



Newsletter on the
Latest Technologies
Developed by RTRI

Railway Technical Research Institute
2-8-38 Hikari-cho, Kokubunji-shi
Tokyo 185-8540, JAPAN
URL: <http://www.rtri.or.jp>

Editorial Office: Ken-yusha, Inc.
URL: <http://www.kenf.or.jp/en/>

Copyright © 2010 Railway Technical Research Institute.
All rights reserved.
Reproduction in whole or part without permission is
prohibited. Printed in Japan.

Railway Technology Avalanche

December 24, 2010 No.33

GENERAL INFORMATION

- Preface
Hiroshi TANAKA 191
- 10th China-Japan-Korea Railway Research Technical Meeting
Manabu IKEDA 192

ARTICLES

- Development of a Workload Evaluation Scale for Drivers
Mitsugu SAWA 193
- Development of a Small-Scale Superconducting Magnet Using YBCO High-Temperature Superconducting Wire
Masafumi OGATA 194
- Research on the Prediction and Evaluation Method of Rolling Noise
Toshiki KITAGAWA 195
- Mass Production of Low-Cost LREBa₂Cu₃O_y Bulk Superconductors for Railway Systems Using a Novel Seed in the Batch Process
Miryala MURALIDHAR 196

Preface

Hiroshi TANAKA

Director, Railway International Standards Center

In recent years, the introduction of railway systems that are energy efficient and environmentally-friendly has been accelerated and has become a worldwide trend. Meanwhile, responses to technological progress and compliance with higher safety requirements are increasingly demanded in the railway business. Appropriate technical standards are essential to meet these requirements, and thus the development of international standards for the railway business has become increasingly important.

The Railway International Standards Center (RISC) of the Railway Technical Research Institute (RTRI) was founded and commenced its activities on April 1, 2010.

RTRI has been acting as the national secretariat of the International Electrotechnical Commission's Technical Committee 9: Electrical equipment and systems for railways (IEC/TC9). We have thus been able to grasp quickly the overall trends relating to IEC standards for the rail industry. However, until now there has been no focused Technical Committee (TC) for railways in the International Standardization Organization (ISO), and therefore several different TCs have been covering the standards that relate to railways. In addition, various different national secretariats and representatives have managed the review work for international standardizations.

Since this situation has made it difficult to systematically monitor the railway-oriented ISO standards in Japan, there was a pressing need to establish a new organization to take an overall view of the ISO standards, in addition to performing the work as the national secretariat of IEC/TC9.

Our center was founded on consensus between the government, railway operators, railway-related industries and



technical associations involved with the development of standards following discussions that mainly focused on the government's strategy concerning international standards. It is a membership organization and is composed of individuals who represent a broad spectrum of the railway industry and its technologies in Japan. We will propose plans and strategies for international standardization that will be valuable for the development of railway-related industries, and we will provide central administration and review international standards. We will also gather and disseminate information and support human resource development to aid in the promotion of international standardization.

I hope that our activities will contribute to the continued future development of the worldwide rail industry.

田中 裕

10th China-Japan-Korea Railway Research Technical Meeting

Manabu IKEDA

Former Manager, R&D Planning, Research & Development Promotion Division

The 10th China-Japan-Korea Railway Research Technical Meeting (hereinafter referred to as the CJK Meeting) was held on September 7 to 8, 2010 at the Korea Railroad Research Institute, in Uiwang-city, South Korea. Three organizations —Railway Technical Research Institute (RTRI), China Academy of Railway Sciences (CARS), and Korea Railroad Research Institute (KRRI) — have held the CJK Meeting every year since 2001.

This year's CJK Meeting was attended by 52 people from the three organizations. They included the President of RTRI, Mr. Tarumi and 12 other staff, the Deputy President of CARS, Mr. Kang and 13 other staff, the President of KRRI, Mr. Choi and 24 other staff (Fig. 1).

The summit meeting and the preparatory meeting were held on September 7, as were the meetings of persons in charge of each research theme. Three representatives from RTRI attended the summit meeting: the President Mr. Tarumi, the Director of the Research & Development Promotion Division Mr. Takai, and the Director of the International Affairs Division Mr. Goto. The meeting discussed the operational method for carrying out collaborative research over a longer period, ways to achieve more positive communication between the three organizations, as well as information exchange among researchers, and mutual use of facilities in each organization, etc.

On September 8, the Annual Meeting was held as follows:

- (1) Opening welcome: KRRI greeted participants at the opening session.
- (2) Keynote lecture: each of the three organizations gave a keynote lecture :
 - “Strategies for the future Railway 2020”, by KRRI
 - “CARS’ Development Goals and Key Tasks in Five Years”, by CARS
 - “Master Plan of RTRI “RESEARCH 2010”- In Pursuit of Sustainable Development for Railways”, by RTRI
- (3) Debriefing session about achievements: 14 presentations in total were given about the achievements

of collaborative research and the planning of new collaborative research (four items by RTRI, three items by CARS, and seven items by KRRI). Questions and answers were then exchanged.

- (4) Signing of the minutes of the meeting:

the minutes of the CJK Meeting were signed by the representatives of the three organizations (Fig. 2).

As for the China-Japan-Korea collaborative research, a total of 20 research projects are in progress at the present time in October, 2010. Among these, RTRI is participating in the following nine themes which include three new themes:

- Measurement methods on pantograph and catenary system and its application to maintenance works
- Prevention of accidents by human factors (New)
- Study on the research and sharing mechanism of railway scientific technological literature resources
- Research on evaluation method and criteria on derailment safety for high speed train-track system
- Research on the management mechanism of mutual use of research or testing facilities among CARS, KRRI and RTRI laboratories
- Study on wheel/rail adhesion and creep test methods (New)
- Standardization of EMC tests
- Investigation of microorganisms in railway system (New)
- Study on the remediation of railroad contaminated soil

The next CJK Meeting is scheduled to be held in September 2011 at RTRI.



Fig.1 Participants in the 10th China-Japan-Korea Railway Research Technical Meeting



Fig.2 Signing the minutes of the meeting

Development of a Workload Evaluation Scale for Drivers

Mitsugu SAWA

Senior Researcher, Ergonomics, Human Science Division



The work of train drivers is irregular because it is determined in accordance with the requirements of train operation. To take account of this when determining the workload of train drivers, many railway companies specify standards such as the length of a duty, late night working, and the duration of uninterrupted driving. However, most of these standards have been drawn up through accumulation of experiences, and it is hard to say that there are sound reasons behind particular standards. Although work schedules taking account of workloads are prepared using these standards, they largely depend on the experiences of the staffs in charge.

A number of attempts have been made to develop techniques for supporting the workload management of drivers. One of these includes a "Workload Evaluation Scale" which predicts the workload experienced by drivers. This scale evaluates a degree of fatigue at an arbitrary point in time as a proportion of the accumulated workload on the basis of the human's standard physiological rhythm for 24 hours. The scale allocates marks in a table to estimate the effect of times and hours of operation and sleeping, multiplied by the weighting coefficient depending on the kind of operation and the condition of rest (Table 1). It also uses a correction factor (Table 2) for main line driving that is the core of railway operation in Japan. The adequacy of this scale has been verified by the work of 36 drivers over 18 days. However, there were problems with the use of this scale such as:

- (1) It only handles average workloads at normal times;
- (2) The mark allocated for the effect of resting at home is obtained assuming that the driver sleeps for all the time spent at home; and

- (3) The evaluation standard does not identify when the workload reaches a level that may compromise safety.

Accordingly, thanks to an experiment using a train operation simulator,

we have made it possible to reflect, in the scale of marks allocated, the effect of operations being accelerated in order to recover from delays to the timetable. Further, we applied the new calculation method to the marks allocated for the resting effect, and we also added the evaluation standard for the mark given for the various workloads. Making use of this improvement, we created a new scale which increases the accuracy of the process of evaluating the driver's workload and which allows evaluation of the workload in a variety of different circumstances, for example when a driver is making up lost time after a delay.

As for utilization of this scale, for example, when several work diagrams are considered, it is possible to evaluate which one is suitable for a driver. Figure 1 shows the workload curve when a driver works continuously for two nights from the first day to the third day, and then continuously for two nights from the fifth day to the seventh day when the work flow is the opposite to that of the former work. By obtaining the total of the maximum values of the respective workload marks for the work occupying two nights, the former work corresponds to a score of 188 and the latter work corresponds to a score of 205. It is understood that the former two nights of continuous work with the smaller total value of the workload mark is suitable for a driver.

In addition, it is possible to simulate the workloads for various conditions, such as the case of driving a one-man train, the case of driving both on a single track and on a double track line, and the case of accelerated operations to make up for delays to the timetable. The new scale can also be utilized to identify train services where the driver needs to pay particular attention to safety for accident prevention and to draw the driver's attention to particular priority rosters for rest management.

Table 1 Weight coefficient for types of operation and rest conditions (Extract)

Name of operation	Busy line with dense traffic	Ordinary line
On-train working	1.00	1.00
Shunting	0.81	0.84
Entering and exiting depots	0.78	0.82
On-train without working	0.41	0.54
Preparation	0.36	0.65
Sort-out time	0.31	0.46
Turn-back	0.70	0.62
Training	0.70	0.79
Additional time	0.61	0.69
Rest at a private room in own depot	-0.70	-0.73
Rest at a private room in other depots	-0.62	-0.67
Rest at a shared room in own depot	-0.44	-0.49
Rest at a shared room in other depots	-0.42	-0.44
Rest in own depot	-0.41	-0.39
Rest in other depots	-0.33	-0.33
Rest at home	-1.00	-1.00
Outfitting	0.00	0.00
Commute	0.60	0.67

Table 2 Weighting coefficient of correction factor for main line driving (Busy line with dense traffic)

Kind of vehicle, train		Average nonstop (time)		Others	
Item	Coefficient	Item	Coefficient	Item	Coefficient
EC	1.00	Less than 3 min	1.05	One-man	1.18
DC	1.03	Less than 6 min	1.00	Mixture of single/double	1.08
EL, passenger	1.03	6 min or more	0.95	Recovery operation	1.30
EL, freight	0.95			Passing type	0.83
DL, passenger	1.02				
DL, freight	0.93				
TEC	0.89				

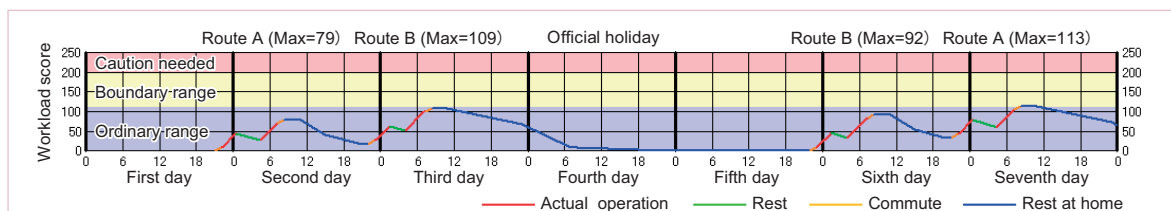


Fig. 1 Example of display of workload curve

Development of a Small-Scale Superconducting Magnet Using YBCO High-Temperature Superconducting Wire

Masafumi OGATA
Senior Researcher, Cryogenic Systems, Maglev Systems Technology Division

Railway Technical Research Institute (RTRI) is studying the possibility of applying an yttrium-based high-temperature superconducting wire, the performance of which has recently been remarkably improved, to a superconducting magnet used in maglev systems. The application of the yttrium-based wire, which can be used at a higher temperature than a conventional niobium-titanium wire, can improve the stability of the superconducting state of a superconducting coil and reduce the weight and power consumption of a cryocooler for cooling the superconducting coil. The results of the study have clarified that these advantages are greatest when the superconducting magnet is used at approximately 50 K (Kelvin: unit of absolute temperature, 50 K = -223°C).

Accordingly, RTRI fabricated a high-temperature superconducting coil about one quarter of the size of a real machine using the yttrium-based wire and completed a small-scale superconducting magnet by inserting the fabricated superconducting coil in a cryostat capable of long-term cold insulation (Fig. 1). Further, this superconducting magnet is not fitted with its own cryocooler, although a cryocooler can be connected when required. RTRI's objective was to try and develop an ultimate form of the superconducting magnet using the yttrium-based high-temperature superconducting wire.

This superconducting magnet can generate a magnetic field stronger than 1 T (Tesla: unit of a magnetic field) at a coil temperature of 50 K (Fig. 2).

(For reference: the magnetic field to be generated by the superconducting magnet used in maglev systems is approximately 5 T.) Further, this superconducting magnet has been shown to have a cold insulation performance that is able to keep the coil temperature lower than 50 K for nine hours after the coil is first cooled (Fig. 3). To do this it utilizes the heat capacity of a metal arranged around the high-temperature superconducting coil, together with a mechanism to maintain the vacuum in the cryostat with activated carbon.

With this level of cold insulation performance, this superconducting

magnet can generate the required magnetic field for a long time even after an excitation power source and the cryocooler have been separated from the superconducting magnet. Although there is a time limitation, RTRI has succeeded with this new type of superconducting magnet in overcoming the problem of cooling, which in the past has been essential for superconducting magnets. This means that RTRI has developed a new form of superconducting magnet which was not envisaged from the conventional superconducting magnet, that is, a superconducting magnet which is highly portable and easy to handle like a permanent magnet. From now on, RTRI is going to carry out research and development with the aim of producing a higher magnetic field and a larger version of the high-temperature superconducting magnet.

This work has been carried out with the support of a government subsidy from the Ministry of Land, Infrastructure, Transport and Tourism.

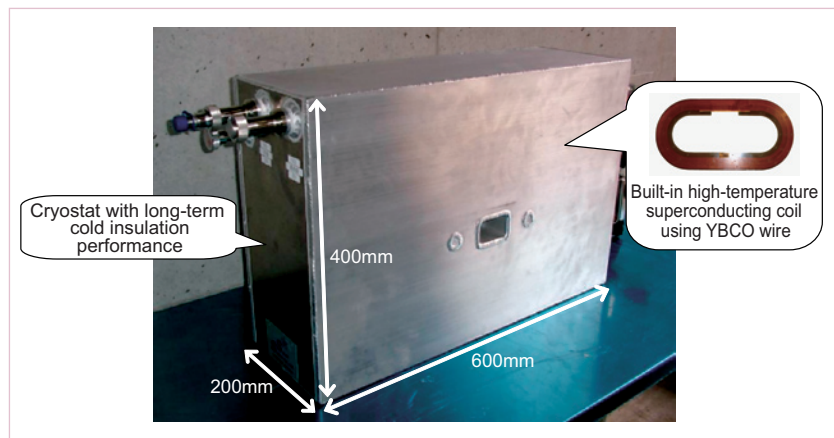


Fig.1 Small-scale superconducting magnet using YBCO high-temperature superconducting wire

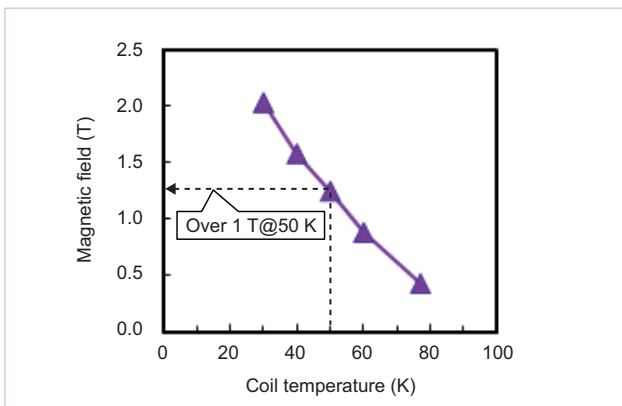


Fig.2 Magnetic field performance

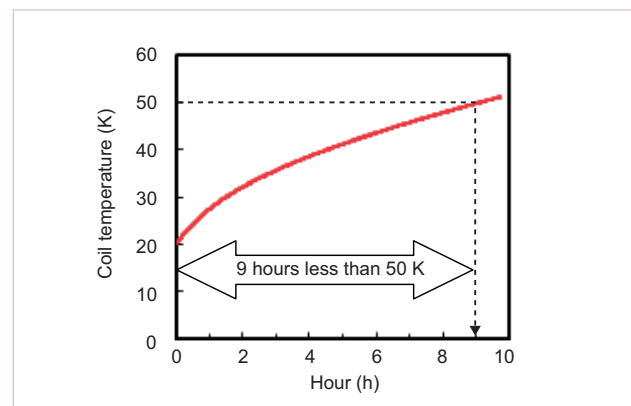


Fig.3 Cold insulation performance

Research on the Prediction and Evaluation Method of Rolling Noise

Toshiki KITAGAWA

Senior Researcher, Noise Analysis, Environmental Engineering Division



Railway noise is generated from various components that form the track and rolling stock. In the case of railways in Japan, rolling noise is a significant sound source. Rolling noise is generated by the vibration of wheels and rails due to the forces of wheel/rail interaction, caused by micron-order roughness existing on the surface of wheels and rails (Fig. 1). In order to understand how rolling noise is generated, RTRI has conducted research on the roughness distribution on the surface of wheels and rails and on the vibration and acoustic characteristics of wheels and track by carrying out field tests and numerical simulation. Further, RTRI has developed vibration and acoustic models related to the generation of rolling noise. These models are based on the concept of TWINS (Track-Wheel Interaction Noise Software), which is widely used in Europe.

Validation of the vibration/acoustic models was carried out on four sections of railway lines. It was found that the predicted results show good agreement with the measured results. The difference in noise level was about 1 dB on average and standard deviation was about 3 dB (Fig. 2). In determining the contribution of each sound source to the total rolling noise generated on meter-gauge lines, it was evident that rails are the main sound source in the frequency range of 500 to 1,600 Hz, and that wheels are the dominant sound source above 2,500 Hz (Fig. 3).

RTRI next quantified the effects of various wheel/track parameters on the generation of rolling noise by using the models, and then proceeded to develop measures to reduce noise (Fig. 4). Controlling the roughness of wheels and rails has a great effect on rolling noise. In particular, it was found that rail grinding reduces rolling noise by up to about 7 dB on sections where rail roughness has not been controlled. Roll-

ing noise also depends on rail pad stiffness. Soft rail pads, have been applied as one way of reducing noise on bridges. However, soft rail pads increase rolling noise, especially noise generated by the rails. This is due to the fact that: (1) rail vibration is increased at lower frequencies; (2) rail vibration propagates for a long distance along the rail. Increasing the loss factor of the rails by installing rail dampers has the effect of reducing rolling noise by about 1 dB. This is because the damper increases the track decay rate, and then reduces the effective noise radiation length. Installing damping devices on wheels such as damping rings has a small effect on the total rolling noise. This is because: (1) damping devices such as damping rings are effective for only a few wheel vibration modes; (2) the damping generated on wheels when running on rails is greater than that attained by the damping rings. These results have been partly verified by the measured results. By using the models, it has become possible to investigate the mechanism of noise reduction for measures taken to reduce rolling noise which has not been clarified until now. It has also been possible to quantitatively evaluate the effect of noise reduction measures depending on the proportion of the total rolling noise contributed by each sound source. From now on, RTRI is going to work on improving the accuracy of the models, and to carry out research and development related to the impact noise generated by wheel flats and rail joints.

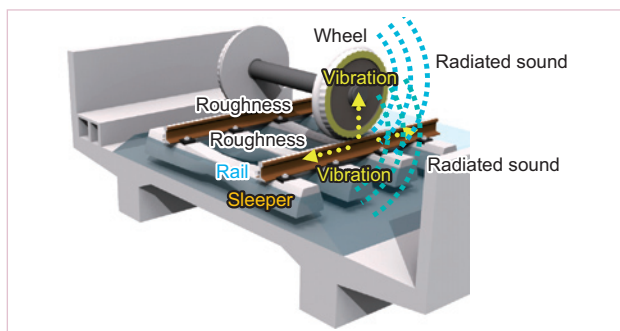


Fig. 1 Generation mechanism for rolling noise

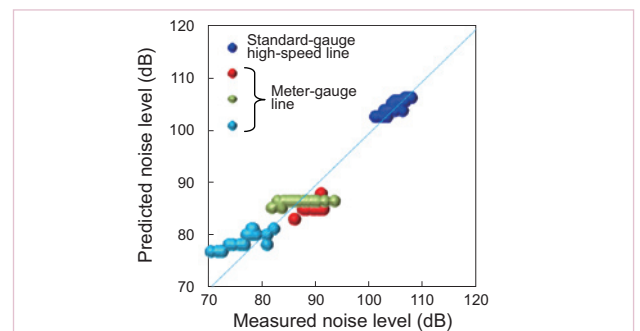


Fig. 2 Validation of the vibration/acoustic models

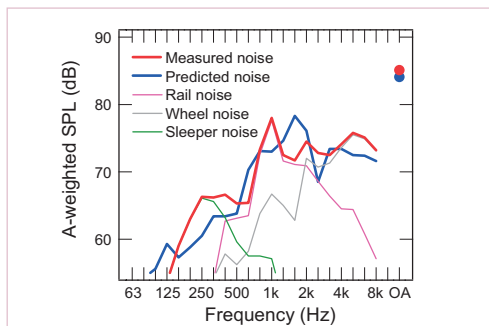


Fig. 3 Contribution of each sound source to rolling noise (meter-gauge line, 80 km/h, ballasted track)

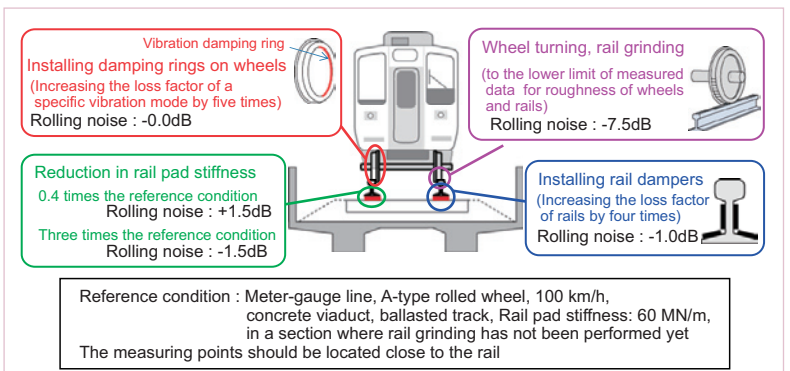


Fig. 4 Noise reduction effects using the models

Mass Production of Low-Cost $\text{LREBa}_2\text{Cu}_3\text{O}_y$ Bulk Superconductors for Railway Systems Using a Novel Seed in the Batch Process

Miryala MURALIDHAR

Senior Researcher, Applied Superconductivity, Materials Technology Division

A batch production method for fabrication of $\text{LREBa}_2\text{Cu}_3\text{O}_y$ (LRE: Sm, Gd, NEG) "LRE-123" pellets in air and Ar-1% O_2 using a novel thin film of Nd-123 seeds grown on MgO crystals has been developed at the Railway Technical Research Institute (RTRI). A novel thin film of Nd-123 seed grown on a MgO crystal, compatible with all LRE-123 materials, is the key prerequisite for successful batch production. As a result, we are able to fabricate Sm-123, Gd-123, and NEG-123 compounds with large single-grain pellets (> 45 mm), exhibiting high pinning and good quality at a dramatically reduced cost. Further, we made more than 130 single-grain pucks within a couple of months. Taking advantage of the single-grain batch processed material we constructed a chilled levitation disk, which was used during an RTRI open day. The present results prove that a high-performance good-quality $\text{LREBa}_2\text{Cu}_3\text{O}_y$ material can be comfortably scaled up from laboratory to industrial production.

The performance of $\text{LREBa}_2\text{Cu}_3\text{O}_y$ material has reached the level necessary for industrial applications including railways, and we believe that bulk superconducting magnets will in the near future enter the market as basic components for various utilities. In all these cases a large number of pieces with equally high quality are required. Batch-processing of LRE-123 materials with uniform properties is the essential requirement in this process. For batch production of LRE-123, we used a special box furnace with the utility volume of $20 \times 50 \times 25 \text{ cm}^3$, in which a vertical temperature gradient could be created (see Fig. 1). Twelve to twenty LRE-123 pellets were placed on yttrium-stabilized ZrO_2 rods inside the furnace. Subsequently, the MgO crystals covered by the Nd-123 thin film were placed centrally on the top of each pellet and they were then melt-grown in air. The melt textured samples were eventually annealed at 400-450 °C for 250-450 hours in flowing pure O_2 gas.

Recently, for the first time in the world, we successfully and repeatedly batch-processed multiple high-quality melt-textured $\text{LREBa}_2\text{Cu}_3\text{O}_y$ blocks (see Fig. 2). Trapped field experiments confirmed that all batch-processed samples were single domain and high performance. The superconducting transition measured at various positions of the batch-processed single-grain Gd-123 material was sharp (around 1 K width) with the highest onset T_c around 93.5 K, similar to the samples melt-processed in a reduced oxygen atmosphere. The self-field J_c of 70 kA/cm^2 was achieved in various positions of the pellet at 77 K and with H//c-axis. The trapped field observed in the best 45 mm single-grain puck

of Gd-123 was in the range of 1.35 T and 0.35 T at 77.3 K and 87.3 K, respectively (see Fig. 3). We thus produced more than 130 single-grain pucks within a couple of months. The reproducible quality and quantity of the batch processed LRE-123 bulks allowed us to construct a home-made levitation disk. This is one of the important steps on the way to potentially replace the superconducting coils on a Maglev vehicle by bulk super-magnets cooled by liquid nitrogen, which is far more economic than the present method, or by cryogen-free refrigeration. The disk was used for the public during the RTRI open day on October 9, 2010. More than 150 children stood on the disk and enjoyed the experience of levitation (see Fig. 4). We also loaded a maximum weight of around 35 kg with the gap maintained at around 5 mm. Further improvements to the levitation disk (e.g. by adding an additional ring of magnets) are underway, and these will make it possible to levitate adult people. These results prove that the novel seeds have a great potential for batch-processing of large single grain LRE-123 pucks, reducing the production time and cost.

In summary, the batch-processed LRE-123 composites are suitable for industrial super-magnet applications including Maglev, for power storage units using HTS flywheels, and for current-limiting devices etc. The present technology opens the way for more practical and reliable next generation railway systems.



Fig. 1. Furnace designed for batch production of LRE-123

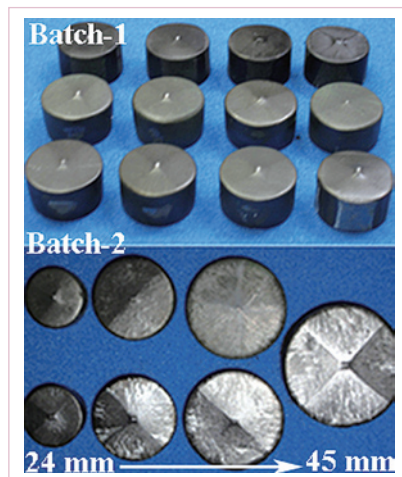


Fig. 2. A photograph of batch processed as-grown LRE-123 samples prepared by the cold seeding method using a Nd/MgO film as a seed crystal

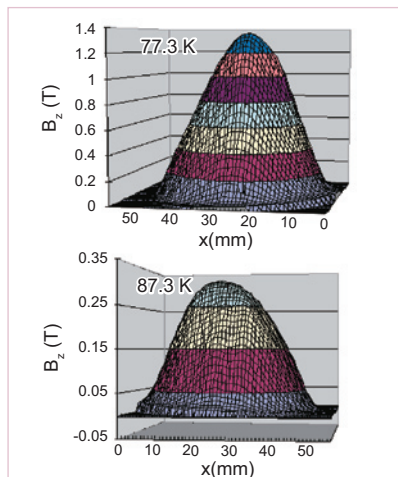


Fig. 3. Performance of the batch processed 45 mm diameter Gd-123 single grain material at 77.3 K and 87.3 K. The trapped field of 1.35 T and 0.35 T was achieved in the remnant state



Fig. 4. Levitation of child using a repulsive force between home made batch processed LRE-123 pellets and home made permanent magnet disk