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Data Article

Dataset of the temperature rise during granular flows in a rotating drum

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ABSTRACT

This paper provides experimental data on the temperature rise during granular flows in a small-scale rotating drum due to heat generation. All heat is believed to be generated by conversion of some mechanical energy, through mechanisms such as friction and collisions between particles and between particles and walls. Particles of different material types were used, while multiple rotation speeds were considered, and the drum was filled with different amounts of particles. The temperature of the granular materials inside the rotating drum was monitored using a thermal camera. The temperature increases at specific times of each experiment are presented in form of tables, along with the average and standard deviation of the repetitions of each setup configuration. The data can be used as a reference to set the operating conditions of rotating drums, in addition to calibrating numerical models and validating computer simulations.

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Specifications Table

Subject	Chemical Engineering: Process Chemistry and Technology
Specific subject area	Thermal behaviour of granular flows in rotating drums
Type of data	Tables
How the data were acquired	The temperature of the granular materials inside the rotating drum was measured using a thermal camera (FLIR A700-EST – Teledyne Flir LLC, Wilsonville, Oregon, USA). A small region of interest was chosen using the camera's web interface for thermal image analysis, and the mean temperature inside this region was taken as representative of the flow.
Data format	Raw and analyzed data
Description of data collection	In each experiment, the temperature rise during the granular flow, with respect to the initial (room) temperature, was measured every 5 minutes, for a total of 30 minutes. Monodisperse spherical particles of 4 different materials were used, 3 rotation speeds were considered, and the drum was filled with 3 different amounts of particles.
Data source location	Institution: University of Surrey City/Town/Region: Guildford, Surrey Country: United Kingdom
Data accessibility	Repository name: Zenodo Data identification number (DOI): 10.5281/zenodo.7930954 Direct URL to data: https://zenodo.org/record/7930954#.ZGH2VHZByUl Data is also provided with the article.
Related research article	R.L. Rangel, F. Kisuka, C. Hare, V. Vivacqua, A. Franci, E. Oñate, C.Y. Wu, Experimental investigation of heat generation during granular flow in a rotating drum using infrared thermography, Powder Technology, 426 (2023), 118619. 10.1016/j.powtec.2023.118619

Value of the Data

- The data assess the relevance of heat generation by energy dissipation during granular flows in rotating drums and provide information on how the temperature rise of the granular materials depends on the material type of particles and the operating conditions of the drum (i.e. the rotation speed and the fill ratio).
- Chemical process engineers who work on industrial processes such as mixing, drying, granulation and milling can benefit from the data. The data can also be used by researchers and scientists who develop computer codes for numerical simulation.
- The data can be used to set the operating conditions of rotating drums when temperature rises should be avoided, as well as to numerical models of heat generation and to validate computational simulations of the thermal behavior of granular flows in rotating drums.

1. Objective

The heat generated from conversion of mechanical energy in granular media, through friction and collisions between particles and between particles and walls, leads to an increase in temperature. A typical situation where this can occur is granular flow in rotating drums, which are common ly used in several industrial applications. However, the relevance of the temperature increase due to heat generation in these applications is still unclear, as is the sensibility of temperature increase to the type of particle material and the operating conditions of the drum, such as rotation speed and fill ratio. Therefore, experiments were carried out focusing on heat generation in a small-scale rotating drum to quantify the temperature rise by varying the aforementioned parameters. It is also intended to generate experimental data to support computational simulations. This paper extends its related research work [1] by providing the raw and analyzed data of all experiments performed.

2. Data Description

A total of 36 sets of experiements were performed by combining 4 materials for the particles, 3 drum rotation speeds, and 3 particle fill levels. Each of these experiments was repeated 5 times, totaling 180 runs. In each run, the temperature rise during granular flow inside the drum was measured with respect to the initial temperature of the particles, which was the same as the room temperature. This measurement was performed every 5 minutes, and the total duration of each experiment was set as 30 minutes. Tables 1-36 provide the change in temperature at specific times for the 5 repeated runs of each setup configuration. The average value and standard deviation of the temperature rises of the 5 repeats are also given in these tables.

Table 1
Temperature rises for 400 plastic particles at a drum rotation speed of 15 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.1	0.0	0.0	0.1	0.0	0.04	0.05
10	0.1	0.1	0.2	0.1	0.1	0.12	0.04
15	0.2	0.1	0.2	0.2	0.1	0.16	0.05
20	0.2	0.2	0.3	0.2	0.1	0.20	0.07
25	0.2	0.2	0.4	0.2	0.2	0.24	0.09
30	0.2	0.2	0.4	0.3	0.2	0.26	0.09

Table 2
Temperature rises for 400 plastic particles at a drum rotation speed of 35 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.1	0.2	0.1	0.1	0.1	0.12	0.04
10	0.2	0.2	0.2	0.2	0.1	0.18	0.04
15	0.3	0.3	0.4	0.2	0.2	0.28	0.08
20	0.4	0.4	0.5	0.3	0.3	0.38	0.08
25	0.4	0.5	0.6	0.3	0.4	0.44	0.11
30	0.5	0.6	0.7	0.4	0.4	0.52	0.13

Table 3
Temperature rises for 400 plastic particles at a drum rotation speed of 55 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.2	0.2	0.1	0.2	0.2	0.18	0.04
10	0.3	0.2	0.3	0.3	0.3	0.28	0.04
15	0.4	0.4	0.5	0.5	0.5	0.46	0.05
20	0.6	0.5	0.7	0.6	0.6	0.60	0.07
25	0.7	0.6	0.9	0.7	0.7	0.72	0.11
30	0.8	0.7	1.0	0.8	0.9	0.84	0.11

Table 4
Temperature rises for 600 plastic particles at a rotational speed of 15 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.1	0.1	0.1	0.1	0.0	0.08	0.04
10	0.2	0.2	0.1	0.1	0.1	0.14	0.05
15	0.3	0.2	0.2	0.1	0.2	0.20	0.07
20	0.3	0.3	0.2	0.2	0.2	0.24	0.05
25	0.4	0.3	0.2	0.2	0.2	0.26	0.09
30	0.4	0.3	0.3	0.2	0.2	0.28	0.08

Table 5
Temperature rises for 600 plastic particles at a drum rotation speed of 35 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.2	0.2	0.1	0.1	0.1	0.14	0.05
10	0.3	0.3	0.2	0.2	0.2	0.24	0.05
15	0.5	0.4	0.4	0.3	0.3	0.38	0.08
20	0.6	0.4	0.5	0.4	0.4	0.46	0.09
25	0.8	0.4	0.6	0.5	0.4	0.54	0.17
30	0.9	0.5	0.6	0.5	0.5	0.60	0.17

Table 6
Temperature rises for 600 plastic particles at a drum rotation speed of 55 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.2	0.2	0.1	0.2	0.2	0.18	0.04
10	0.4	0.5	0.3	0.3	0.4	0.38	0.08
15	0.6	0.6	0.5	0.5	0.6	0.56	0.05
20	0.8	0.8	0.6	0.7	0.7	0.72	0.08
25	0.9	0.9	0.7	0.9	0.8	0.84	0.09
30	0.9	1.1	0.8	1.1	0.9	0.96	0.13

Table 7
Temperature rises for 800 plastic particles at a drum rotation speed of 15 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.2	0.0	0.1	0.1	0.1	0.10	0.07
10	0.2	0.1	0.2	0.2	0.1	0.16	0.05
15	0.3	0.1	0.2	0.2	0.3	0.22	0.08
20	0.5	0.1	0.3	0.3	0.3	0.30	0.14
25	0.6	0.2	0.3	0.3	0.3	0.34	0.15
30	0.6	0.2	0.3	0.4	0.3	0.36	0.15

Table 8
Temperature rises for 800 plastic particles at a drum rotation speed of 35 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.1	0.1	0.1	0.2	0.1	0.12	0.04
10	0.2	0.3	0.4	0.3	0.2	0.28	0.08
15	0.3	0.3	0.5	0.3	0.4	0.36	0.09
20	0.4	0.4	0.5	0.5	0.4	0.44	0.05
25	0.6	0.6	0.6	0.6	0.4	0.56	0.09
30	0.7	0.8	0.6	0.7	0.5	0.66	0.11

Table 9
Temperature rises for 800 plastic particles at a drum rotation speed of 55 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.2	0.1	0.2	0.2	0.2	0.18	0.04
10	0.4	0.3	0.4	0.3	0.5	0.38	0.08
15	0.7	0.4	0.5	0.4	0.7	0.54	0.15
20	0.9	0.5	0.6	0.6	0.8	0.68	0.16
25	1.1	0.7	0.8	0.7	0.9	0.84	0.17
30	1.2	0.8	0.9	0.8	1.1	0.96	0.18

Table 10
Temperature rises for 400 glass particles at a drum rotation speed of 15 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.1	0.1	0.1	0.0	0.1	0.08	0.04
10	0.2	0.1	0.1	0.1	0.1	0.12	0.04
15	0.2	0.2	0.2	0.1	0.2	0.18	0.04
20	0.2	0.2	0.3	0.2	0.2	0.22	0.04
25	0.2	0.3	0.3	0.2	0.2	0.24	0.05
30	0.2	0.3	0.3	0.3	0.2	0.26	0.05

Table 11
Temperature rises for 400 glass particles at a drum rotation speed of 35 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.1	0.2	0.1	0.2	0.1	0.14	0.05
10	0.2	0.3	0.3	0.2	0.3	0.26	0.05
15	0.2	0.5	0.4	0.3	0.5	0.38	0.13
20	0.4	0.6	0.4	0.5	0.6	0.50	0.10
25	0.6	0.7	0.5	0.6	0.7	0.62	0.08
30	0.7	0.9	0.6	0.7	0.7	0.72	0.11

Table 12
Temperature rises for 400 glass particles at a drum rotation speed of 55 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.1	0.2	0.2	0.2	0.2	0.18	0.04
10	0.3	0.3	0.4	0.4	0.4	0.36	0.05
15	0.4	0.5	0.5	0.5	0.7	0.52	0.11
20	0.6	0.7	0.6	0.6	0.9	0.68	0.13
25	0.7	0.9	0.8	0.7	1.1	0.84	0.17
30	0.8	1.0	1.0	0.8	1.2	0.96	0.17

Table 13
Temperature rises for 600 glass particles at a drum rotation speed of 15 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.2	0.1	0.1	0.2	0.1	0.14	0.05
10	0.2	0.2	0.2	0.2	0.2	0.20	0.00
15	0.3	0.2	0.2	0.3	0.3	0.26	0.05
20	0.3	0.3	0.3	0.4	0.3	0.32	0.04
25	0.3	0.3	0.3	0.4	0.4	0.34	0.05
30	0.4	0.3	0.4	0.5	0.4	0.40	0.07

Table 14
Temperature rises for 600 glass particles at a drum rotation speed of 35 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.2	0.3	0.3	0.3	0.2	0.26	0.05
10	0.4	0.4	0.4	0.5	0.3	0.40	0.07
15	0.5	0.5	0.5	0.6	0.4	0.50	0.07
20	0.6	0.7	0.7	0.9	0.5	0.68	0.15
25	0.7	0.8	0.7	1.1	0.6	0.78	0.19
30	0.8	1.1	0.9	1.2	0.6	0.92	0.24

Table 15
Temperature rises for 600 glass particles at a drum rotation speed of 55 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.2	0.2	0.3	0.3	0.2	0.24	0.05
10	0.5	0.4	0.4	0.4	0.4	0.42	0.04
15	0.6	0.8	0.6	0.6	0.6	0.64	0.09
20	0.7	1.0	0.8	0.8	0.7	0.80	0.12
25	0.8	1.1	0.9	0.9	0.9	0.92	0.11
30	0.9	1.1	1.0	1.0	1.0	1.00	0.07

Table 16
Temperature rises for 800 glass particles at a drum rotation speed of 15 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.1	0.2	0.2	0.1	0.2	0.16	0.05
10	0.1	0.3	0.3	0.2	0.3	0.24	0.09
15	0.2	0.4	0.5	0.4	0.3	0.36	0.11
20	0.3	0.4	0.6	0.4	0.4	0.42	0.11
25	0.3	0.5	0.6	0.4	0.4	0.44	0.11
30	0.4	0.5	0.7	0.4	0.4	0.48	0.13

Table 17
Temperature rises for 800 glass particles at a drum rotation speed of 35 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.2	0.2	0.3	0.3	0.3	0.26	0.05
10	0.5	0.4	0.6	0.4	0.4	0.46	0.09
15	0.6	0.8	0.7	0.4	0.4	0.58	0.18
20	0.7	0.8	0.8	0.5	0.6	0.68	0.13
25	0.8	1.0	0.9	0.6	0.8	0.82	0.15
30	1.0	1.1	1.0	0.7	0.9	0.94	0.15

Table 18
Temperature rises for 800 glass particles at a drum rotation speed of 55 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.4	0.4	0.3	0.3	0.3	0.34	0.05
10	0.6	0.6	0.3	0.4	0.5	0.48	0.13
15	0.9	1.0	0.6	0.6	0.7	0.76	0.18
20	1.1	1.3	0.8	0.7	0.9	0.96	0.24
25	1.3	1.5	0.9	0.9	1.0	1.12	0.27
30	1.5	1.6	1.0	1.1	1.2	1.28	0.26

Table 19
Temperature rises for 400 steel particles at a drum rotation speed of 15 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.3	0.4	0.4	0.4	0.4	0.38	0.04
10	0.6	0.6	0.5	0.8	0.7	0.64	0.11
15	0.8	0.8	0.8	0.9	0.9	0.84	0.05
20	0.9	0.9	1.1	1.1	1.1	1.02	0.11
25	1.0	1.1	1.2	1.2	1.3	1.16	0.11
30	1.1	1.2	1.3	1.2	1.3	1.22	0.08

Table 20
Temperature rises for 400 steel particles at a drum rotation speed of 35 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.7	0.8	1.0	0.9	0.9	0.86	0.11
10	1.3	1.6	1.4	1.3	1.4	1.40	0.12
15	1.9	2.0	1.9	1.8	1.7	1.86	0.11
20	2.0	2.3	2.4	2.1	1.9	2.14	0.21
25	2.2	2.5	2.6	2.3	2.2	2.36	0.18
30	2.3	2.5	2.8	2.4	2.3	2.46	0.21

Table 21
Temperature rises for 400 steel particles at a drum rotation speed of 55 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	1.0	1.1	0.9	1.1	1.3	1.08	0.15
10	1.8	1.8	1.7	1.9	2.0	1.84	0.11
15	2.3	2.3	2.1	2.3	2.8	2.36	0.26
20	2.7	2.7	2.5	2.6	3.1	2.72	0.23
25	2.9	3.0	2.8	2.9	3.4	3.00	0.23
30	3.1	3.2	3.0	3.2	3.5	3.20	0.19

Table 22
Temperature rises for 600 steel particles at a drum rotation speed of 15 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.3	0.3	0.4	0.4	0.3	0.34	0.05
10	0.6	0.6	0.7	0.7	0.6	0.64	0.05
15	0.7	0.8	1.0	1.0	0.9	0.88	0.13
20	0.8	1.0	1.2	1.1	1.0	1.02	0.15
25	1.0	1.2	1.2	1.2	1.1	1.14	0.09
30	1.2	1.4	1.3	1.3	1.2	1.28	0.08

Table 23
Temperature rises for 600 steel particles at a drum rotation speed of 35 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.8	0.7	0.9	1.0	0.9	0.86	0.11
10	1.3	1.3	1.5	1.6	1.4	1.42	0.13
15	1.8	1.7	2.0	1.9	1.8	1.84	0.11
20	2.3	2.1	2.3	2.4	2.1	2.24	0.13
25	2.5	2.6	2.7	2.6	2.5	2.58	0.08
30	2.8	2.7	3.0	2.9	2.8	2.84	0.11

Table 24
Temperature rises for 600 steel particles at a drum rotation speed of 55 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	1.1	1.2	0.8	1.1	1.2	1.08	0.16
10	1.9	2.0	1.4	1.8	2.0	1.82	0.25
15	2.7	2.6	2.1	2.5	2.5	2.48	0.23
20	3.0	3.0	2.5	2.9	2.9	2.86	0.21
25	3.4	3.3	2.9	3.2	3.0	3.16	0.21
30	3.8	3.6	3.1	3.4	3.2	3.42	0.29

Table 25
Temperature rises for 800 steel particles at a drum rotation speed of 15 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.3	0.3	0.3	0.4	0.4	0.34	0.05
10	0.5	0.8	0.6	0.7	0.6	0.64	0.11
15	0.8	1.0	0.9	0.9	0.9	0.90	0.07
20	0.9	1.1	1.1	1.2	1.1	1.08	0.11
25	1.0	1.2	1.3	1.3	1.2	1.20	0.12
30	1.3	1.4	1.4	1.4	1.3	1.36	0.05

Table 26
Temperature rises for 800 steel particles at a drum rotation speed of 35 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.8	0.9	0.8	0.9	0.9	0.86	0.05
10	1.5	1.5	1.9	1.5	1.6	1.60	0.17
15	2.1	2.1	2.2	2.1	2.2	2.14	0.05
20	2.4	2.5	2.6	2.4	2.5	2.48	0.08
25	2.7	2.9	3.1	2.9	2.9	2.90	0.14
30	3.3	3.3	3.4	3.1	3.3	3.28	0.11

Table 27
Temperature rises for 800 steel particles at a drum rotation speed of 55 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	1.3	1.3	1.2	1.0	1.2	1.20	0.12
10	1.9	2.1	2.0	1.8	2.1	1.98	0.13
15	2.4	3.1	2.5	2.3	2.7	2.60	0.32
20	3.0	3.5	3.1	2.8	3.2	3.12	0.26
25	3.6	4.0	3.5	3.3	3.7	3.62	0.26
30	4.1	4.4	3.9	3.6	4.1	4.02	0.29

Table 28
Temperature rises for 400 lead particles at a drum rotation speed of 15 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	0.8	0.9	0.9	0.8	0.9	0.86	0.05
10	1.0	1.1	1.2	1.0	1.2	1.10	0.10
15	1.1	1.3	1.4	1.1	1.4	1.26	0.15
20	1.2	1.4	1.5	1.2	1.5	1.36	0.15
25	1.2	1.6	1.5	1.3	1.7	1.46	0.21
30	1.3	1.7	1.6	1.3	1.7	1.52	0.20

Table 29
Temperature rises for 400 lead particles at a drum rotation speed of 35 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	1.8	1.7	1.8	1.7	1.8	1.76	0.05
10	2.5	2.2	2.3	2.2	2.5	2.34	0.15
15	2.8	2.6	2.6	2.6	2.8	2.68	0.11
20	3.0	2.7	2.9	2.7	3.0	2.86	0.15
25	3.1	2.9	3.1	2.9	3.2	3.04	0.13
30	3.3	3.1	3.2	3.1	3.3	3.20	0.10

Table 30
Temperature rises for 400 lead particles at a drum rotation speed of 55 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	2.7	2.5	2.4	2.4	2.7	2.54	0.15
10	3.3	3.4	3.1	3.1	3.4	3.26	0.15
15	3.8	3.8	3.7	3.7	3.8	3.76	0.05
20	4.3	4.2	4.1	4.1	4.3	4.20	0.10
25	4.6	4.6	4.3	4.3	4.7	4.50	0.19
30	4.9	4.9	4.7	4.7	5.0	4.84	0.13

Table 31
Temperature rises for 600 lead particles at a drum rotation speed of 15 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	1.1	0.9	1.0	0.8	1.1	0.98	0.13
10	1.3	1.3	1.2	1.2	1.4	1.28	0.08
15	1.4	1.4	1.3	1.4	1.5	1.40	0.07
20	1.6	1.5	1.5	1.6	1.7	1.58	0.08
25	1.7	1.6	1.6	1.8	1.8	1.70	0.10
30	1.8	1.6	1.7	1.8	1.9	1.76	0.11

Table 32
Temperature rises for 600 lead particles at a drum rotation speed of 35 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	2.0	2.1	2.1	2.3	1.9	2.08	0.15
10	2.8	2.9	2.8	3.0	2.7	2.84	0.11
15	3.3	3.5	3.3	3.6	3.2	3.38	0.16
20	3.6	3.9	3.8	4.0	3.5	3.76	0.21
25	3.9	4.2	4.1	4.3	3.8	4.06	0.21
30	4.0	4.4	4.3	4.5	4.0	4.24	0.23

Table 33
Temperature rises for 600 lead particles at a drum rotation speed of 55 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	2.6	2.7	2.6	2.5	2.8	2.64	0.11
10	3.4	3.3	3.4	3.2	3.6	3.38	0.15
15	3.9	3.8	3.9	3.7	4.1	3.88	0.15
20	4.2	4.2	4.4	4.1	4.5	4.28	0.16
25	4.5	4.4	4.7	4.4	4.8	4.56	0.18
30	4.8	4.7	5.1	4.6	5.2	4.88	0.26

Table 34
Temperature rises for 800 lead particles at a drum rotation speed of 15 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	1.0	0.8	1.0	1.1	0.8	0.94	0.13
10	1.4	1.2	1.3	1.4	1.2	1.30	0.10
15	1.5	1.4	1.5	1.6	1.4	1.48	0.08
20	1.7	1.6	1.6	1.8	1.5	1.64	0.11
25	1.8	1.7	1.8	2.0	1.6	1.78	0.15
30	1.9	1.8	1.9	2.0	1.8	1.88	0.08

Table 35
Temperature rises for 800 lead particles at a drum rotation speed of 35 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	2.1	2.3	2.2	2.1	2.3	2.20	0.10
10	3.0	3.2	3.1	3.0	3.2	3.10	0.10
15	3.6	3.8	3.6	3.5	3.9	3.68	0.16
20	3.8	4.3	3.9	3.7	4.3	4.00	0.28
25	4.1	4.5	4.2	4.1	4.5	4.28	0.20
30	4.2	4.7	4.5	4.2	4.8	4.48	0.28

Table 36
Temperature rises for 800 lead particles at a drum rotation speed of 55 rpm.

	Temperature rise (K)						
Time (min)	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Average (K)	Std. deviation
0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
5	2.8	2.6	2.6	2.8	2.6	2.68	0.11
10	3.4	3.3	3.4	3.5	3.3	3.38	0.08
15	4.0	3.8	4.0	4.1	3.8	3.94	0.13
20	4.3	4.2	4.4	4.4	4.2	4.30	0.10
25	4.5	4.6	4.7	4.8	4.5	4.62	0.13
30	4.9	4.9	5.0	5.1	4.8	4.94	0.11

The dataset is also publicly available in an online repository [2], where the datasets are separated into 4 *.xlsl* files, one for each material, as indicated in the file name. Each file has 3 tabs, one for each fill level considered (i.e. number of particles used). Each file tab, in turn, contains 3 tables, one for each drum rotation speed.

3. Experimental Design, Materials and Methods

3.1. Setup Configurations Tested

- Particle materials: Polyoxymethylene (POM) acetal plastic, soda-lime glass type S, 420 stainless steel, and lead.
- Drum rotation speeds: 15 rpm, 35 rpm, and 55 rpm.
- Number of particles to fill the drum: 400, 600, and 800.

3.2. Rotating Drum Specifications

The drum was positioned horizontally above two free-rotating cylinders connected to a motor.

- Inner diameter: 250 mm.
- Depth: 12.7 mm.
- Rear wall material: Acrylic plastic.
- Front wall material: Metallic mesh with a grid size of 420 μm (the same mesh used in granulometry sieve no. 40).
- Circumferential wall material: Wood coated with sandpaper on the inner face.

3.3. Thermal Camera Specifications

The camera was positioned at a distance of 1.0 m from the front face of the drum.

- Model: FLIR A700-EST (Teledyne Flir LLC, Wilsonville, Oregon, United States).
- Lens: 24º.
- Resolution: 640 $\times$ 480 pixel.
- Thermal sensitivity: $\leq$ 40 mK.
- Accuracy: $\pm$ 0.3 K.

3.4. Particle Properties

Monodisperse spherical particles, approximately 6.3 mm in diameter, of a single material were used in each experimental test. In total, four different material types were employed during experiments: plastic, glass, steel, and lead. These materials can be considered non-porous and non-cohesive, and their thermomechanical properties (i.e. Young's modulus, density, heat capacity and thermal conductivity) were obtained from online databases [3–6]. The emissivity of the particle bed of each material was measured following the procedure described below.

3.5. Thermal Image Parameters

The two parameters that need to be set in the thermal camera settings to make accurate temperature measurements are the reflected apparent temperature of the setup and the emissivity of the target (in this case, the particles). They were determined as described below.

- Reflected apparent temperature of the setup: The *reflector method* was employed as specified in ISO 18434-1:2008 [7]. With the setup prepared for the experiments, this method starts by setting the target emissivity and distance to 1.0 and 0.0, respectively, in the camera settings. Then, a crumpled and re-flattened piece of aluminum foil is used to cover the front wall of the drum with the shiny side facing the camera. From the camera's web interface, a region of interest is drawn inside the area covered by the aluminum foil (the same region used to measure the temperature of the granular flow during experiments). The mean temperature of this region is the reflected apparent temperature of the setup. This value, as well as the correct values of the target emissivity (determined as described in the method below) and distance, must be specified in the camera settings and the aluminum foil must be removed from the front of the drum before running experiments. This procedure of determining the reflected apparent temperature was repeated once a day, before running the experiments.
- Emissivity of particles: The *reference emissivity material method* was employed as specified in ISO 18434-1:2008 [7]. In this method, the particles are heated to a known constant temperature. This was done by laying the particles on a hot plate, which is used to control the temperature of the particles. A thermometer was also used to measure the temperature of the particles and ensure that the desired value was reached. At this point, the reflected apparent temperature for this setup should have been properly determined and set in the thermal camera settings, according to the method described above. Then, from the camera's web interface, a region of interest, the same size as the region used to measure the temperature of the granular flow during experiments, is drawn over an area covered by particles and its temperature is read. The target emissivity in the camera settings is adjusted until the indicated temperature for the region of interest is the same as the real temperature of the particles measured with the thermometer. This emissivity value is the raw emissivity of the particle surfaces. In addition, an adjusted emissivity was estimated to account for the presence of the metallic mesh that covers the particles inside the drum during the experiments. This was done in a similar way to the estimation of the raw emissivity, but placing the metallic mesh above, and in contact with, the particles. These procedures of estimating both raw and adjusted emissivity values were performed once for each of the four particle materials. Different temperature values, from the room temperature (18°C) to 40°C, were used to heat the particles and ensure that the estimated emissivity values are constant for the temperature range considered in this work.

3.6. Data Acquisition Methodology

During the experiments, a small rectangular region of interest was defined, using the thermal camera's web interface, within an area of the flow that is constantly covered by particles. The mean value of the temperature inside the region of interest was recorded right after the periodic calibration of the camera, which was automatically carried out every 5 minutes. This value was considered to be the average temperature of the particle flow inside the drum.

Ethics Statements

The authors declare that this work meets the ethical requirements for publication in Data in Brief and that it did not involve human subjects, animal experiments, or any data collected from social media platforms.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Dataset of the temperature rise during granular flows in a rotating drum (Original data) (Zenodo).

CRediT Author Statement

Rafael L. Rangel: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing – original draft; **Francisco Kisuka:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing – review & editing; **Colin Hare:** Conceptualization, Writing – review & editing, Supervision; **Vincenzino Vivacqua:** Conceptualization, Writing – review & editing, Supervision; **Alessandro Franci:** Writing – review & editing, Supervision; **Eugenio Oñate:** Writing – review & editing, Supervision; **Chuan-Yu Wu:** Methodology, Resources, Writing – review & editing, Supervision, Project administration, Funding acquisition.

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