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**What does injection molding have to do with math?**

**Video:** [**https://youtu.be/\_dk7r0oKjLI**](https://youtu.be/_dk7r0oKjLI)

**Lesson Plan**

**Teacher Note:** Please preview the entire video and pre-work the solutions in order to anticipate students’ needs, misconceptions and materials unique to your classroom.

You will also need to determine the background knowledge of your students regarding the following topics, and decide the best method for providing that background in order to support the conceptual understanding of the mathematics shown in the video.

* + Using a spreadsheet as a way to organize data
  + Using graphs to display data
  + Using spreadsheets and graphs of data to gain information and make decisions.

**Common Core Mathematical Content Standards**

* **6.SP.5** Summarize numerical data sets in relation to their context.
* **7.SP.1** Understand that statistics can be used to gain information about a population by examining a sample of the population.
* **6.RP** Understand ratio concepts and use ratio reasoning to solve problems.
* **7.RP** Analyze proportional relationships and use them to solve problems.
* **S-IC** Make Inferences and justify conclusions from sample surveys, experiments and observational studies. Use the given Excel sheet of downtime and scrap data and the Extension Section below.

**Common Core Mathematical Practice Standards**

1. Make sense of problems and persevere in solving them.

2. Reason abstractly and quantitatively

3. Construct viable arguments and critique the reasoning of others.

**Company Information**

In 1941, when Krueger Metal Products, Inc. was founded, the war made resources scarce. Daily, founder Al Krueger would call on steel companies to purchase materials to make folding chairs. The scrap available determined what he could produce…a novel way of manufacturing.  Today, KI is still known for innovative manufacturing. What’s different is that innovation also includes the approach it takes with its workforce.

That approach helped the company expand its portfolio well beyond the folding chair. The Green Bay plant manufactures various seating products, Manitowoc focuses on architectural wall and panel systems, while Bonduel produces fixed seating and tables.

KI purposely cultivates a work environment that encourages employees to share ideas and try new things. During a shift, you won’t just see repetitive work at a single machine. Rather, employees also engage in all facets of the business – from cross-training in other cells to planning sessions and discussions with customers.

KI prides itself on mentoring the next generation of skilled workers. KI has partnered with local schools, supports both youth and adult apprenticeships, and supports continuing education for all employees. KI has entered into a unique partnership that pairs high school students with the company’s engineers to solve real-world manufacturing problems. During its busy summers, the company hires more than 400 students across its three plants.

That’s why KI’s tagline “Furnishing Knowledge” is so fitting…it offers far more than furniture.

Learn More About KI Manufacturing <QR CODE to manufacturing video: <https://www.youtube.com/watch?v=huFCL-7S42s&t=26s>>

**Summary**

Companies are always trying to find ways to save money while still maintaining the quality of their products. Looking at data regarding production downtime and how to minimize it can provide a cost savings. Gathering downtime data, interpreting that data and problem solving are necessary when making these decisions. In this video we will investigate data from a new injection molding process that uses different colors for chair backs and seats at KI.

**Pre-Activity Discussion:**

* This video takes students through a real world problem solving process from start to finish. A new injection molding process for a two color chair seat and back needs to be analyzed due to cost issues.
* Vocabulary
  + Polypropylene – Thermoplastic polymer. A plastic material the becomes moldable at a specific temperature and solidifies upon cooling
  + Color change – The process in which one color of polypropylene is purged out of the injection molding machinery and another color polypropylene is put in.
  + Purging agent – a material that is put into the injection molding machine to clean out the previous colorant so that it does not mix with the new colorant.
  + Down Time – any time the injection molding machine is not producing high quality, sellable chair backs and seats.
  + Scrap – the chair backs and seats that are produced that do not meet quality standards, and are not sellable.
  + Pivot Tables - Pivot tables are used in [data processing](https://en.wikipedia.org/wiki/Data_processing) and are found in data visualization programs such as [spreadsheets](https://en.wikipedia.org/wiki/Spreadsheet) or [business intelligence](https://en.wikipedia.org/wiki/Business_intelligence) software. Such programs can automatically sort, count, total or average the data stored in one table or spreadsheet, displaying the results in a second table — the pivot table — showing the summarized data. The user often sets up and changes the summary's structure by [dragging and dropping](https://en.wikipedia.org/wiki/Drag_and_drop) fields graphically. This "rotation" or pivoting of the summary table gives the concept its name. (Wikipedia)

**Differentiation:**

* The questions on the student handout are scaffolded to meet the needs of students who may need extra support.
* Eliminating some of the added questions, and just posing the questions from the video would be a possible differentiation strategy for students who do not need the extra support.
* Students may also benefit by working with others as part of a partner/group investigation.

**Part 1: (0:00 – 0:55)**

BREAK 1

* Have students brainstorm answers to the following questions:
  1. What types of situations cause machine “downtime”
  2. What kinds of data could be gathered about these downtime situations?
  3. How could it be collected?
  4. How could it be organized and displayed?
* Have students use part one of student handout to document their discussion.
* Share ideas whole group

**Part 2: (0:58 – 2:27)**

BREAK 2

* Revisit the downtime situations that the students discussed. Do they match the situations Andy investigated ( see labels on graph in video and on Excel data sheet provided)
* 100 color changes that total 5,991 minutes of downtime
* 8 machine breakdowns that total 3,225 minutes of downtime
* Use the data given above and the student handout to discuss unit rates, calculate them and determine which unit rate would be most useful (color changes per minute or minutes per color change and breakdowns per minute or minutes per breakdown)
* Compare and contrast the differences in downtime minutes and the differences in the unit rates.

**Part 3: (2:30 –** **3:23)**

BREAK 3

* Downtime is one concern for manufacturers. Scrap, or waste material is also a concern. Tables help us organizing the data we collect. We saw that graphs are useful tools to help us analyze large amounts of collected data like the downtime minutes. We also may want our data to be sorted and put into a different table depending on certain characteristics. Andy used a pivot table to do just that with the scrap data.
* Students are asked to state the definition of pivot table in their own words on the student handout.

**Part 4: (3:26 – 4:43)**

BREAK 4

* What is the financial impact of machine downtime? We know that color changes cause the most machine downtime.
* We will investigate the “real cost” of a color change. Students will need to use their unit rate for color change from #6 to help solve the cost of Labor and Overhead. **There are two color change overs per run.**
  + Labor and Overhead - $70/**HOUR**
  + Cost of wasted polypropylene - $0.91/lb. (100 lb. needed)
  + Cost of purging compound - $3.50/lb. (25 lb. needed)
  + Cost of scrap seats - $35.45
  + Cost of scrap backs -- $28.00
* Students will calculate the total cost on the student handout.
* Before showing Part 5 have students share their answers and problems solving methods.

**Part 5: (4:48 – 6:31)**

* Discuss any errors or misconceptions in student thinking and calculations.

**Extension:**

* Using the total minutes for each category as your data set, have students determine if the color change downtime is an outlier using the 1.5 x IQR rule.
* Using the total minutes as your data set, what is the z-score of the color change downtime minutes? Interpret your result in context.
* Brainstorm ways to reduce the cost of downtime.

**Student Handout - *What does injection molding have to do with math?***  Name(s):

**Pre-Video Discussion:**  *Notes on important background information.*

**Problem:** *How can we collect, display, interpret, and use data to reduce machine downtime?*

**Break 1:**

1. What types of situations cause machine “downtime”
2. What kinds of data could be gathered about these downtime situations?
3. How could it be collected?
4. How could it be organized and displayed?

**Break 2:**

* 100 color changes that total 5,991 minutes of downtime.
* 8 machine breakdowns that total 3,225 minutes of downtime

1. What is the difference in the number of color change minutes of downtime and the number of machine breakdown minutes of downtime?
2. Using the color change data, calculate and interpret both unit rates. Which one is the most useful in this problem situation?
3. Using the machine breakdown data, calculate and interpret both unit rates. Which one is the most useful in this problem situation?
4. Changing the color of the polypropylene being injected into the mold caused more total minutes of downtime, but the unit rates tell us something else about the downtime. What information do the unit rates tell us?

**Break 3:**

1. Find a definition for *Pivot Table*. Restate the definition in your own words.

**Break 4:**

1. Using the information given in the video, complete the table below. What is the final dollar amount that a color change “costs” KI

|  |  |  |  |
| --- | --- | --- | --- |
| **Color Change Downtime Items** | **Cost** | **Calculations** | **Total Cost** |
| **Labor and Overhead** |  |  |  |
| **Polypropylene** |  |  |  |
| **Purging Compound** |  |  |  |
| **Scrap Seats** |  |  |  |
| **Scrap Backs** |  |  |  |
|  | | |  |

**Break 5:**

1. Pretend that you have been asked to share your cost analysis results with the KI production team. Write a short paragraph explaining your answer to #10.

**ANSWER KEY – What does injection molding have to do with math?**

**Break 1:**

1. What types of situations cause machine “downtime”

**Answers Vary**

1. What kinds of data could be gathered about these downtime situations?

**Answers Vary**

1. How could it be collected?

**Answers Vary**

1. How could it be organized and displayed?

**Answers Vary**

**Break 2:**

* 100 color changes that total 5,991 minutes of downtime.
* 8 machine breakdowns that total 3,225 minutes of downtime

1. What is the difference in the number of color change minutes of downtime and the number of machine breakdown minutes of downtime?

**5991 – 3225 = 2766 more minutes of downtime due to color changes**

1. Using the color change data, calculate and interpret both unit rates. Which one is the most useful in this problem situation?

**5991 min / 100 color changes = 59.91 min per color change**

**100 color changes / 5991 minutes = 0.0167 color changes per minute**

**The number of minutes per color change**

1. Using the machine breakdown data, calculate and interpret both unit rates. Which one is the most useful in this problem situation?

**3225 min / 8 machine breakdowns = 403.125 min per machine breakdown**

**8 machine breakdowns / 3225 minutes = 0.0025 breakdowns per minute**

**The number of minutes per breakdown**

1. Changing the color of the polypropylene being injected into the mold caused more total minutes of downtime, but the unit rates tell us something else about the downtime. What information do the unit rates tell us?

**While the total downtime minutes is greater for color changes, the unit rates tell us that machine breakdowns cause the machine to be down for a longer time span while being repaired.**

**Break 3:**

1. Find a definition for *Pivot Table*. Restate the definition in your own words.

**Answers Vary**

**Break 4:**

1. Using the information given in the video, complete the table below. What is the final dollar amount that a color change “costs” KI

|  |  |  |  |
| --- | --- | --- | --- |
| **Color Change Downtime Items** | **Cost** | **Calculations** | **Total Cost** |
| **Labor and Overhead** | ***$70/hr.*** | ***59.91 min / 60 min per hour = 0.999 hours***  ***$70 x 0.999 = $69.93***  ***$69.93 x 2 changeovers*** | ***$139.86*** |
| **Polypropylene** | ***$0.91/lb.*** | ***$0.91 x 100 = $91.00***  ***$91.00 x 2*** | ***$182.00*** |
| **Purging Compound** | ***$3.50/lb.*** | ***$3.50 x 25 = $87.50***  ***$87.50 x 2*** | ***$175.00*** |
| **Scrap Seats** | ***$35.45*** |  | ***$35.45*** |
| **Scrap Backs** | ***$28.00*** |  | ***$28.00*** |
|  | | | $560.31 |

**Break 5:**

1. Pretend that you have been asked to share your cost analysis results with the KI production team. Write a short paragraph explaining your answer to #10.

**Answers Vary**