Lion Corporation

Effective ventilation for quickly drying wet laundry indoors by hanging clothes in an arch on square hangers (published on *Lidea*)

Cradle CFD
Case study interview

Using many different media, the Lion Corporation delivers useful tips and advice about how to effectively use everyday household and health care products for better living. scSTREAM is used for fluid analyses to improve the reliability and quality of the information communicated. Using scSTREAM capabilities to animate the results has made their recommendations more convincing.

今日を愛する。
LION

Lion Corporation

www.lion.co.jp/en/

Business founded	1891
Lion Corporation established	1918
Head office	Sumida-ku, Tokyo, Japan
Representative	Itsuo Hama (President)
Number of employees	6,816 (consolidated) [as of December 31, 2015]
Businesses	The manufacture and sale of toothpastes, toothbrushes, soaps, cleansers, hair- and skin-care products, cooking-related products, and pharmaceuticals. Exports to overseas affiliates.

Picture 1:
Mr. Yoshifumi Yamagata (D.Eng),
Lion Corporation, Washing Specialist (Meister),
Textiles Evaluation Specialist

Managing a website to provide tips for better living

The Lion Corporation manufactures and sells toothpastes, toothbrushes, hair and skin care products, pharmaceutical products, cooking related products, and other household related products. Established in 1891, they celebrated their 125th anniversary in 2016. The Lion Corporation develops a wide range of products used for everyday living, which are incredibly popular among consumers in Japan.

The effectiveness of household products can be maximized when appropriate amounts are used in the most efficient ways. One example is washing clothes. Dirt will not be removed effectively if the proportion of laundry detergent, amount of clothes, and water are not appropriate. In addition to conventional sales methods, the Lion Corporation also provides customers with ways to use their products more efficiently, as well as advice on everyday household tasks. *Lidea* (**https://lidea.today/**) was launched in 2014, to offer useful articles designed to help solve customer everyday home-related problems and suggest improvements.

Lidea publishes articles written by 5 specialists (known as Meisters), which are categorized into cleaning, oral care, health care, and washing topics. Research is conducted at the company's living comfort laboratory and the findings are used to update the articles. Each specialist offers advice based on their expertise. Dr. Yoshifumi Yamagata, Washing and Textiles Evaluation Specialist from Lion Corporation, (Picture 1) is one of them.

Most effective drying layout of laundry validated by research data

A recent article on *Lidea* suggests the most effective way to hang wet laundry indoors is in an arch using square hangers. When the weather is not suited to hanging wet laundry outside, clothes are often dried indoors. When drying clothes indoors, a discomforting odor can be generated from insufficiently dried clothes. The odor is caused by bacteria growing in dirt that was not removed from the fabric during washing. As a solution, the Lion Corporation developed several small super-concentrated laundry detergents. This includes a bactericidal laundry detergent called Heyaboshi (Hang-to-Dry Indoors) TOP, which is designed to eliminate existing bacteria. A second product is an antibacterial washing powder Top HYGIA, which is designed to prevent bacteria from growing in the fabric. Top HYGIA was chosen as the Nikkei hit product rankings bestselling product of the year in 2012.

Even if the detergent is antibacterial or bactericidal, Dr. Yamagata stresses the need "to use the detergent properly and to dry the laundry sufficiently to maximize these effects." Test[1] results show that the wet smell is generated when wet laundry is not completely dried for five hours after being washed. This means that wet laundry must be dried within five hours.

Although evaluations have been undertaken to validate the most effective layout for drying wet laundry, Dr. Yamagata reveals that the data was not yet fully conclusive. They conducted tests to determine the effectiveness of three drying layouts using square hangers. They were: 1) arch layout, 2) in-turn layout, and 3) V-shape layout. The arch layout hangs wet laundry in an arch pattern, with long laundry hung at both ends and short laundry in the middle. The in-turn layout alternates long and short laundry. The V-shape layout hangs short laundry at both ends and long laundry in the middle. The tests were undertaken indoors at 25°C and 65% relative humidity. The time required to dry the wet laundry using the arch layout was 4 hours. It took 4.5 hours to dry the laundry using the V-shape layout. Drying time was even longer for the in-turn layout. This suggested that hanging laundry using an arch layout is the most effective among the tested layouts[2].

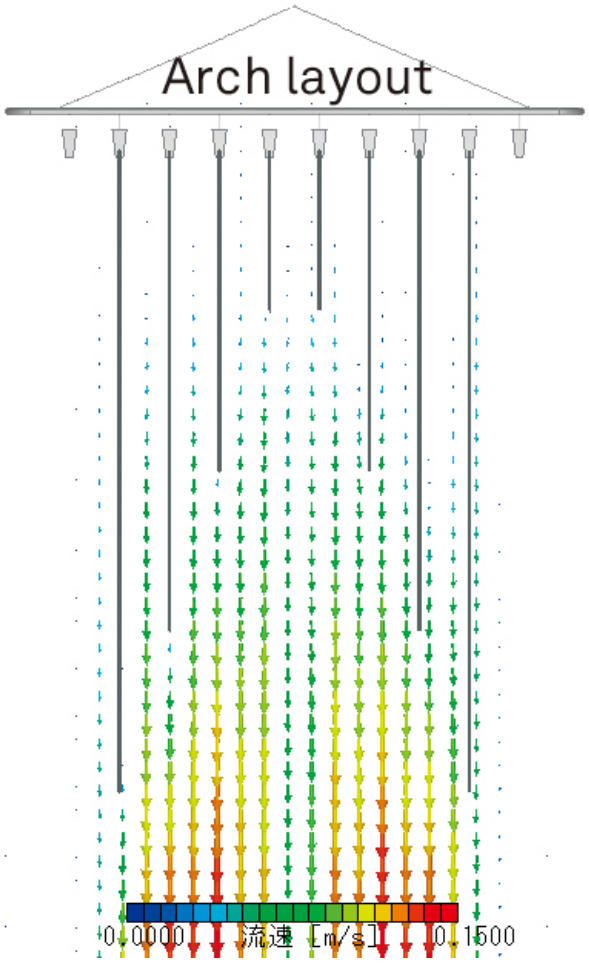

Figure 1: Velocity distribution when wet laundry is hanged in an arch. Transient analyses were performed using linear low-Reynolds number model

Unexpected findings from simulation results

Test results suggested that hanging wet laundry in an arch is the most effective among the tested drying layouts, but the explanation for why was unknown. Dr. Yamagata assumed the drying process involved updraft caused by stack effects. A block of air with a temperature higher than the surroundings rises upward due to its lower density. This is the same mechanism used when air in a chimney rises. Updraft from the collected vapor is created below the wet laundry when the wet laundry is hung in an arch. The updraft moves upward due to the lower density, which helps dry the wet laundry faster.

Dr. Yamagata had been searching to find an alternative means to validate why the arch layout appeared to be the most effective drying layout, other than undertaking more tests. This is when he came up with the idea of using simulations. Software Cradle was recommended by university researchers investigating airflow in indoor living spaces. Dr. Yamagata decided to consult Software Cradle for further help.

Having received a request from Dr. Yamagata, Software Cradle performed computational analyses using scSTREAM, and compared the analysis results with the test findings. As shown in Figure 1, the analysis results show that the drying process involves downdraft, and not updraft. The heat of vaporization created by vapor from the wet laundry cools the surrounding air. The cooled air is collected below the arched laundry, which creates downdraft (results shown in Figure 2).

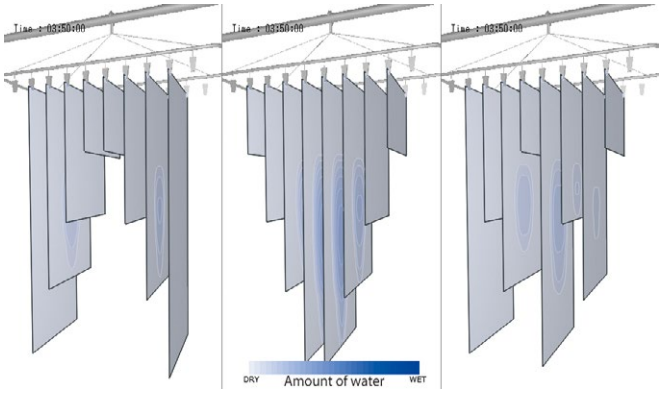

Figure 2: Analysis results of arch layout (left), V-shape layout (center), and in-turn layout (right)

Analyzing interior airflow

Dr. Yamagata has used scSTREAM to perform other analyses. Some of these include identifying the ideal places in a house for drying wet laundry, and validating the effectiveness of using a fan/humidifier to augment drying. Animations of the results have been posted on *Lidea*. Analysis results show that it is vital to hang wet laundry where air movement is the largest. As shown in Figure 3 - an animation of the computational results - the ideal places for hanging wet laundry can be easily identified using these visualization tools.

An important point to note, when using a clothes drying fan/humidifier, is to close the doors and windows in the room. If a dehumidifier is used, it should be located near the floor. “When we use air cooling fans, we often mount them horizontally to us. We also tend to locate the dehumidifier in the same way. But the most efficient way to dry laundry using a dehumidifier is to place it on floor,” says Dr. Yamagata. To validate the effectiveness of the location of the humidifier, a test was conducted at 25°C room temperature and 80% relative humidity. A dehumidifier was placed in two locations as shown in Figure 4. 150 minutes were needed to dry the clothes when the dehumidifier was located horizontally from the clothes. In comparison, only 120 minutes was needed when the dehumidifier was located below the laundry.

Picture 2: Top HYGIA, a small, super-concentrated anti-microbial liquid laundry detergent

More convincing findings and diverse applications

Dr. Yamagata notes that using scSTREAM for analysis enabled him to explain why wet laundry dries faster when hung using an arch layout. Visualization results to show the drying process also drew much attention. Articles posted on *Lidea* have been popular and shared on many curation websites, steadily increasing page views. “Page view patterns have demonstrated that it is more convincing to visually show the drying process rather than present analysis results using charts and graphs,” says Dr. Yamagata. The Lion Corporation has succeeded in solving potential end-users’ problems for everyday living topics. They’ve also improved product credibility by performing detailed computational analyses to validate product effectiveness. Visualizing results is not only appealing to the eyes, but is also more convincing when combined with logical explanations.

Dr. Yamagata also comments that simulation analysis results can be used in diverse ways. Animations can be used as promotional videos in stores. Animations also enabled them to identify how air flow patterns, and resulting drying effectiveness, are different depending on where the wet laundry is hung in the room.

At the same time, several challenges still remain. For example, the analyses did not account for how towels waver while being dried. Dr. Yamagata expects that the results will be more accurate if interaction effects between the air flow and towels are considered in the analyses.

To perform a drying analysis of towels, Dr. Yamagata used an scSTREAM function that enables release and transfer of water in an object. This is a special function available in scSTREAM, which is usually used when analyzing building materials that possess dehumidifying or moisturizing

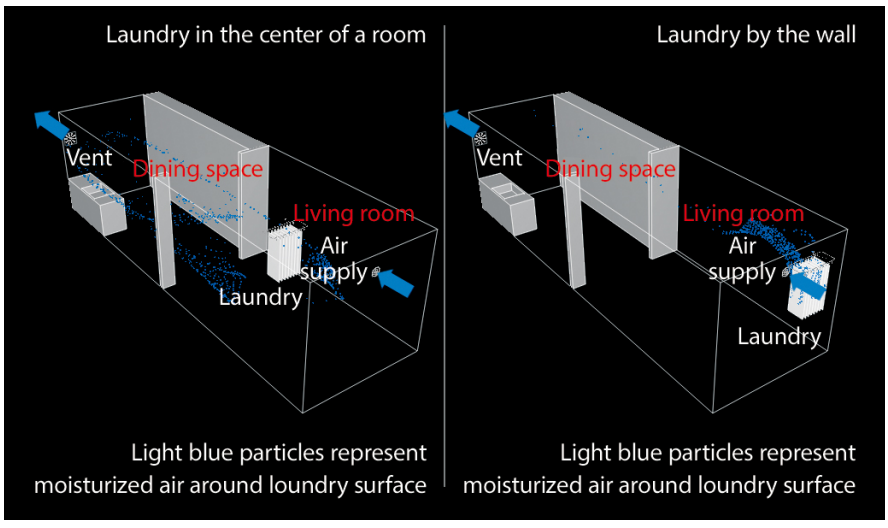

Figure 3: To quickly dry wet laundry indoors, identify the place where air movement is highest. Steady-state analysis was performed using linear low-Reynolds number model

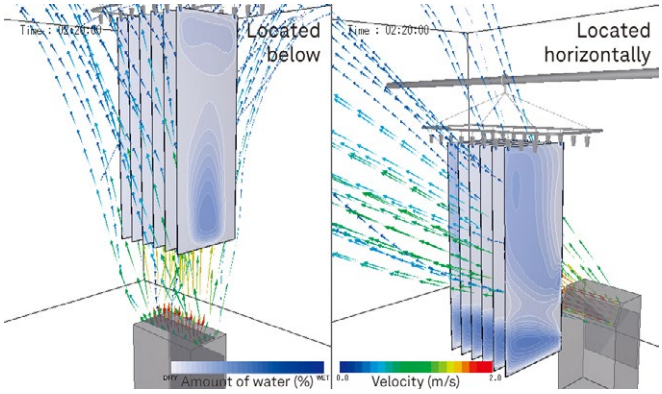

Figure 4: Wet laundry is being dried by dehumidifier. Transient analyses were performed using linear low-Reynolds number model

characteristics. For the towel analysis, pile surface resistance was considered. Performing computational analysis and using the test data to tune the models produced the best results.

Dr. Yamagata intended to commission Software Cradle for the Lion Corporation fluid analyses from the beginning. As a rheology specialist, Dr. Yamagata had experience performing polymer molecule simulations, but air flow simulations were beyond his expertise. A substantial amount of time and work would have been needed for him to perform the air flow simulations himself. While using scSTREAM is relatively easy, setting parameters and boundary conditions can be quite involved. Dr. Yamagata would have to construct logical hypotheses for every experiment to define the necessary inputs. This would require accumulated experience and know-how. This was not a realistic expectation for Dr.Yamagata to get involved in the detailed processes of performing the analyses.

Fluid analyses can be effective for everyday home-related issues

Dr. Yamagata hopes to apply the fluid analysis tool "in the field that can improve people's everyday home-related concerns in many ways." This includes examples already discussed that are closely linked to everyday issues. Topics can be diverse; while not as extreme as calculating how far a tsunami can reach, they appeal to concerns that many people face each day. By analyzing and visualizing these phenomena, results become more reliable and convincing. The Lion Corporation offers many different fluid-related products, so fluid analyses will be useful.

Another example involves cleaning a bathroom or locker room, which may require removing ceiling mold. To solve this problem, the Lion Corporation developed the *LOOK Bath Anti-mold Fogger*, which uses bactericidal smoke

to clean the room and prevent further mold. Validating the effectiveness of this product will help identify conditions needed for sufficient ventilation. "Another challenge is how to convey these findings to consumers and win empathy," says Dr. Yamagata.

Dr. Yamagata is also interested in performing fluid analyses to predict how laundry can get tangled when being washed. Observing what is happening inside a washing machine, while laundry is being washed, is difficult to accomplish. Dr. Yamagata has discussed this with a household appliance manufacturer and asked whether a transparent washing machine could be produced. Unfortunately, such a machine would be difficult to make because it would have to be strong enough to withstand the substantial centrifugal force applied during the spin process. Dr. Yamagata comments: "scSTREAM is a useful tool that visualizes what cannot be properly perceived by our eyes. I hope that the software will be used in diverse fields. Thanks to technical advances, analyses that used to take one week to perform can now be done in few minutes. I'm looking forward to further improvements in analysis technology."

Notes

(1) Satoshi Matsunaga: Nichijo seikatsu ni okeru sentaku iryo no heyaboshishu to sono yokusei, Journal of Japan Association on Odor Environment, Vol. 36 (2005) No. 2.
(2) Presented at the Japan Research Association for Textile End-Uses in 2013.

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Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

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