

PROPOSAL FOR THE EXTRUSION OF A
GLOW-IN-THE-DARK PLASTIC

by
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ABSTRACT

In this proposal, the members of Group B (Weston Eldredge, Ryan Martin, Daniel Reese, and Lauren Whatley) experimented with the extruder located in the Chemical Engineering Projects Laboratory to produce a round, thin string (diameters less than one-tenth of an inch) of high-density polyethylene. Various flow rates and draw ratios were explored to find a desirable product. Favorable qualities included a consistent diameter, smooth surface, and even appearance. The operating temperature was 150°C.

After determining sufficient operating parameters, we selected an appropriate glow additive. The ProGlow company produces a ready-made glow product (MasterBatch) that is compatible with our polyethylene in the laboratory. The ProGlow is simply added to the polyethylene in the following ratio: three parts polyethylene to one part ProGlow for the maximum luminosity. We received a small sample of the ProGlow MasterBatch. It was mixed with the polyethylene and ran through the extruder at 150°C, and we successfully produced glow-in-the-dark string. We are requesting \$43 to purchase one-half kilogram of the MasterBatch—which is available from ProGlow and can be shipped in a few days. We will develop three stocks of the glowing string (three different diameters). We plan to mix the ProGlow with the polyethylene at various ratios to find the optimal ratio for the lowest amount of glow additive without compromising the glow intensity. We will quantifiably measure the luminescence of the glow products with the use of a light meter (with permission from the Industrial Assessment Center), and thus establish a correlation between luminosity and ratio of ProGlow in the feed stock.

In this proposal, we describe the many applications for glow-in-the-dark products. We will also discuss the benefits of the work, cost, environmental impact, and a detailed schedule of the tasks necessary to accomplish the project.

1. TECHNICAL BACKGROUND

1.1 Identification of the Problem

A single-screw-polymer extruder is located in room 3520 of the Merrill Engineering Building at the University of Utah. Currently, the extrusion apparatus is employed to perform several experiments involving the extrusion of high-density polyethylene (HDPE) through a rectangular-shaped die. Recently, the extruder apparatus was equipped with a cylindrical die, including a newly machined sleeve insert with a 0.125-inch diameter opening. At present the Chemical Engineering Department's catalog of experiments for the extruder apparatus does not include an experiment that is specifically based on the use of the cylindrical die. Furthermore, there does not appear to be an experiment that involves the investigation of mixing polymer pellets with other materials to produce an extrudate with unique properties.

The results of the work outlined in this proposal will likely provide a basis for the development of several new experiments involving the use of the extruder apparatus and the newly equipped cylindrical die. Future participants in the Chemical Engineering Projects Laboratory course will benefit from an augmented inventory of interesting experiments involving the extruder.

Additionally, the unique products that result from the proposed work will be of value to the Beehive State Engineers. Not only will these products have the potential to be produced and sold for profit, but also the process for their production would make up an intriguing demonstration during the High School Engineering Days and other such exhibitions of the University of Utah Chemical Engineering Department. Moreover, the resulting products would provide a one-of-a-kind souvenir gift for the viewers of the demonstration.

1.2 Justification of Proposed Work

1.2.1 Theory

Extrusion is the process of molding a plastic or other malleable substance into a specific shape using pressure. Historically, metals, especially aluminum, have been extruded by the use of ram-

driven machines. Today, the most common way to apply pressure to the plastic material is with a screw. An Archimedean screw is commonly used and is found in the apparatus for this project. The screw consists of a shaft and a thread, whose diameter is constant from the feed point to the die. The constant diameter of the screw portion allows a tight fit in the barrel of the extruder apparatus as well as a consistent flow of polymer material through the machine. The shaft portion of the screw increases in diameter as the polymer approaches the die. The greater the diameter of the shaft, the lower the depth of the channel and the greater the pressure exerted on the polymer. This pressure is what drives the polymer through the extruder. Almost every material that is extruded must be heated until it can be deformed under the pressure of the extruder.

The extrusion process has four phases. The purpose of the first phase, or feed phase, is to preheat the polymer and deliver it to the next phase. During the feed phase the diameter of the shaft portion of the screw is kept constant to allow a consistent delivery of the material. The second phase is the compression phase where the shaft of the screw increases in diameter, and pressure is applied to the polymer. The pressure eliminates any air bubbles in the polymer. Also, because the channel decreases in depth, the heat transfer to the thinner polymer increases. An interesting feature of the compression phase is that the zone for compression will vary depending on the polymer used. For polymers that melt quickly, the compression zone is relatively small (nylon is an example). For polymers that are very difficult to compress, the compression zone almost occupies the whole screw (PVC plastic is a good example of this type of polymer). High-density polyethylene, the polymer used for this project, is moderate in its resistance to deformation in the extruder. The compression zone on a polyethylene screw is about the same length as the other zones.

The next phase is the metering phase. Here, the diameter of the shaft remains constant to supply the melted polymer to the die at a constant temperature and pressure. The last phase in the extrusion process is the die phase. The die contains a perforated steel plate called a breaker plate, and a sieve pack of several layers of wire gauze. These components serve to filter out any foreign material (dirt, unmelted polymer pellets, etc.). They also create a pressure head by providing resistance to the pumping action of the metering zone. Lastly, they remove any

“turning memory” from the melted polymer, so that the final product can be shaped to any desired form.

1.2.2 Theoretical Modeling

One major concern in the development of this extrusion process is the need to make polymer string product with a consistent diameter. String polymer taken from the extruder can be sized by applying tension to the string as it exits. A take-up roller is used to apply the needed tension. The faster the take-up roll moves, the more tension is applied to the exiting polymer, and the thinner the string will be. A useful quantity in controlling the string diameter is the draw ratio, *DR*. This quantity can be defined as follows:

$$DR = \frac{V_2}{V_1} = \frac{A_1}{A_2}, \quad (1)$$

where V_1 is the axial velocity of the polymer film at the exit of the extruder die, and V_2 is the axial velocity of the polymer film at the entrance of the take-up rollers. A is the cross-sectional area of each of the respective polymer films. The draw ratio can be adjusted by altering the rotational speed of the take-up rollers or the screw in the extruder. Then the area, and therefore the diameter of the product string can be regulated. Since the die exit is only 1/8 of an inch, A_1 is fixed. If the speed of the extruder screw is kept constant, then the diameter of the string can be determined by the take-up roller speed.

Calibration curves are listed in Appendix A that relate the percentage power on the take-up roller to the radial velocity in radians per second. Measurements were also taken on the mass flow rate of the polymer coming from the die. The mass flow rate was determined to be 0.0365 ± 0.0005 g/s. The diameter of the take-up roller was measured at 2.49 inches. Therefore, the circumference of the roller is 7.8125 inches. It was then possible to make predictions on the final diameter of the string product from the draw ratio calculations and the measurements by the use of the following relations:

$$A_1 = \frac{(.125 \text{ in})^2}{4} \rho = 0.0123 \text{ in}^2 \quad (2)$$

$$V_1 = \frac{\dot{m}}{\rho A_1} = \frac{0.0000365 \text{ kg/s}}{(950 \text{ kg/m}^3)(7.91e-6 \text{ m}^2)} = 4.85e-3 \text{ m/s} = 11.46 \text{ in/min} . \quad (3)$$

$$V_2 = D_R \rho \omega . \quad (4)$$

$$A_2 = \frac{A_1 V_1}{V_2} . \quad (5)$$

$$D_1 = \sqrt{\frac{4A_2}{\rho}} . \quad (6)$$

In these relations D_R is the diameter of the roller, ω is the radial velocity of the roller in radians per second, and D_1 is the diameter of the string product. Table 1 below shows the speed of the roller with the predicted and measured diameters for the string product.

Table 1. This table compares the actual measured diameters of string product from the extruder to the predicted values given by the model. The model is based on draw ratios.

Roller Speed	15%	100%
Predicted Diameter	0.0079	0.0222
Measured Diameter	0.1105	0.0286
Error	0.928507	0.223776

The model shows a very large degree of error. This is likely due to measurement error (mass flow rates, lengths, radial velocities, etc.) This shouldn't affect the product quality since a consistent diameter has already been produced from determined settings obtained through trial-and-error.

Another technical issue affecting the quality of the string is the cool-down time for the string when it leaves the extruder. If the string does not cool down past its deformation temperature (assumed to be at 60°C) before it enters the take-up roller, the shape of the string could deform, thus effecting the quality of the product. The heat-transfer coefficient for a cylinder in stagnant fluid conditions was calculated by the use of methods summarized by Dewitt and Incropera (2001). The calculation assumed free convection, and it calculated the time it would take for string leaving the extruder to cool from 150°C to 60°C. Lumped capacitance assumption was employed to simplify the calculation once the properties of polyethylene and the heat-transfer coefficient were known. The estimated cool-down time for the string (1/8-inch diameter) was 2.2 minutes. Since the string will be stretched to a thinner diameter, the actual cool-down time will be less. For example, at 1/16-inch diameter the cool-down time is predicted to be no more than 47 seconds. The problem comes if the roller pulls the string so quickly that the string has not cooled below deformation temperature (estimated at around 60 degrees) when it enters the roller apparatus. In cases of higher roller speeds this is a potential problem. To address the problem, a fan is placed next to the die where it delivers a small current of air to raise the heat-transfer coefficient and thus allow the string to cool before it enters the roller. The fan is not used for larger diameter strings since they cool before they enter the roller (because the roller isn't moving as fast). Also, the fan tends to warp the shape of the string at lower roller speeds.

1.2.3 Critical Needs

The last technical issue to be addressed for this project is the mixing of glow additive with the regular polyethylene feed stock. The manufacturer of the glow material recommends a mixture of one part glow material to three parts (by volume) polymer for optimal glow effect. So far only a one-to-four ratio has been applied. Pictures of a sample of product with glow material at a one-to-four ratio are included in Figure 8 in section 5.2. If an acceptable level of glow can be obtained from a larger ratio of glow material to polymer, then it will be economically viable to go with the higher ratio. The only difficulty will be to ensure that the glow material and the polymer are well-mixed. Without good mixing of the two components, the product will not have a uniform, attractive glow. A previous test run of the apparatus has shown that the extruder tends to distribute the two components well when they travel through the screw. Additionally,

the material will already be well-mixed when it enters the hopper. Several ratios of the mixtures will be used and compared in the duration of this project.

2. TECHNICAL APPROACH

2.1 Objectives

Several major objectives are contained within this project. They include the following:

- a. We will determine a set of operating conditions that will produce a favorable product using the cylindrical die and a mixture of the ProGlow additive with the existing high-density polyethylene (HDPE) pellets. For the purposes of this project, a favorable product will be defined as having a smooth surface, constant diameter, and consistently round polymer string.
- b. We will use the polymer and glow additive mixture to extrude three different rolls of feed stock material, each a different diameter between 0.02 to 0.10 inches. In so doing, the concept of draw down is to be employed.
- c. We anticipate experimenting with different mixture ratios of the ProGlow additive and polyethylene pellets in an effort to find optimal ratios for maximum luminosity while at the same time economically using the ProGlow additive. As part of this objective, each of the three rolls of polymer string from Objective 2 will be composed of a different mixture ratio of glow additive and will be labeled with its corresponding luminescent light output, in lumens, as measured by a standard light-sensing meter.
- d. We will develop a prototype of at least one potentially marketable product from each of the three rolls of polymer string that will be produced.

The fulfillment of these objectives will potentially lead to the development of several new Senior Projects Laboratory experiments, involving the use of the extruder apparatus and the newly equipped die. Additionally, the product prototypes that will be developed could eventually be carried to production and distribution.

2.2 Statement of Work

2.2.1 Project Tasks

Group B has established four primary tasks required to create glow-in-the-dark products. In the work completed thus far in the project, we have determined appropriate screw speed and draw ratio parameters for the maximum diameter (1/10 inch) from the circular die on the extruder. In Task 1, we will establish appropriate parameters for two other diameters—one with a very small diameter and the other in between the two. Task 2 includes finding mix ratios between the polyethylene and the ProGlow MasterBatch glow material that provide optimal glow luminescence while minimizing the amount of MasterBatch used. For example, we will ascertain whether there is a significant difference in mixing three parts polyethylene to one part MasterBatch versus five parts polyethylene to one part MasterBatch. In so doing, we can find the most economic product without compromising glow properties. In Task 3, we will quantify the results from Task 2 by directly measuring the luminescence of the different MasterBatch to polyethylene mix ratios. We anticipate using the Industrial Assessment Center's (IAC) light meter. To reduce variability and error, all samples will be kept in a dark box or equivalent and then placed under a light for a uniform amount of time before the luminosity is measured in a dark room. Finally, Task 4 involves putting together prototypes of the various glow-in-the-dark products that we suggest be made.

2.2.2 Project Schedule

A timetable for the project to extrude glow-in-the-dark products is given in Table XX. It includes all tasks mentioned in the previous sections, time to wrap up any last minute laboratory work, and the time required to prepare a detailed report on the project—including findings, conclusions and recommendations. The schedule also provides a contingency for unanticipated delays related to equipment or product problems as well as unforeseen employee illness.

Table 2. The timetable is listed for the extrusion of glow products.

Date	Description of work
Feb. 12 (Wed.)	Task 1
Feb. 19 (Wed.)	Task 1
Feb. 24 (Mon.)	Task 2
Feb. 26 (Wed.)	Task 3
Mar. 3 (Mon.)	Task 4
Mar. 5 (Wed.)	Wrap-up of exp't. work
Mar. 10 (Mon.)	Report write-up
Mar. 12 (Wed.)	Report due

2.2.3 Estimated costs

This project is estimated to cost \$12,300. This net cost includes salaries, wages, and fringe benefits for four engineering personnel. Salaries were calculated based upon 16 base work hours per person per week for four weeks at a base salary of \$24.04 per hour (or an annual rate of \$50,000). The salary total for the project amounted to \$8,185. The only other direct cost involved in this project is the MasterBatch product that costs a total of \$43 for a half-kilogram sample directly from the ProGlow manufacturer. This gives a total direct cost of \$8,228. Indirect costs were estimated at 49.5% of the total direct cost, or \$4,073. Thus the net cost of the project is the sum of the total indirect and direct costs (\$12,300). Figure 1 shows a spreadsheet with the detailed budget calculation for the project.

Budget Calculation for "Extruder-Group B"					
					Lab hours per week
					8
		Labor	Weekly	Dollar	
		Weeks	Rate*	Amount	Work hours outside of class
A. Senior Personnel (list names below)					8
1 Weston Eldredge	1.6	\$ 961.54	\$ 1,538.46		8
2 Ryan Martin	1.6	\$ 961.54	\$ 1,538.46		Total hours per week
3 Daniel Reese	1.6	\$ 961.54	\$ 1,538.46		16
4 Lauren Whatley	1.6	\$ 961.54	\$ 1,538.46		Number of weeks in project
5			\$ -		4
6			\$ -		total labor weeks
A. Subtotal			\$ 6,154		16
* calculated on Labor_Rate_Calc sheet (see tabs at bottom of this sheet)					
		Labor	Weekly	Dollar	
		Weeks	Rate*	Amount	
B Other Personnel					
Engineering Staff		\$ 865.38	\$ -		
Other Professionals (Technician, Programmer, etc.)		\$ 680.00	\$ -		
Secretarial/clerical		\$ 440.00	\$ -		
Other			\$ -		
B. Total Salaries (A+ B)			\$ 6,154		
C. Fringe Benefits			Calculation		
Percentage	33%	\$ 2,031			
C. Total Salaries Wages and Fringe Benefits			\$ 8,185		
D. Equipment (itemize and dollar amount for each)		Item Cost			
Multi-species gas analyzer					
D. Equipment Subtotal			\$ -		
E. Travel			Subtotal		
Domestic					
Foreign					
E. Total Travel			\$ -		
F. Trainee/Participants Costs				N/A	
G. Other Direct Costs			Subtotals		
Materials and Supplies		\$ 43			
Publication Costs					
Consultant Services					
Computer Services					
Subcontracts					
Other					
G. Total Other Direct Costs			\$ 43		
H. Total Direct Costs			\$ 8,228		
I. Indirect Costs					
Percentage	49.5%				
I. Indirect Costs			\$ 4,073		
J. Total Direct and Indirect Costs			\$ 12,300		
<i>This represents total actual cost of the project</i>					
K. Cost Sharing			\$ -		
L. Net Cost of Project			\$ 12,300		

Figure 1. A spreadsheet is shown for the proposed budget.

3. CAPABILITIES

3.1 Project Team and Key Personnel

The workload to formulate the proposal was divided equally among the team members of Group B. It is summarized in the following flow diagram in Figure 2.

Project Team and Team Member Responsibilities

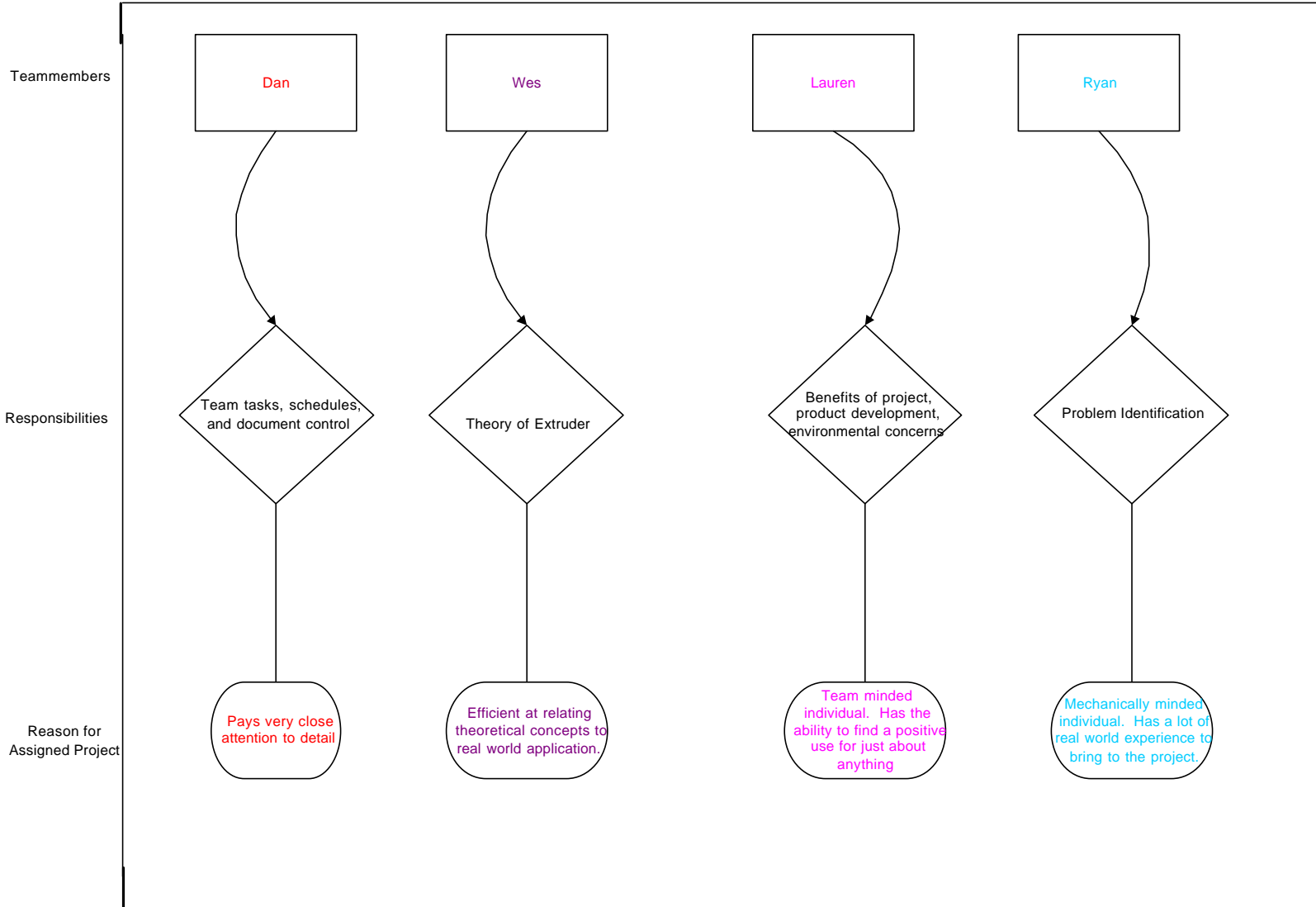


Figure 2. A flowsheet is given for the team member responsibilities.

3.2 Equipment and Facilities

The Chemical Engineering Laboratory is equipped with a C.W. Brabender manufactured single-screw extruder. A 3.4-horsepower electric motor drives the extruder screw. An Opto 22 control system and a PC computer provide control of the extruder apparatus. Recently, the extruder was equipped with a cylindrical die, including a newly machined sleeve insert with a 0.125-inch diameter opening. A photograph of the single screw extruder is shown in Figure 3 and a schematic drawing is shown in Figure 4. The feed hopper and the four zones of the extruder are displayed and labeled in the drawing.

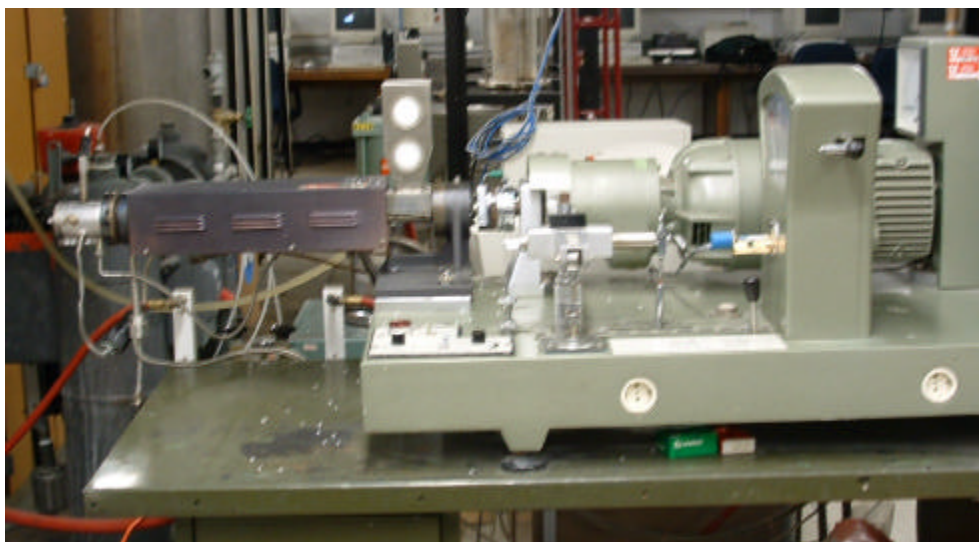


Figure 3. A photograph of the single screw extruder, used in this project, is shown here. The PC computer and the Opto 22 controller are located behind the apparatus as it is shown here.

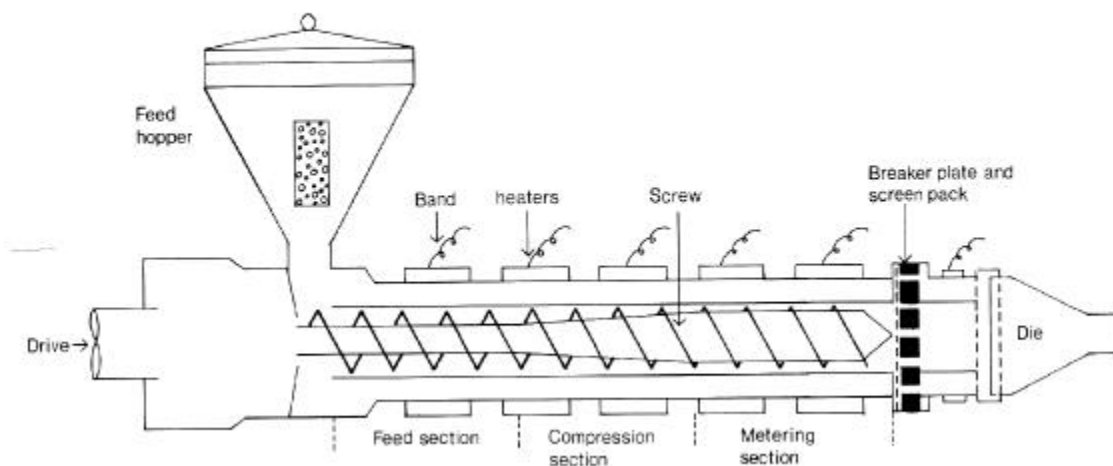


Figure 4. A schematic diagram of the single screw extruder used in this experiment is shown here. The feed section corresponds to zone 1 of the extruder apparatus. The compression section, the metering section, and the die correspond to zones two, three, and four, respectively. The feed hopper, heaters, breaker plate, and screen pack are also shown. The narrowing screw channel in the compression zone is well demonstrated in this diagram.

The laboratory is also equipped with a UNIVEX TAKE-OFF, CW Brabender, type SFP-100, take-up roller apparatus. The take-up assembly consists of two large water-cooled rollers, a small roller located above the large rollers, and a reel-up roller that collects the polymer product. The main take-up roller is powered by an electric motor. A dial, labeled in units of percentage of full scale, on the take-up apparatus instrumentation console controls the roller speed. Control of the roller speed is independent of the Opto 22 control system. A photograph of the take-up assembly is shown in Figure 5 and a schematic drawing is shown in Figure 6.

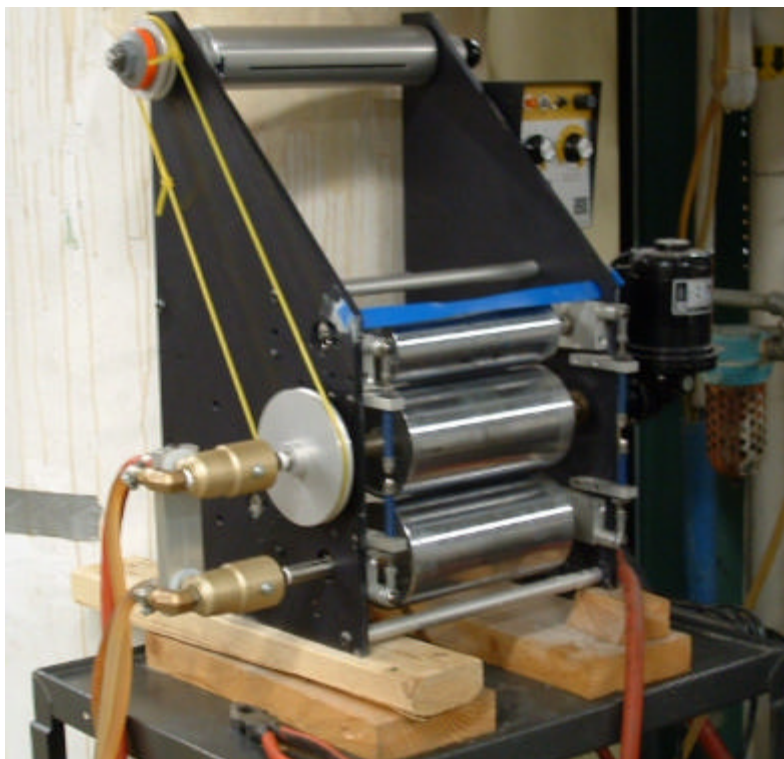


Figure 5. A photograph of the take-up apparatus used in this experiment is shown here. The two lower rollers are water-cooled and assist in the hardening of the polymer effluent. The roller speed control instrumentation is located at the upper right-hand corner of the apparatus.

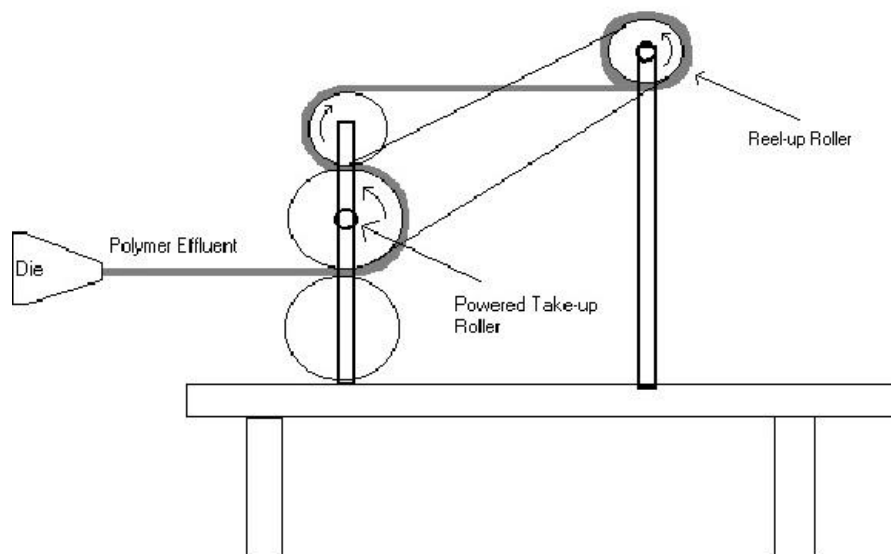


Figure 6. A schematic diagram of the take-up apparatus used in this experiment is shown here. The gray line that enters the rollers from the die represents the polymer effluent. The main take-up roller shown is powered by a small electric motor. The turn of a small dial controls the rotational speed of the powered roller.

Also provided in the Chemical Engineering Projects Laboratory is a generous supply of white high-density polyethylene pellets. The manufacturer's data sheet provided the necessary properties of density and melting point temperature. The density of the HDPE polymer material is 954 kg/m^3 , and the melting point is 130°C .

Based on trial runs with the extruder apparatus (which includes a cylindrical die, take-up rollers, and HDPE pellets), the existing equipment has been demonstrated to be suitable for the completion of the proposed project. Photographs displaying several of the resultant polymer products from the above mentioned trial runs are found in Figures 7 & 8. Furthermore, feedback from the ProGlow distributor indicates that the existing HDPE polymer pellets will mix well with the glow additive, and that the glow additive mixture will be compatible with the existing extruder apparatus.

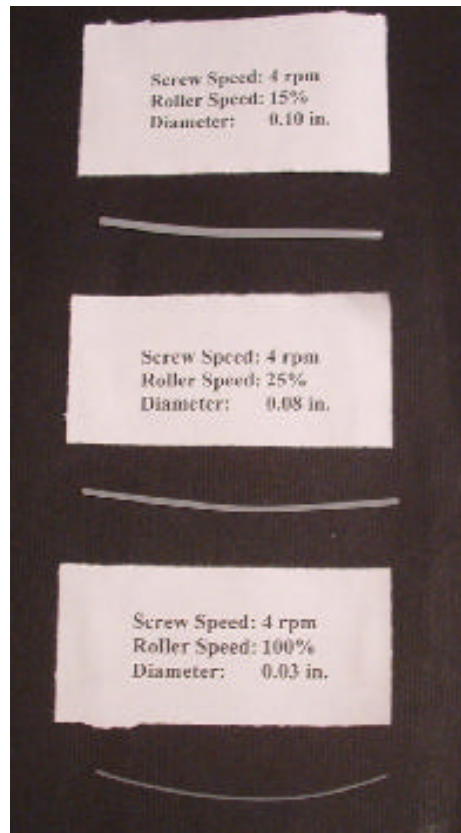


Figure 7. Three desired polyethylene diameters are shown.



Figure 8. Our glow product is shown in the dark.

The only equipment or material purchase that is anticipated to be necessary for the completion of this project is the ProGlow MasterBatch glow additive. The cost of this additive was quoted at \$85.97 per kilogram. We anticipate that one half kilogram of this glow additive will be sufficient to complete the project.

4. ANTICIPATED BENEFITS OF PROPOSED WORK

Currently, several markets are in need of a glow-in-the-dark product that essentially never dies. ProGlow lasts for up to 20 hours and only needs to be recharged for approximately 20 minutes to return to its original intensity. There are several possible uses for the final extruded glow-in-the-dark product manufactured in this experiment. These benefits will not only reap a hefty economic profit, but also provide an overall service to society in the area of public safety.

We plan to use the final extruded product to make glow-in-the-dark jewelry to accommodate the ever-growing teen rave party scene. Longer lasting necklaces and bracelets will soon become the expected norm for these all-night party animals. The product can also be used in the fishing tackle industry. The power of the glow-in-the-dark lure has just recently become apparent to the savvy fisherman. Traditionally, those lures that have the reputation to catch the most fish sell the strongest in the retail market. Glow-in-the-dark fishing flies are already used by fishermen. It is projected that we can sell our long-lasting glow lures at a competitive retail price, obtaining profit through the sheer volume of sales at the wholesale level.

Glow components add an extra degree of safety to almost anything. Our thin, tube-shaped product can potentially be used around traffic signs in order to illuminate them during the night. It can also be used in bike helmets and construction hard hats. Glow-in-the-dark tubing can also be used in pet collars to avoid the tragic loss of a loved pet. An illuminated collar allows a driver to be aware of the presence of an animal before it is too late.

The uses of a long-lasting, glow-in-the-dark product are endless. We have presented only a few potential economically-viable product options. Our equipment has the ability to manufacture a plethora of different die diameters. If another product is desired we can consider the feasibility to manufacture this product as the issue arises.

5. ANTICIPATED ENVIRONMENTAL IMPACT OF PROPOSED WORK

The extrusion of polyethylene delivers little environmental impact, although proper handling and safety precautions must be followed in order to ensure safety. The polyethylene pellets and ProGlow used in the experiment are both non-flammable. Heating polyethylene to temperatures greater than 200°C may release a toxic fume, though. Therefore, during the extrusion process, careful attention should be paid to the temperature profile of the extruder to avoid the accidental release of these toxic fumes. As long as the operators pay careful attention to the temperature along the length of the extruder, especially in the die region, no environmental complications should arise. Polyethylene is safe to throw away, but also easy to recycle. The proposed experiment will not produce enough polyethylene waste to be of any environmental concern. According to its material safety data sheet (MSDS), ProGlow is as benign as HDPE (high density polyethylene). The only warning given by the manufacturer is that it should not come into contact with acids. ProGlow can be disposed of in the same manner as polyethylene.

NOMENCLATURE

A	Cross-sectional area
D_R	Roller diameter
DR	Draw ratio
\dot{m}	Mass flow rate
V	Axial velocity
ρ	Density
ω	Radial velocity of the roller
HDPE	High density polyethylene
MSDS	Material safety data sheet

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APPENDIX A: CALIBRATION

Table A-1. Data are given for the roller speed vs. rpm.

Roller Speed (% of full-scale)	Rotations	Time (sec.)	rad/sec	Linear Take-up speed (in./min.)
0	0	0	0	0
20	1	30	0.2094	98.17477
30	1	14	0.4488	210.3745
40	2	18	0.6981	327.2492
50	3	21	0.8976	420.749
60	3	17	1.1088	519.7488
70	4	19	1.3228	620.0512
80	4	17	1.4784	692.9984
90	5	18	1.7453	818.1231
100	5	16	1.9635	920.3885

Circumference (in.):	7.8125
Diameter (in.):	2.4868

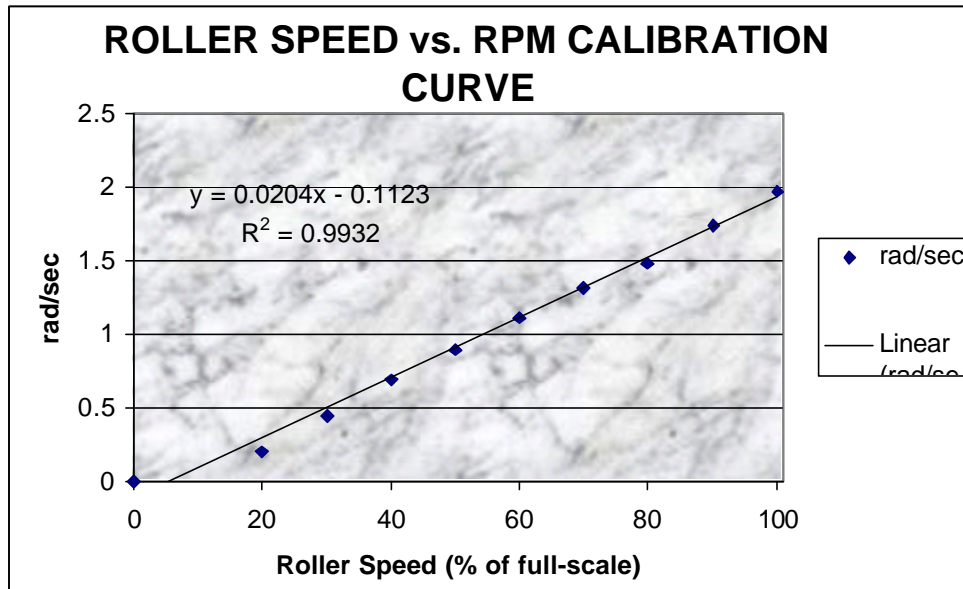


Figure A-1. A plot of rollers speed vs. revolutions per minute is shown.

APPENDIX B: EXPERIMENTAL DATA

Figure B-1. Data are listed for the diameter results of the experiment.

LAB RESULTS				03-Feb-02	05-Feb-03
The search for parameters for the largest and smallest diameter glow string					
Run	1	2	3	4	1
Screw Speed (rpm):	5	4	4	4	4
Roller Speed (% full scale):	25	25	20	15	100
Cart Location	All the way back.	At the line	12.25 in. from table	12.25 in. from table	12.25 in. from table
Diameter Measurements (inches):	0.071	0.083	0.089	0.100	0.03
	0.068	0.078	0.085	0.087	0.03
	0.082	0.086	0.088	0.090	0.028
	0.073	0.082	0.085	0.106	0.03
	0.081	0.083	0.086	0.103	0.028
	0.078	0.082	0.082	0.101	0.029
	0.078	0.080	0.103	0.106	0.027
	0.079	0.083	0.082	0.102	0.027
	0.083	0.087	0.095	0.108	0.029
	0.082		0.086	0.097	0.028
	0.091		0.078	0.107	0.028
	0.085		0.088	0.109	0.027
	0.077		0.083	0.086	0.029
	0.084			0.095	0.029
	0.084			0.105	0.029
				0.103	0.03
				0.101	0.028
				0.096	
				0.100	
				0.113	
				0.093	
				0.104	
Average:	0.0797	0.0827	0.0869	0.1005	0.0286
Median:	0.0810	0.0830	0.0860	0.1015	0.0290
STD Deviation:	0.0059	0.0027	0.0063	0.0071	0.0011