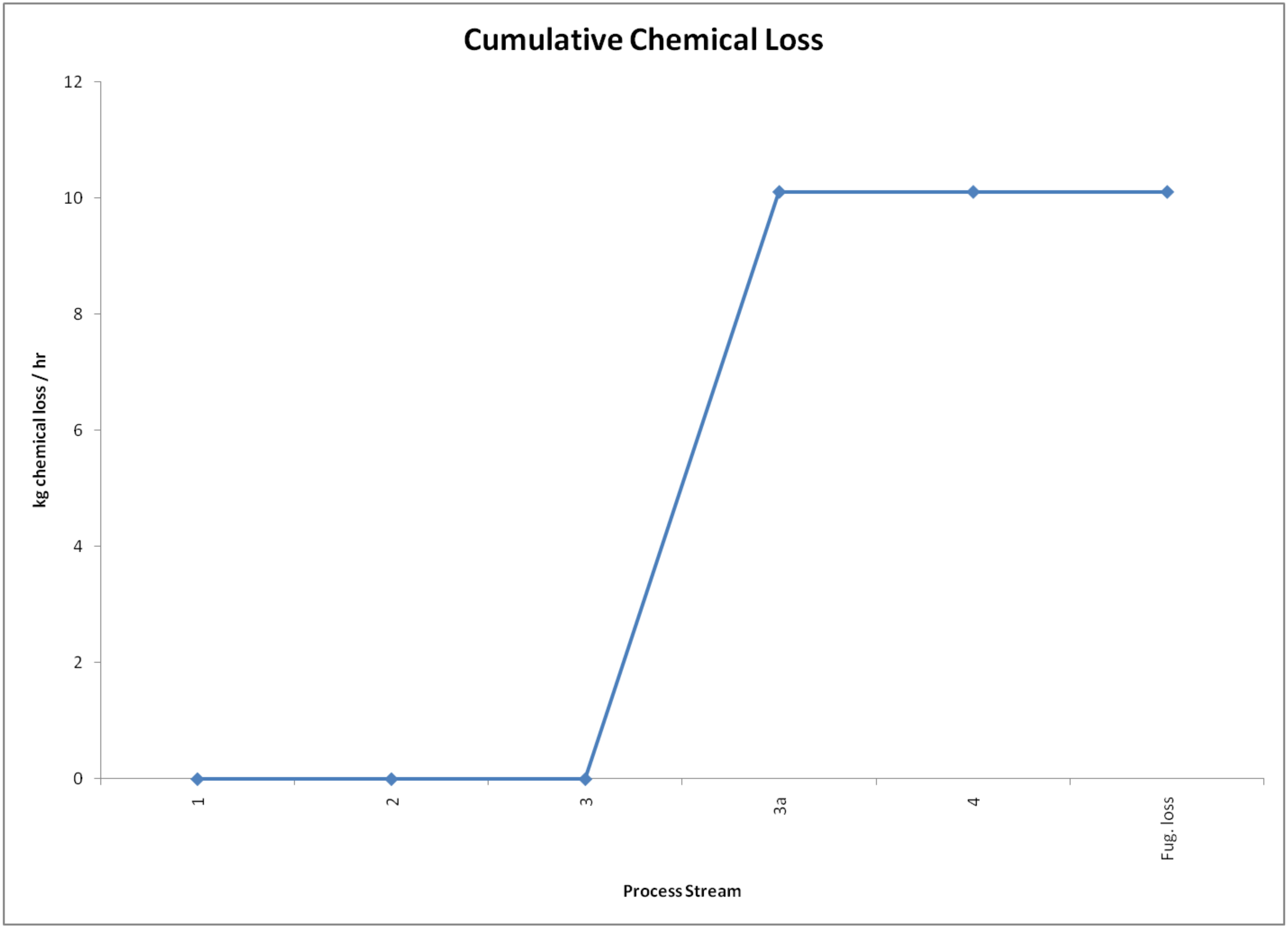
All flow rates are given in kg / hr
Physical state of chemical losses:

Gas
Liquid
Solid

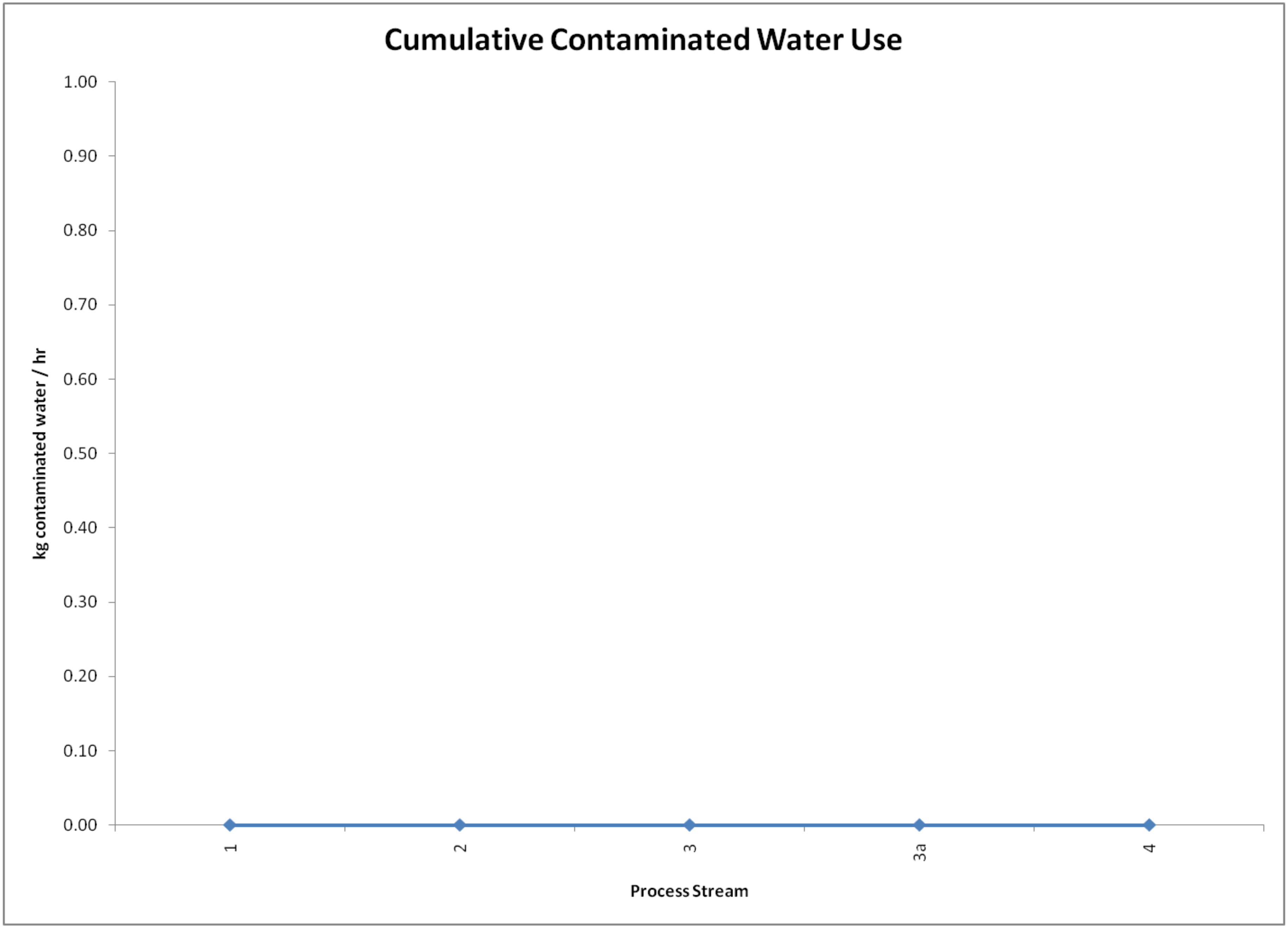
	Comments	Streams	Temp [C]	P	Phase	Total Flow	Water	Polyethylene(92mol%)-methyl acrylate copolymer	outerbagEMAC
Input	copolymer	1	25.0	1.00	s	1010		1010	
Display in PFD	extrusion	2	225	1.00	l	1010		1010	
Display in PFD	vitrifying	3	25.0	1.00	s	1010		1010	
Waste		3a	25.0	1.00	s	-10.1		-10.1	
Main product	sheet	4	25.0	1.00	s	-1000			-1000
		Product purity (%)			:	100			
		Main product			:	outerbagEMAC			
		Overall Rxn coefficients			:				
		Total yield of process (from reactant)			:				NA
Waste		Fugitive Losses (Total)			g	0	0	0	0
		Input Sum			:	1010	0	1010	0
		Fugitive Replacement of Reactants			:	0			
		Total Input (Input + Fugitive Replacement)			:	1010	0	1010	0
		Product Sum			:	1000	0	0	1000
		Main product flow			:	1000	0	0	1000
		Net Input (in - out, omitting fugitives)			:	5.86E-14			

Type	Label	Temp, C	P, atm	Phase	Total flow	Steam	Water
Input	C1	20.0	1.00	l	5037		5037
Cooling out	C2	50.0	1.00	l	-5037		-5037

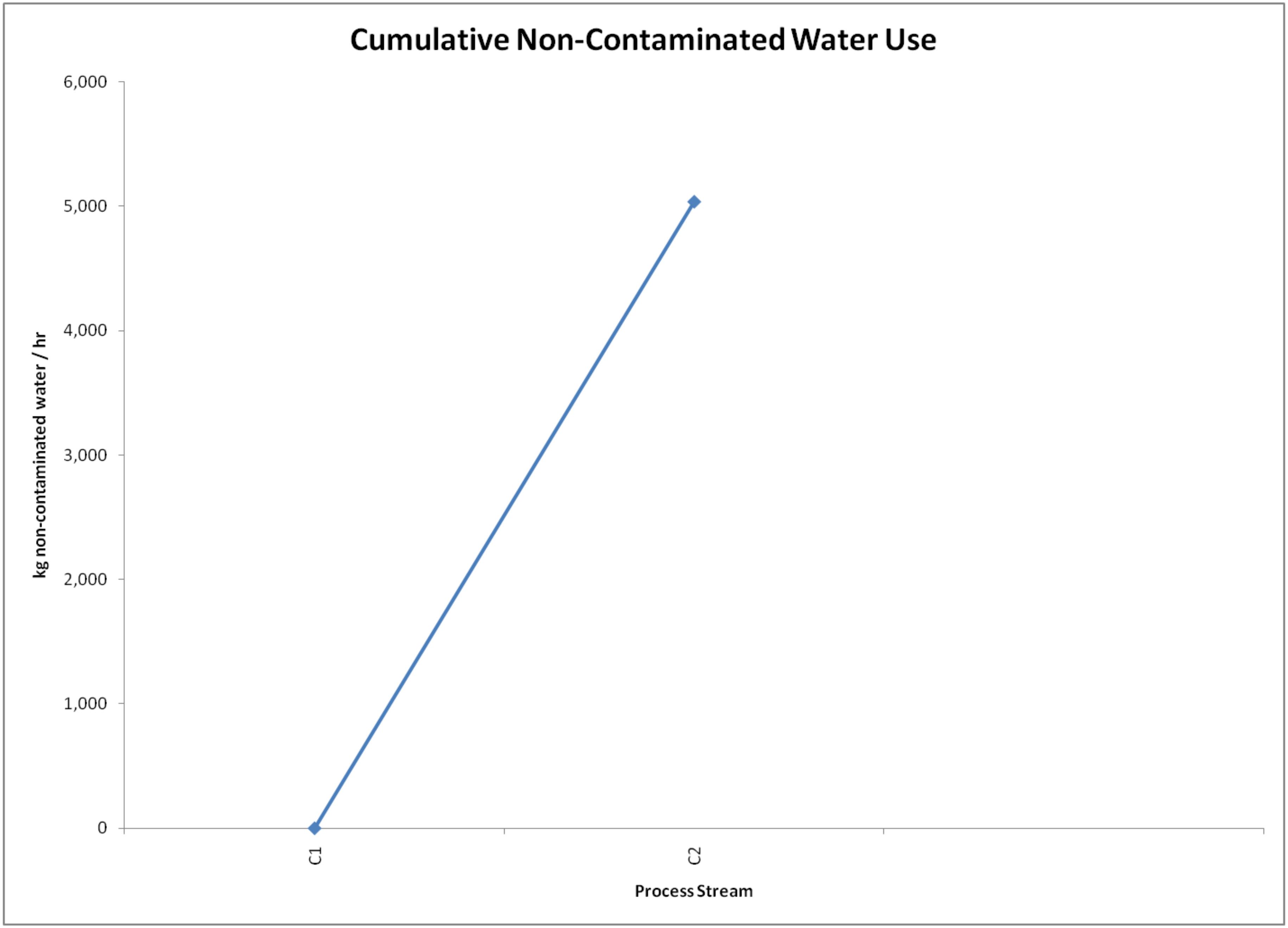
Graph of Cumulative Chemical Losses through Manufacturing Process



Graph of Cumulative Contaminated Water Use / Emission through Manufacturing Process



Graph of Cumulative Non-Contaminated Water Use / Emission through Manufacturing Process



Energy Input for each Unit Process, Cumulative Energy Requirements, Cooling Requirements (exotherms), and Assumed Heat Recovery from Hot Streams Receiving Cooling

Energy Input [MJ / hr]						Cooling Requirements [MJ / hr]							
Process Diagram Label	Unit	Energy input [MJ / 1000 kg Product]	Cumulative energy [MJ / 1000 kg Product]	To [C] (Used to determine energy type)	Energy Type	Process diagram label	Unit	Energy Loss	Cumulative cooling water energy	Tef [C] (for recovery efficiency)	Recovery Efficiency	Energy Recovered	Cumulative recovered [MJ / 1000 kg Product]
extruder	extruder	804	804	0	E	Hx1	Heat exchanger 1	-744	-744	225	0	0	0
winding	winding	149	953	0	E								
	Potential recovery	0	953										
	Net energy		953				Potential recovery:						0
	Electricity	953	E	[MJ/hr]									
	DowTherm	0	D	[MJ/hr]									
	Heating steam	0	S	[MJ/hr]									
	Direct fuel use	0	F	[MJ/hr]									
	Heating natural gas	0	G	[MJ/hr]									
	Diesel process	0	Ds	[MJ/hr]									
	Undefined	0	U	[MJ/hr]									
	Heating coal	0	C	[MJ/hr]									
	Energy input requirement	953		[MJ/hr]									
	Cooling water	-744		[MJ/hr]									
	Cooling refrigeration			[MJ/hr]									
	Potential heat recovery	0		[MJ/hr]									
	Net energy	953		[MJ/hr]									

Graph of Cumulative Energy Requirements