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DEVELOPMENT OF SPACE SHOWER MADE IN JAPAN

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Abstract

The era of commercial space travel has begun, and people from all over the world can now go to space. As more and more space travelers start to venture into space, it is easy to imagine that the need for showers and baths will increase. However, at present, showers and baths are not installed in long-duration spacecrafts such as the International Space Station. On the other hand, in Japan, where natural disasters such as earthquakes and typhoons are common, there are many companies that provide water circulation showers and water reclamation systems for disaster relief. ASTRAX is planning to develop a shower for space use by combining these technologies and products. In this paper, we will present the development status, progress, and future plans of ASTRAX space showers.

Keywords: Bath, Shower, Space Bath, Space Shower, Space Travel, Made in Japan

1. Introduction

In the past, space showers have actually been tested. On the other hand, the International Space Station currently in operation is not equipped with baths or showers. People keep themselves clean by regularly wiping their bodies with wet towels.

However, it is easy to imagine that in the coming era of space travel, the need for baths and showers will inevitably increase as the public goes to space to enjoy a leisure time, and as the duration of stay in space becomes longer. As a commercial astronaut myself, I like baths and showers and would like to take a bath in space as well.

In places where there is gravity, such as the Moon or Mars, it would be possible to develop baths. However, in a spacecraft in zero gravity, it is not realistic to build a bathtub and fill it with hot water for soaking. Therefore, the first step would be to develop a shower that can be used in space.

ASTRAX, a Japanese commercial space business company, is trying to develop a prototype space shower by combining various technologies and products on the ground in order to develop a full-scale practical space shower. Before the actual prototyping and development, we will first introduce a survey of past space showers and the results of our study of the feasibility of a space

shower by combining and applying existing technologies.

2. Examples of Past Space Showers

In the past, showers have been used on the U.S. space station Skylab and the Russian space station, Mir. The following is an overview of those space showers and the conditions of their use.

Table 1. Summary of Shower on Skylab and Mir

Issue	Skylab	Soviet Stations	Other designs	Comments & Measures
Water temperature	Long wait, poor control	Long wait,		SL design was intentionally limited; no technology issue. <i>Use appropriate interfaces & integrated heater</i>
Water quantity	No control	?		s.a. <i>Provide appropriate allocation & information display.</i>
Shower time need	45 min "from start to finish" – too long	20 min		?? no great differences from ground. <i>Ease some constraints through hygiene compartment design.</i>
Drying options	Vacuum too long? / toweling	Toweling only		Unclear: toweling's major issue is humidity burden to cabin's air. <i>Make both options available.</i>
Clean-up time	30 min – too long	20 min – too long	Too long	Design issue. <i>Use self-cleaning wall finishes, etc.</i>
Vacuuming power	inadequate for drying	Not available		Design issue. <i>Provide sufficient suction margin.</i>
Clean-up conditions	astronaut gets cold	Difficult water removal, dirt accumulation		Design issue of drying process; poor stall temperature control; procedural aspect. <i>S.a.; offer good temperature control in hygiene compartment & stall.</i>
Floating water safety	too much water floating around	Breathing hose – not used		<i>Better flow control; breathing mask may serve contingency purposes.</i>
Detergents quality	Too concentrated, stick & stinks on skin	Acceptable?		Clearly, an area for more work!
Stall temperature	Cold on touch			Facility design issue. <i>S.a.</i>
Cabin conditions	Dry, no sweat	(high humidity)		!! <i>A general, obvious recommendation: operate cabin at low RH (50%).</i>
Reliability	Blower failure (water contamination?)	water leakage		
Need assessment	No medical need for 76 d	–	Not needed for up to 90 d	Relative validity; and longer durations need consideration

2.1 Showers on the U.S. Space Station Skylab

During NASA's Skylab program in 1974, the astronauts were allowed to take a shower once a week on board.

The shower stall was a 90-cm-diameter cylindrical fabric shower, a hose spraying water directly onto the body, and a fan sucking out the excess water. (Some astronauts wore goggles and nose plugs in the shower.)

Also, it took about an hour to wipe off all the water droplets inside after use, which was not comfortable, and was not well received by the astronauts. After that effort, they started to wipe themselves with a wet towel once a day instead of taking a shower.



Fig.1. Shower in Skylab [76]

2.2 Shower on Russian Space Station, Mir

The Russian space station Mir also had a shower with hot water coming out of the ceiling. However, it took too long to wipe off the water droplets, so it gradually fell into disuse and eventually became a storage space.

Like Skylab, it was not well received by the astronauts. In addition to the difficulty of preparation and cleanup, the showers on Mir were more difficult than comfortable, as the humidity in the showers caused mold to form. Russian cosmonaut Sergey Avdeyev, who stayed on Mir for three long-duration expeditions and stayed in space for a total of 748 days said, “I gradually stopped using the space shower” in a speech in Japan in 2007.

Based on the experiences shown in 2.1 and 2.2, and as a result of practical considerations, showers were not installed on the Space Shuttle, but was developed later, and also on the International Space Station, which is currently in operation.

3. Investigation of existing products that could be used as space showers

Considering the past examples of NASA and Russia shown in Chapter 2, showering in space may be considered impractical. This is the case for astronauts whose priority is the mission.

On the other hand, for space travelers, if there is a way to solve the inconvenience, it would be better to have a shower or bath-like device for washing the body during long stays in space.

We investigated several simple showers for ground use in Japan that could be applied as space showers. In addition, we also introduce a circulating water reclamation system to reclaim and reuse the water used in the shower.

3.1 Japanese Simple Showers for Terrestrial Use that may be Applicable to Space Showers

3.1.1 SANYO Human Washing Machine Ultra Sonic Bath

One of the most talked-about exhibits at the 1970 Osaka Expo in Japan was the “Ultra Sonic Bath,” a human washing machine exhibited by SANYO Electric (now Panasonic). When a person enters the capsule, which is about 2 meters in diameter, with his or her head uncovered, hot water showers are emitted from nozzles at the front and rear to wash the body with bubbles generated by ultrasonic waves.

Finally, warm air is blown over the body, and the drying process is fully automated. During the drying process, infrared and ultraviolet rays are used to improve blood circulation and sterilize the body. Colorful massage balls with protrusions move in the water to enhance the washing effect and relax the body.

The sales price after the exhibition was approximately 8 million yen. According to Yoko Kawahara, deputy director of the Panasonic Museum (Kadoma City, Osaka Prefecture), “There are no exact records, but it is reported that several units were sold”. The human washing machine later became a hint for the development of a nursing care bathing device. Mitsuru Haruyama, president of a nursing care product development company and himself afflicted with muscular dystrophy, an intractable disease that causes muscle weakness, and designers from the time of the Expo who remained within Sanyo collaborated on the development.

The product was launched in 2003 as a bathtub for nursing care.

Later, Sanyo, which had fallen into financial difficulties, became a subsidiary of Panasonic, and the nursing care bathtub was no longer sold. The human washing machine is now open to the public at the Panasonic

Museum's Monozukuri Ism Museum, where the excitement of that moment is still being felt today.

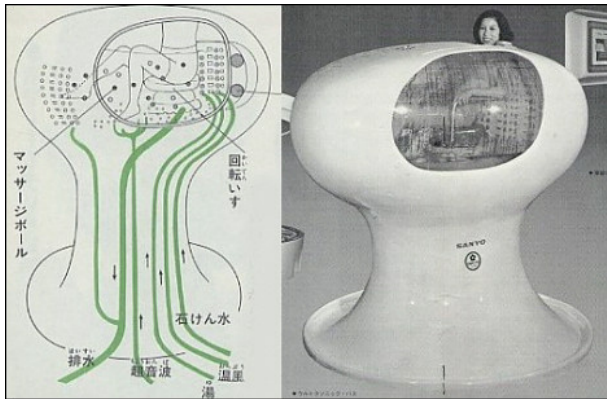


Fig. 2. The Human Washing Machine

3.1.2 AVANT Corporation "Santelban 999"

AVANT Corporation, a Japanese manufacturer of massage-related equipment and other health products, has created a product called "Santelban 999".

It uses robot technology to automatically wash and even sterilize a person's body. The user lies down inside the machine, which applies soap and lotion to the body. It also applies a seaweed pack, which has excellent moisturizing properties, to take care of the skin.

The machine also has a massage function. Sound therapy, aroma therapy, and infrared therapy are used to heal the body's fatigue and prevent illness. Sound therapy is a health treatment that uses sound and vibration to influence the human senses to cure and prevent illness. Aroma therapy is a treatment that uses fragrances and oils extracted from herbs.

The cleaning steps of "Santelban 999" are as follows;

(4) Body shampoo

Cleanse the entire body with a far-infrared & steam sauna mist body shampoo.

(2) Washing

Hot water shower swings left and right while spraying warm water. It also has a massaging effect.

(3) Sauna

Far infrared & steam sauna

(4) Healing

Sound therapy

Aromatherapy

(5) Seaweed pack (only for pack course)

A pack containing seaweed extract is sprayed over the entire body

(6) Body lotion

The body is moisturized with a mist of body lotion.



3.1.3 Science Holding's "New Human Washing Machine (tentative name)"

This bathtub is an updated version of the "human washing machine" described in 3.1.1, using state-of-the-art fine bubble technology. The bathtub not only washes the body, but also relaxes the "mind" while enjoying beautiful images and music, providing a healing space. Sensors measure the state of the sympathetic and parasympathetic nerves to create the most relaxing environment. The hope is that people in today's stressful society will regain their physical and mental health by making bath time more comfortable.

In cooperation with the developer of the human washing machine (the one in 3.1.1) that was exhibited at the 1970 Expo and a laboratory at Osaka University, they also plan to develop a bath that can be used for bathing in space.



全自動の人間洗濯機。
全ての機能をスイッチひとつで
快適にコントロールできる。

- ボディシャンプー
- 洗 浄
- 遠赤外線 & スチームサウナ
- サウンドセラピー
- アロマセラピー
- 海藻パック
- ボディローション



Fig. 3. Santelban 999

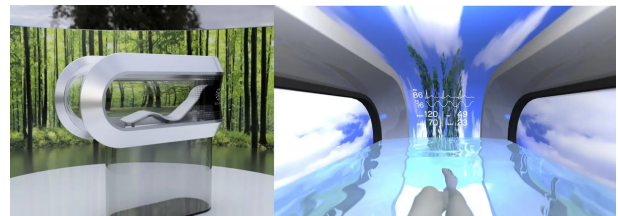




Fig.4. New human washing machine

3.2 Other idea

Although it is not a shower, one of the spa facilities in the space hotels owned by private companies, has an idea of a space pool.

As shown in the figure 5, the wearer wears underwater glasses that cover up to the nose and jumps around in a sphere along with a ball of water to wet his/her body with water. Therefore, it is thought that by simultaneously washing the body with a jet of foam, dirt and grease on the body can be removed to some extent. Once the dirty water is removed, water is again added for rinsing, where the rinsing part is considered to be similar as taking a bath.

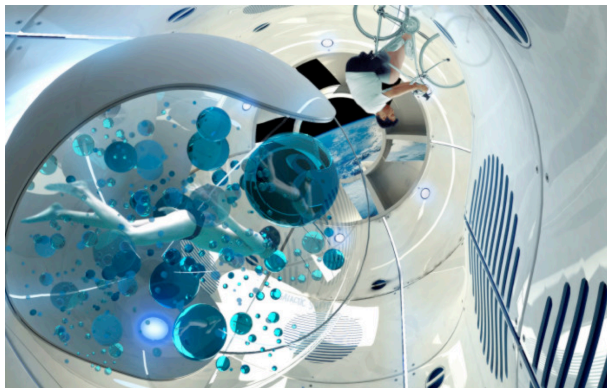


Fig. 5. Space pool

3.3 Circulating Water Reclamation System “WOTA”

The equipment shown in 3.1 and 3.2 would require a large amount of water. However, since water is limited and very expensive in space, it is undesirable to consume large amounts of water for showers. Therefore, we would like to use a Japanese circulating water reclamation system to completely reuse the water used for space showers. This paper introduces the WOTA BOX by WOTA Inc.

The water quality of water regenerated by WOTA BOX is a system that uses AI, sensors, and filters to continuously purify and supply water. 100 liters of water can be used repeatedly by 100 people for showers by maintaining the water regeneration process at WHO (World Health Organization) standards of cleanliness. The system saves approximately 98% of water compared to an ordinary shower.

Sensors evaluate filter performance in real time by comparing water quality before and after passing through the filter as well as water contamination. This information is then fed back to the machine for optimal control to meet target water quality standards and cost efficiency.

A shower typically uses about 50 liters of water per person; 100 people would require 5,000 liters of water, but the WOTA BOX uses 100 liters of water repeatedly, requiring only 2% of the normal amount of water. In other words, 98% of water can be saved, and 100 people can use the amount of water in a WOTA BOX, whereas there will only be enough water for two people in a normal shower. WOTA BOX can be used in areas where water has been cut off, such as in disaster-stricken areas, and it is energy-efficient enough to run on small generators or storage batteries, making it easy to take a shower even in areas where electricity has been cut off.

The wastewater from the showers is first removed from large debris in a trash pocket like those found in washing machines, and then passed through six filters, including an activated carbon membrane and reverse osmosis (RO) membrane, to remove 99.9999% of trash, soap components, bacteria, viruses, metal ions, and other debris.

For example, viruses are about 100 nanometers in size, but the pores in RO membranes are about 1 to 2 nanometers in size, meaning almost all viruses can be removed.

It also irradiates ultraviolet light and uses chlorine to disinfect and sterilize the water. The treated water meets WHO water quality standards and is safe to drink. However, the water is not intended for drinking, as drinking it would reduce the amount of water used for circulation.

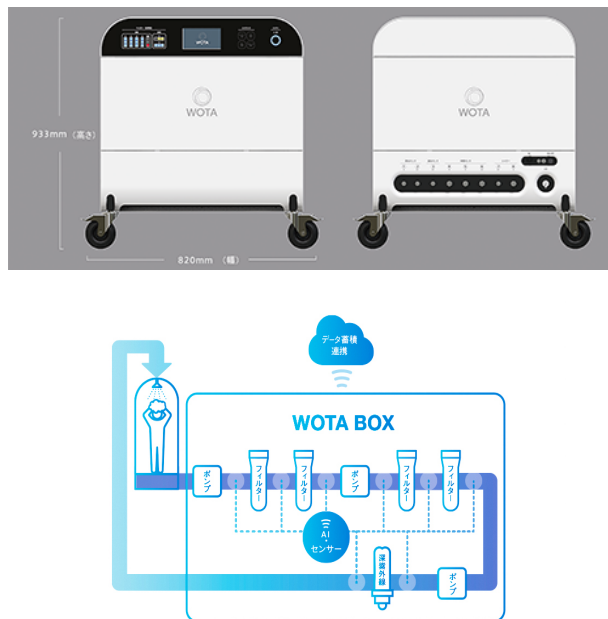


Fig.6. WOTA BOX (Top) and WOTA BOX purification flow (Bottom)

4. Results

As shown above, many simple shower systems and circulating water reclamation systems have been developed and used in Japan, with some of them likely to be applicable in space. However, this is not a complete survey, and further research will be required.

5. Discussion

It is apparent that the installation and improvement of these devices must be verified to see if they can actually be used in the space environment. At the same time, it will also be necessary to examine from the user side whether the showers meet the needs of those who will actually use them. As discussed in Chapter 2, if the actual use is inconvenient or uncomfortable, users may end up preferring to wipe themselves with a towel.

What is important is not to spend a large amount of money on a single development project for space use, but to use (or combine) existing products and technologies, and to make improvements while obtaining feedback from the user perspective on a regular basis. To this end, ASTRAX intends to conduct the following experiments and verifications in the future.

- ASTRAX spacecraft education and training simulator
- Test at the ASTRAX LUNAR CITY simulation facility

- Use in conjunction with disaster prevention measures, leisure campsites, etc.
- Repeated improvements based on the results of actual use
- Demonstration tests in zero gravity flight
- Comparison of water reclamation by filter and distillation
- Study on integration of space toilet and space shower (or integration of partial functions)
- Demonstration tests in space
- Practical application in actual space travel

6. Conclusion

ASTRAX is developing various space products and services for the coming era of space travel by applying existing technologies, products, and services, rather than basically developing from scratch. Similarly, we would like to develop this space shower by successfully connecting existing technologies so that we can create and provide services that are fast, inexpensive, and easy to use.

In addition, we believe it is important to proceed with the development of space showers in parallel, assuming that they will be used not only in space, but also on the ground. In particular, since there is affinity in the elements that need to be considered for use in space and use in disaster-stricken areas, we believe that development should be carried out while keeping both in mind, so that products that can be used in each, will be created. Thereby increasing efficiency.

Along with the development of “Space Benking” shown in the paper on “space toilets” which will be presented simultaneously with this paper at the International Space Conference 2022 in Paris in 2022 [56], we will continue our study for the development of “space shower” in the future.

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DEVELOPMENT OF SPACE SHOWER MADE IN JAPAN

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Abstract

The era of commercial space travel has begun, and people from all over the world can now go to space. As more and more space travelers start to venture into space, it is easy to imagine that the need for showers and baths will increase. However, at present, showers and baths are not installed in long-duration spacecrafts such as the International Space Station. On the other hand, in Japan, where natural disasters such as earthquakes and typhoons are common, there are many companies that provide water circulation showers and water reclamation systems for disaster relief. ASTRAX is planning to develop a shower for space use by combining these technologies and products. In this paper, we will present the development status, progress, and future plans of ASTRAX space showers.

アブストラクト

民間宇宙旅行時代が始まり、世界中の人たちが宇宙に行ける時代がやってきました。これからたくさんの宇宙旅行者が宇宙に飛び出していくようになると、シャワーや風呂のニーズが高まるのが容易に想像できます。しかし、現在、国際宇宙ステーションなどの長期滞在宇宙船にはシャワーやお風呂は搭載されていません。一方、地震や台風などの自然災害が多い日本には、防災 & 災害用の水循環型シャワーや水再生装置などを提供している企業がたくさんあります。そこでASTRAXでは、それらの技術や製品を組み合わせた宇宙用のシャワーの開発を行なうことを計画しています。本論文では、ASTRAXによる宇宙用シャワーの開発状況や進捗、今後の計画などについて発表します。

Keywords: Bath, Shower, Space Bath, Space Shower, Space Travel, Made in Japan

1. はじめに(序論)

過去に実際に宇宙シャワーの検証が行われてことがあった。一方、現在運用されている国際宇宙ステーションでは、風呂やシャワーは設置されておらず、定期的に体を濡れタオルで拭くということで体を清潔に保っている。

しかし、これからの宇宙旅行時代において、一般人がレジャーや余暇を楽しむために宇宙に行くようになり、さらに宇宙での滞在期間が長くなると、どうしても風呂やシャワーのニーズが高まってくることが容易に想像できる。私自身も宇宙飛行を行う民間宇宙飛行士であり、風呂やシャワーが好きで、宇宙でも風呂に入りたいと思っている。

月面や火星など、重力がある場所では風呂の開発も可能になるだろう。しかし、重力が無い宇宙船においてはバスタブを作ってそこにお湯を張って浸かるというのは現実的ではない。そのため、まずは宇宙で利用できるシャワーの開発を行うことから始めようと考えている。

ASTRAX では、本格的に実用的な宇宙シャワーの開発に向けて、まずは地上にあるさまざまな技術や製品を組み合わせることで、宇宙用シャワーの試作を行おうとしている。まずは実際の試作や開発を行う前に、過去の宇宙シャワーの調査及び、既存の技術を組み合わせることで宇宙シャワーが実現できないか検討した結果について紹介する。

2. 過去の宇宙シャワーの例

過去にアメリカの宇宙ステーション「スカイラブ」やロシアの宇宙ステーション「ミール」でシャワーが使用されたことがある。そこで、それらの宇宙シャワーについて、概要及び使用状況について以下に紹介する。

表 1. スカイラブとミールのシャワーの概要

Issue	Skylab	Soviet Stations	Other designs	Comments & Measures
Water temperature	Long wait, poor control	Long wait,		SL design was intentionally limited: no technology issue. <i>Use appropriate interfaces & integrated heater</i>
Water quantity	No control	?		s.a. <i>Provide appropriate allocation & information display.</i>
Shower time need	45 min "from start to finish" – too long	20 min		!! no great differences from ground. <i>Ease some constraints through hygiene compartment design.</i>
Drying options	Vacuum too long? / toweling	Toweling only		Unclear: toweling's major issue is humidity burden to cabin's air. <i>Make both options available.</i>
Clean-up time	30 min – too long	20 min – too long	Too long	Design issue. <i>Use self-cleaning wall finishes, etc.</i>
Vacuuming power	inadequate for drying	Not available		Design issue. <i>Provide sufficient suction margin.</i>
Clean-up conditions	astronaut gets cold	Difficult water removal, dirt accumulation		Design issue of drying process; poor stall temperature control; procedural aspect. <i>S.a. offer good temperature control in hygiene compartment & stall.</i>
Floating water safety	too much water floating around	Breathing hose – not used		<i>Better flow control; breathing mask may serve contingency purposes.</i>
Detergents quality	Too concentrated, stick & stinks on skin	Acceptable?		Clearly, an area for more work!
Stall temperature	Cold on touch			Facility design issue. <i>S.a.</i>
Cabin conditions	Dry, no sweat	(high humidity)		!! <i>A general, obvious recommendation: operate cabin at low RH (50%).</i>
Reliability	Blower failure (water contamination?)	water leakage		
Need assessment	No medical need for 76 d	–	Not needed for up to 90 d	Relative validity; and longer durations need consideration

2.1 アメリカの宇宙ステーション「スカイラブ」のシャワー

1974 年の NASA のスカイラブ計画では、1週間に 1 回、船内でシャワーを浴びることができた。直径 90cm の円筒型の布製のシャワールームにゴーグルをかけて入り、ホースから直接からだに水を吹きかけ、余分な水をファンで吸引するというものである。

無重力で浮かんだ水滴が鼻の穴に入ってきたりもする（そのためゴーグルと鼻栓をしてシャワーをあげた飛行士もいる）。また、使い終わったあと約 1 時間かけて中の水滴を全部ふき取る手間を考えると、快適とは言えず、宇宙飛行士たちの評判も良くなかった。結局その後シャワーの代わりに一日に一度濡れタオルで体を拭くようになった。



図1 スカイラブのシャワー

2.2 ロシアの宇宙ステーション「ミール」のシャワー

ロシアの宇宙ステーション「ミール」にも、天井からお湯が出るタイプのシャワーがついていたが、やはり水滴のふき取りに時間がかかりすぎたため、徐々に使われなくなり、いつしか物置きになってしまった。

スカイラブと同じく宇宙飛行士達からの評判もあまりよくなかった。準備や後片づけが大変なうえ、ミールでは、シャワーを使うと湿気でカビが発生したりして「快適さ」より「大変さ」が勝っていた。ミールに 3 度長期滞在し、通算 748 日の宇宙滞在記録を持つロシアのセルゲイ・アヴデエフ宇宙飛行士は、2007 年に日本で講演したとき「次第に宇宙シャワーは使わなくなった」と語っている。

2.1 及び 2.2 に示す経験を踏まえて、現実的に検討した結果、その後開発されたスペースシャトルや、現在運用が行われている国際宇宙ステーションではシャワーは設置されなかった。

3. 宇宙シャワーとして利用できそうな既存製品の調査

2 章で示した NASA やロシアの過去の例を考えると、宇宙でのシャワーは現実的ではないと考えられるかもしれないが、これはミッションを優先する宇宙飛行士の場合である。一方宇宙旅行者の場合、もし使い勝手の悪さを解決する手段があるのであれば、やはり長期間の宇宙滞在にはシャワーや風呂のような体が洗える装置はあった方がいいと考える。

そこで、日本における地上用簡易シャワーで、宇宙シャワーとして適用できる可能性があるものをいくつか調査した。さらに、シャワーで使った水を再生して再利用できるようにするための循環型水再生装置についても紹介する。

3.1 宇宙シャワーに適用できる可能性のある日本の地上用簡易シャワー

3.1.1 SANYO 人間洗濯機ウルトラソニックバス

1970 年に日本で開催された大阪万博で最も話題を集めた展示の一つが、三洋電機（現パナソニック）が出展した人間洗濯機「ウルトラソニックバス」である。人が頭を出した状態で直径 2 メートルほどのカプセルに入ると、前後のノズルから温水シャワーが出て、超音波で発生させた気泡で体を洗う。最後に温風を吹き付け、乾燥までを全自動で行う装置である。

乾燥時は赤外線と紫外線で血行を良くし、殺菌も行う。突起のついた色とりどりのマッサージボールが水中で動き、洗浄効果を高めると共に体をほぐす機能もあった。

展示後の販売価格は約 800 万円だった。当時の高卒初任給は約 2 万円なのでかなりの高額だが、パナソニックミュージアム（大阪府門真市）の川原陽子副館長によると「正確な記録は残っていないが、数台が売れたと伝わる」とのこと。

人間洗濯機はその後、介護用入浴装置を開発するヒントになった。介護用品開発会社の社長で、自身も筋肉が衰える難病である筋ジストロフィーを患う春山満氏と、三洋社内に残っていた万博当時の設計者らが協力して開発に着手。2003 年に介護用浴槽として発売した。その後、経営難に陥った三洋がパナソニックの傘下に入り、介護用浴槽の販売はなくなった。人間洗濯機はパナソニックミュージアムの「ものづくりイズム館」で一般公開され、当時の熱気を今に伝えている。

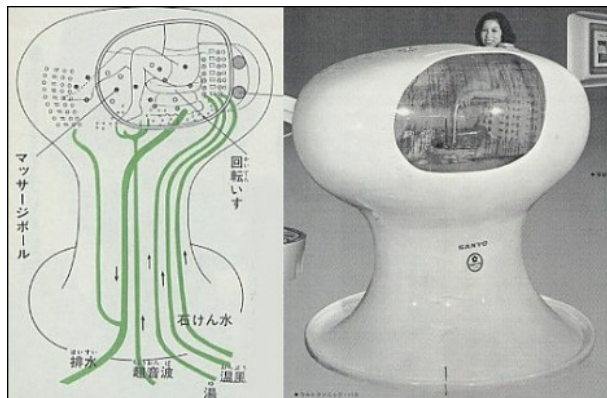


図2 三洋考案の人間洗濯機

3.1.2 株式会社 AVANT 「サンテルバン 999」

日本のあんま関連機器など健康用品メーカーであるアバント社が作った「サンテルバン 999」という製品がある。ロボット技術を利用して自動で人の身体を洗い、殺菌までしてくれる。機械の中に入って横になれば石けんをつけて洗い、ローションを塗ってくれる。また保湿作用がすぐれた海藻パックで肌の管理までしてくれる。

さらに、マッサージ機能もある。音療法、アロマ療法、赤外線療法で体の疲れを癒し、疾病予防をしてくれる。「音療法」とは音と震動を利用して人間の感性に影響を及ぼすもので、疾病を治療、予防する健康法だ。またアロマ療法

は香りを利用した治療法で、ハーブから抽出したオイルを利用した治療法である。

「サンテルバン 999」の洗浄ステップを以下に示す。

- (1)ボディシャンプー
遠赤外線 & スチームサウナ霧状のボディシャンプーで全身をきれいに洗う
- (2)洗浄
温水シャワーが左右にスイングしながら温水を吹きつける。マッサージ効果もある
- (3)サウナ
・ 遠赤外線 & スチームサウナ
- (4)癒し
・ サウンドセラピー
・ アロマセラピー
- (5)海藻パック(パックコースの場合のみ)
海藻エキスを含んだパックが全身に吹きつけられる
- (6)ボディローション
霧状のボディローションでボディがピカピカになる。





**全自動の人間洗濯機。
全ての機能をスイッチひとつで
快適にコントロールできる。**

- ボディシャンプー
- 洗 浄
- 遠赤外線 & スチームサウナ
- サウンドセラピー
- アロマセラピー
- 海藻パック
- ボディローション



3.1.3 サイエンスホールディングスの「新人間洗濯機(仮称)」

3.1.1 で示した「人間洗濯機」を、最先端のファインバブル技術でアップデートした浴槽である。単に体を洗うだけではなく、きれいな映像や音楽を楽しみながら“こころ”を解きほぐし、癒しの空間を提供できる。センサーで交感神経・副交感神経の状態を計測し、最もリラックスできる環境を作り出す。ストレスの多い現代社会においてもお風呂の時間をもっと快適にすることで、心身ともに健康を取り戻してほしい、そんな願いを込めている。

1970 年の万博で展示された人間洗濯機(3.1.1 のもの)の開発者と大阪大学の研究室とも協力し、さらに宇宙で入浴できる風呂も開発する予定である。

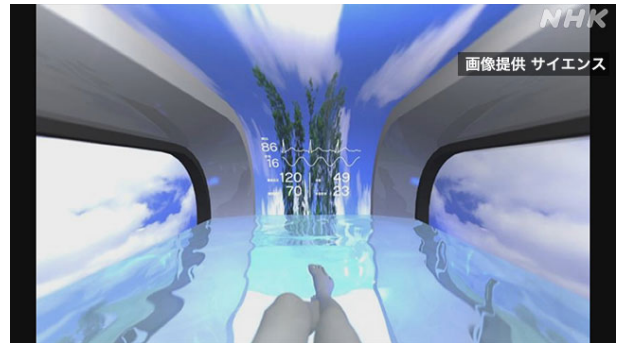
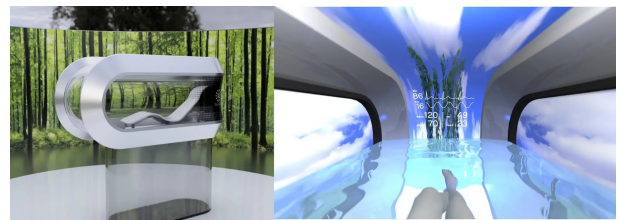


図 3 Santelban999



図 4 新人間洗濯機

3.2 その他のアイデア

シャワーではないが、民間企業による宇宙ホテルに SPA の設備の一つとして宇宙プールのアイデアがある。

以下の図 5 のように、鼻まで覆われている水中メガネを装着し、水の玉と共に球体の中で飛び回することで身体を水で濡すことができる。

そこで、同時に泡を噴射して身体を洗うことで、ある程度身体の汚れや脂分は取り除けるのではないかと考えられる。一旦汚れた水を除去し、再び濯ぎのために水を入れて、洗い流せば、風呂に入ったのと同じような状態になると考えられる。

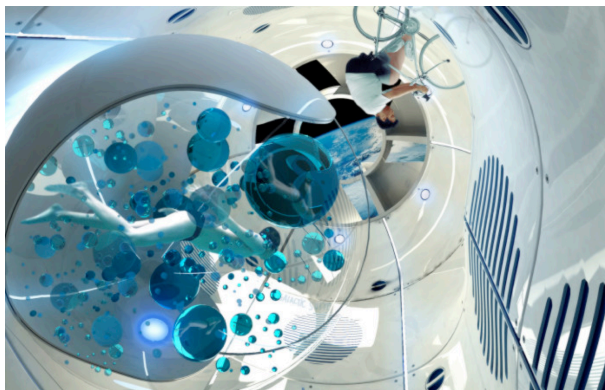


図 5 宇宙プール

3.3 循環型水再生装置「WOTA」

3.1, 3.2 に示した機材を使うとなると、大量の水が必要になる。しかし、宇宙は水が限られており、非常に高価であるため、シャワーのために大量の水を消費することは望ましくない。そこで、日本の循環型水再生装置を使って、宇宙シャワーで使用した水を完全に再利用できるようにしたいと考えている。そこで、本論文では、株式会社 WOTA の WOTA BOX を紹介する。

WOTA BOX によって再生された水の水質は AI やセンサー、フィルターを駆使して、水を絶えず浄化して供給するシステムである。WHO (世界保健機関) 水準の清潔さに維持しつつ水再生処理を行うことで、100 リットルの水で 100 人がシャワーを繰り返し使用できる。普通のシャワーに比べて約 98% の節水ができる。

センサーは水質の汚れだけでなく、フィルターを通る前と後の水質を比べることで、フィルター性能をリアルタイムで評価する。それらの情報をマシンにフィードバックし、目標の水質基準やコスト効率を満たすよう、最適に制御する。

シャワーは通常 1 人で約 50 リットルの水を使う。100 人なら 5000 リットルの水が必要になるが、WOTA BOX は 100 リットルの水を繰り返し使うので、必要な水の量は通常の量のわずか 2% である。つまり 98% の節水ができ、普通のシャワーなら 2 人しか浴びられない水量でも、WOTA BOX では 100 人が利用できる。被災地のような断水した場所でも使えるし、小さな発電機や蓄電池でも稼働できるよう省エネ化しているので、電気が遮断している場所でも手軽にシャワーを浴びることができる。

シャワーの排水は、まず洗濯機にあるようなゴミポケットで大きなゴミを取り除いた後、活性炭膜や逆浸透膜 (RO 膜) など 6 本のフィルターを通し、ゴミ、せっけんの成分、細菌、ウイルス、金属イオンなどを 99.9999% 取り除く。例えばウイルスの大きさは 100 ナノメートル程度だが、RO 膜の孔 (あな) の大きさは約 1~2 ナノメートルなので、ウイルスをほぼ全て除去できる。AI はセンサーで得た汚れの情報を元に、どのような水処理をすべきかを自動的に判断し、アクチュエータを制御する。

さらに紫外線の照射や塩素による殺菌・消毒も行う。処理した水は WHO の水質基準を満たしており、口に入っても支障ないクオリティである。ただ、飲んでしまうと、循環するための水が減るので飲用は想定していない。



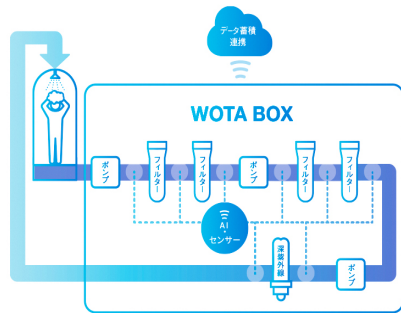


図 6 WOTA BOX(上)と WOTA BOX の浄化の流れ (下)

4. 結果

このように、日本では、たくさんの簡易なシャワー装置や循環型水再生装置が開発され、また利用されており、そのうちのいくつかは宇宙においても応用できそうであることがわかった。

ただし、今回だけでは完全に調査しきれていないため、今後さらなる調査が必要になると考えている。

5. ディスカッション

これらの装置を設置したり、改良することで、実際に宇宙の環境での利用ができるかという検証が当然必要となる。

また、同時に、実際に利用する人たちのニーズに応えられるかというユーザー側の側面から検討を行っていく必要もあるだろう。

2 章で示したように、実際に使ってみると不便だったり、それほど快適でなかったりすると、結局タオルで身体を拭いた方がいいということになりかねないからである。

大事なことは、宇宙用として多額の開発費をかけて 1 回で開発するのではなく、既存の製品や技術を使って(あるいは組み合わせて)、普段から利用者の立場からのフィードバックを得ながら、改良を重ねていくことが重要であると考えている。

そのため、ASTRAX では、今後以下のような実験や検証を行なっていきたいと考えている。

- ・ASTRAX 宇宙船教育訓練シミュレーターで利用
- ・ASTRAX 月面シミュレーション施設で利用
- ・防災対策やレジャーキャンプ場などの連動し利用
- ・実際に利用した結果を踏まえた改良を繰り返す
- ・無重力飛行において実証実験実施
- ・フィルターによる水再生と蒸溜による水再生の比較
- ・宇宙トイレと宇宙シャワーを一体化(あるいは部分的機能の一体化)の検討

- ・宇宙での実証実験
- ・実際の宇宙旅行での実用化

6. 結論

ASTRAX では、基本的に 0 からの開発ではなく、既存の技術や商品、サービスを応用して、宇宙旅行時代の到来に向けたさまざまな宇宙商品や宇宙サービスの開発を行っている。同様に、この宇宙シャワーの開発も既存の技術をうまく結び合わせることで、早く、安く、使いやすいものを作り、サービスを提供していけるようにしていきたい。

また、宇宙だけでなく、同時に地上においても利用することも想定しながら、並行して開発を進めていくことが重要であると考えている。特に宇宙での利用と被災地での利用は考える必要がある要素に親和性があるため、双方を意識しながら開発を進めていくことで、それぞれに利用できるものが出来上がるため、効率が上がると考えている。

2022 年にパリで開催される国際宇宙会議 2022 で本論文と同時に発表される「宇宙トイレ」に関する論文に示した「宇宙ペンキ」の開発とともに、今後も「宇宙シャワー」の開発のための検討を継続していく。

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