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Application, Advancements and Research on Drying- A Review

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Abstract— Drying is one of the important operations in the industries like pharmaceutical, fine chemical and food industries. It is always beneficial to dry the product in less time and less area of drying. The drying of the product reduces its weight and thereby decreases transportation cost and also makes it more durable. Time required for drying and space required for drying are important factors in the operation. The quality of product after drying has to be uniform. Natural and forced circulation drying are two commonly used drying methods. Fluidized bed drying has advantage of uniform contact of drying medium with solid. Solar drying is also used in open and closed drying modes. Also microwave assisted drying has been tried by many investigators and consequently by industries in specific applications. The present review summarizes research carried out on drying, its applications and advancements.
Keywords— Natural draft, forced draft, drying time, moisture, solar drying.

I. INTRODUCTION

Drying normally refers to removal of moisture from the substance. Drying is classified as batch and continuous based on method of operation. It is classified as direct (direct contact of heat) and indirect (indirect contact of heat) base on method of supplying heat [1]. Batch dryers, vacuum shelf dryers and freeze dryers are few equipment used for drying. Fluids and semi fluids are dried in drum dryers. For solutions, slurries and pastes, spray dryers are used. Sun drying is commonly used mode of drying. It is low cost and easy method. The disadvantages are contamination of product, dependence on atmospheric conditions and low rate of drying, non uniform product. The problem of contamination can be overcome by using closed transparent enclosure. The use of microwave assisted drying technique is also growing. The need of pure and high quality product with efficient drying methods has led to various advanced methods of drying. The present review summarizes research on applications and advancements on drying.

II. APPLICATION, ADVANCEMENTS AND RESEARCH ON DRYING

Sander et. al. Investigated drying in a laboratory microwave drier [2]. They approximated experimental data with exponential of Tomas& Skansi model and neural network model. The drying time can be reduced with some increase in the cost due to intense heating source like microwave. Application of neural network helps in handling three important aspects such as complexity, nonlinearity and uncertainty. During microwave drying, overall moisture can be removed unlike other drying methods where material is dried to equilibrium moisture. They observed that results obtained using the neural network show satisfactory compliance with experimental values. Adeniyi et.al carried out analysis of a solar dryer box with ray tracing CFD technique [3].They observed that the maximum temperature in heating chamber reached 320 ^{0}K. They observed that it takes time to warm the box and ambient temperature increases in first three days. They concluded that not very long exposure to sun rays is required to achieve temperatures high enough for preservation. Keranen carried out research on cylinder drying for increasing its efficiency [4].The main purpose of the work was to discover more efficient drying method(s) than the ones in use today. They studied two drying methods, a typical cylinder drying, normal impingement drying on a fabric (with or without suction from the other side) and combination of these two methods. They observed that lower paper temperature was indicated in combined drying compared to cylinder drying. Also drying shrinkage was also reduced in combined drying. Carapelle et.al. carried out studies on vacuum freeze-drying of frozen wet papers[5].They developed a freeze-drying facility for studying the process by monitoring the various physical parameters like pressure, sample temperature, heater temperature, water content of the sample and cold panel temperature. They carried out fifteen vacuum freeze-drying cycles of frozen wet papers. It was observed that only the first few millimetres of ice sublimed faster when the cold panel temperature decreased. They developed phenomenological model to describe the loss of ice content in the sample as a function of time. Sampson and Gasbarro carried out case study on drying Firewood in a temporary solar kiln[6].They carried out investigation when fire wood was dried (1) in a conventional top-covered pile; (2) in a simple, temporary solar kiln; and (5) in tree length. They observed that drying rates were the same for firewood piles in all cases. Ubale et.al. carried out investigation on performance improvisation of conventional grape drying method. They introduced forced air exhaust for this purpose[7]. According to their investigations, if the drying air velocity is kept constant and more than ambient air, drying rate increases by 7%. They compared natural convection shade drying with the forced exhaust air by using a turbo ventilator fan of 24” diameter.

Kumar et.al. used fluidized bed drying for drying of Beetroot (Beta vulgaris L.)[8]. They carried out studies on the effect of inlet air temperature and velocity on the drying characteristics of beetroot’s (Beta vulgaris *L.)* pieces in microwave assisted fluidized bed drying (MAFBD) system. The drying time reduced 2 to 3 times by using MAFBD. According to them, the future research on food drying will inevitably focus on lower energy costs. In these circumstances, MAFBD is expected to play a meaningful role as an attractive option for drying fruits and vegetables. Li et.al. carried out case study on utilization of waste heat from process industries[9]. They used the waste heat for biomass drying. Pine wood chips at 60 wt % moisture were dried and then it was used as fuel for power station. According to them, superheated steam can combine short drying times, good heat recovery and environmental protection. But higher capital cost is a significant issue. Selivanovs et.al. presented results of experimental research on wood chips and sawdust drying in a rotary dryer [10].They created empirical models for the assessment of two dependent parameters of the drying process. They carried out experimentation in industrial conditions with a rotary dryer for sawdust and a wood chips furnace for regeneration of flue gases used as drying agent. Two models, a single factor linear model and a multifactor linear model were used for data processing. Results of their experimental research can be used to propose a number of substantial improvements in the drying processes and technologies related to improved energy efficiency by using waste products for pellet production and dryer material in combustion process.

Mulokozi et.al. carried research on solar drying for vitamin A rich foods [11]. In developing countries, deficiencies in iodine, iron, and vitamin A is a concern. Their focus was to explore improved home-based solar dryers as a means to enhance nutritional quality of vitamin A-rich foods and consumption of those foods by young children. Sonatakke and Salve carried out review on solar drying technology [12].According to their studies, disadvantages of sun or natural drying method takes long time for drying and gives poor product quality. The use of direct drying in closed transparent enclosure can avoid contaminants and the product quality is also better. The disadvantage of this method is high initial and maintenance cost. The mechanized dryers which are powered by electricity are better in terms of drying efficiency and product quality. Burubai and Etekpe carried out investigation on the drying kinetics of African nutmeg and Ogbono kernels in thin-layers [13].They evaluated various drying constants and coefficients using non-linear regression methods. They also observed that the temperature dependence of effective moisture diffusivity obeyed the Arrhenius law. Tenorio et.al. investigated kiln drying of acacia mangium wood[14].They observed that quality parameters (drying defects) such as twist, crook, cup and board-width shrinkage were not affected by the applied drying schedules. Factors such as climate, grain pattern and initial and final moisture contents influenced that quality parameters. They concluded that it is necessary to take into consideration the variables that can directly affect (e.g. distance from pith and drying schedule) moisture content, colour, warp, split and check before and after drying. Basunia et.al. investigated solar drying of lime [15].Their results indicated that the drying was faster in solar tunnel dryer (7 days) than the natural open air sun drying (> 30 days). Panchal et.al. reported the design, construction and testing of a simple solar dryer with roughened surface with solar air heater [16]. They designed the dryer in such a way that solar radiations did not incident on the agricultural goods.The preheated warm air was used for the drying. They concluded that the combined squared and V-shaped strip arrangement took less time than else arrangements and it is quite efficient than the other arrangements.

Singh et.al. performed mathematical modeling to study drying characteristic of apple and potato[17].They observed that time and temperature have significant effects on the moisture removal. They presented the drying characteristics of apple and potatoes in terms of moisture behavior as a function of time. They observed the initial high drying rate is followed by low rate with decrease in moisture content. Coal drying in fluidized bed dryer was studied by Shun et.al. [18]. They developed fluidized bed coal dryer to overcome the disadvantages of low rank coal with high moisture such as low calorific values, costly transportation, high emissions of pollutants, and operational problem. They obtained 80-90 percent moisture removal. With increase in temperature and gas velocity, the drying rate increased. The gas temperature has the limitation that at very high temperature the spontaneous combustion and gas velocity has to be decided considering energy efficiency. Aboltins and Palabinskis reviewed research in brewer’s spent grain (BSG) drying process [19]. According to them, drying has been the most effective method of preserving BSG and to prolong the storage time. Other advantages of drying are reduction in the product volume, and decreases transport and storage costs.Ventilation, according to them is efficient drying method for this product. Genc et.al. analyzed spray drying for producing silk sericin powders[20].They used aqueous sericin solutions as raw material. According to this investigation, moisture content depended mainly on drying air temperature. Carlsen studied effects of freeze drying on paper [21].They observed that freeze drying primarily influences paper characteristics such as moisture content, folding endurance, and tearing résistance. Also it affected mechanical properties of the products but not to the extent that freeze drying should be ruled out as the drying option. Liman et.al. studied effect of three drying techniques on three different green leafy vegetables (Moringa oleifera, Spinacea oleraceae and Vernonia amygdalina)[22].The three drying techniques were sun drying at ambient temperature for 4 days, oven drying at 150 ^{o}C for 4 hours, and drying with electrical moisture analyzer stabilized at 70 ^{o}C for 1 day. According to them it was not possible to draw conclusion about best drying method as no definite pattern was followed by all the samples considered in their retention of different elements when subjected to different drying methods.

Ambrose and Naik carried out curry leaf drying by mechanical drying method[23].According to them removal of water restricts the growth of microorganisms and hence increases the durability. They used fluidized bed drying. They were able to remove the final moisture content to 2 to 5 percent during their research. Misha et.al. used CFD simulation to predict the drying uniformity in tray dryer[24]. Simple and economic design makes tray dryer easy and most sought after alternative. Non uniformity in final moisture content of the product is a drawback. Mass, momentum, and energy balance equations were solved using CFD for predicting the temperature, velocity, and pressure profiles. They observed some products experienced high air velocity, product at tray number 1, 7, 8 and 15. Drying can be improved by use of additional baffles and high air velocity, resulting in increase in cost. Kumar carried out experimental study on forced convection greenhouse papad drying [25]. They investigated the behaviour of heat and mass transfer phenomenon during greenhouse papad drying under forced convection mode. They used experimental data obtained for forced convection greenhouse drying of papad to determine the constants in the Nusselt number expression by using the simple linear regression analysis . Also they evaluated convective and evaporative heat transfer coefficients. These values were 0.759 W/m^2 ^{o}C and 23.48 W/m^2 ^{o}C respectively. Tsegaye et.al. studied coffee drying methods[26]. According to these studies the drying with thin layer of coffee bricks provided uniform and better product. Also they observed that coffee dried on mesh wire scored the highest raw quality mean values. Padmanaban et.al. carried out review on solar dryer performance reaction[27]. According to them it is possible to reduce product wastage, food poisoning and enhance productivity of the farmers by using solar drying method for agricultural products. They concluded that though solar dryer need initial investment, considering product quality, taste and nutrition value these dryers are attractive alternative. Also they are faster, safer, and more efficient than traditional sun drying techniques.

III.CONCLUSIONS

The type of drying or drying technique adopted depends on the product properties such as heat stability and chemical properties. The sun drying in open space is cheapest but has disadvantages like product contamination, nonuniform product quality and dependence on atmospheric conditions. The transparent enclosure can solve the problem of contamination of product. Fluidized bed drying can be used for granular solids. This has advantage of more uniform contact of air and more uniform temperature distribution. The microwave assisted fluidized bed dryer was very useful for vegetables and fruits. The removal of moisture increases the life of the product and reduces its weight. This aspect reduces the transportation cost. It can be concluded that proper drying of product can reduce transportation cost and makes it more durable.

REFERENCES

[1] Mass Transfer, Treybal, Drying, pp.653-6670, Third edition, 1981

[2] A. Sander, N. Bolf, And J. Prliæ Kardum, "Research On Dynamics And Drying Time In Microwave Paper Drying", Chem. Biochem. Eng. Vol.Q. 17 no.2,pp.159–164 (2003).

[3] Akinola A. Adeniyi, Abubakar Mohammed, Kehinde Aladeniyi, " Analysis Of A Solar Dryer Box With Ray Tracing Cfd Technique",International Journal Of Scientific & Engineering Research, vol. 3, no. 10, pp.1-5,October-2012.

[4] Janne Keränen, "Increasing The Drying Efficiency Of Cylinder Drying", Department Of Physics University Of Jyväskylä,Research Report No. 14/2011.

[5] A.Carapelle, M.Henrist, F.Rabecki, "A Study Of Vacuum Freeze-Drying Of Frozen Wet Papers", A.Carapelle@Ulg.Ac.Be. http://orbi.ulg.ac.be/bitstream/2268/4786/1/A%20study%20of%20vacuum%20freeze-rying%20of%20frozen%20wet%20papers.pdf,2001.

[6] George R. Sampson And Anthony F. Gasbarro, " Drying Firewood In A Temporary Solar Kiln: A Case Study", United States Department Of Agriculture Forest Service Pacific Northwest Research Station Research Note Pnw-Rn-450 August 1986.

[7] Mr. Amol Ubale, Dr. Dilip R. Pangavhane, Dr. Arundhati Warke, " Performance Improvisation Of Conventional Grape Drying Method By Introducing Forced Air Exhaust", American International Journal Of Research In Science, Technology, Engineering & Mathematics, vol.7,no.1, pp.1-5, June-August, 2014.

[8] Yashwant Kumar, Mohammad Ali Khan And Krishna Kumar Patel, " Effect Of Microwave On Fluidized Bed Drying Of Beetroot (Beta Vulgaris L.)", American Journal Of Engineering Research (Ajer), vol.3, no.03, pp.267-273, 2014.

[9] Hanning Li, Qun Chen, Xiaohui Zhang, Karen N Finney, Vida N Sharifi, Jim Swithenbank, “Evaluation Of A Biomass Drying Process Using Waste Heat From Process Industries: A Case Study”,

[10] Jevgenijs Selivanovs, Dagnija Blumberga, Jelena Ziemele, Andra Blumberga, Aiga Barisa, “Research Of Woody Biomass Drying Process In Pellet Production”, Environmental And Climate Technologies, vol.10, pp.46-51,2012,Doi: 10.2478/V10145-012-0017-7.

[11] G. Mulokozi, L. Mselle, C. Mgoba,J.K.L. Mugyabuso, And G.D. Ndossi , “Improved Solar Drying Of Vitamin A-Rich Foods By Women’s Groups In The Singida District Of Tanzania”, International Center For Research On Women, Research Report Series,pp.5-28,2000.

[12] Megha S. Sontakke, Prof. Sanjay P. Salve, “ Solar Drying Technologies: A Review”, International Refereed Journal Of Engineering And Science, Volume 4, Issue 4 (April 2015), pp.29-35.

[13] Burubai, W. And Etekpe, G. W., “Microwave-Drying Behaviour Of African Nutmeg (Monodora Myristica)And Ogbono (Irvinga Gabonensis) Kernels”,Advanced Journal Of Agricultural Research,vol. 2, no.12,pp.189-196, December, 2014.

[14] C Tenorio, R Moya, & Hj Quesada-Pineda, “ Kiln Drying Of Acacia Mangium Wood: Colour, Shrinkage, Warp, Split And Check In Dried Lumber”, Journal Of Tropical Forest Science,vol. 24,no.1,pp. 125–139,2012.

[15] M. A. Basunia, H. H. Al-Handali, And M. I. Al-Balushi, “Drying Of Limes In Oman Using Solar Tunnel Dryers”, International Journal Of Environmental Science And Development, vol.4,no.6, pp.6658-661,December 2013,.

[16] Sandeep Panchal, Satish Kumar Solanki, Sunil Yadav, Prof Asim Kumar Tilka, Prof Ravi Nagaich, “Design, Construction And Testing Of Solar Dryer With Roughened Surface Solar Air Heater”, International Journal Of Innovative Research In Engineering & Science, vol.7,no.2,pp.7-17,July 2013.

[17] Fateh Singh, V. K. Katiyar, And B. P. Singh, “ Mathematical Modeling To Study Drying Characteristic Of Apple And Potato”, International Conference On Chemical, Environment & Biological Sciences (Cebs-2014) Sept. 17-18, 2014 Kuala Lumpur (Malaysia),Pp.172-175.

[18] Jaehyeon Park_ Dowon Shun, Dal-Hee Bae, Sihyun Lee, Jeong Hak Seo,Jae Hyeok Park , “The Effect Of Gas Temperature And Velocity On Coal Drying In Fluidized Bed Dryer”, Refereed Proceedings The 13th International Conference On Fluidization - New Paradigm In Fluidization Engineering, Engineering Conferences International,pp.1-9,2010.

[19] Aivars Aboltins, Janis Palabinskis, “Research In Brewer’s Spent Grain Drying Process”, Engineering For Rural Development, Jelgava, pp.230-23520.-22.05.2015.

[20] G. Genç, G. Narin, O. Bayraktar, “ Spray Drying As A Method Of Producing Silk Sericin Powders”, Journal Of Achievements In Materials And Manufacturing Engineering, vol. 37,no.1,pp.78-87,November 2009.

[21] Søren Carlsen, “Effects Of Freeze Drying On Paper”, Prepri Nt From The 9 Th International Congress Of I Ada , Copenhagen , August 15 - 21, 115-120,1999.

[22] Muhammad Gidado Liman, Abubakar Sadiq Abdullahi, Abdul’azeez Lawal Maigoro And Kabiru Jega Umar, “ Effects Of Three Drying Techniques On Mineral Composition Of Some Leafy Garden Vegetables”, Iosr Journal Of Applied Chemistry (IOSR-JAC) E-Issn: 2278-5736,vol.7,no.1,pp.38-42, Feb. 2014.

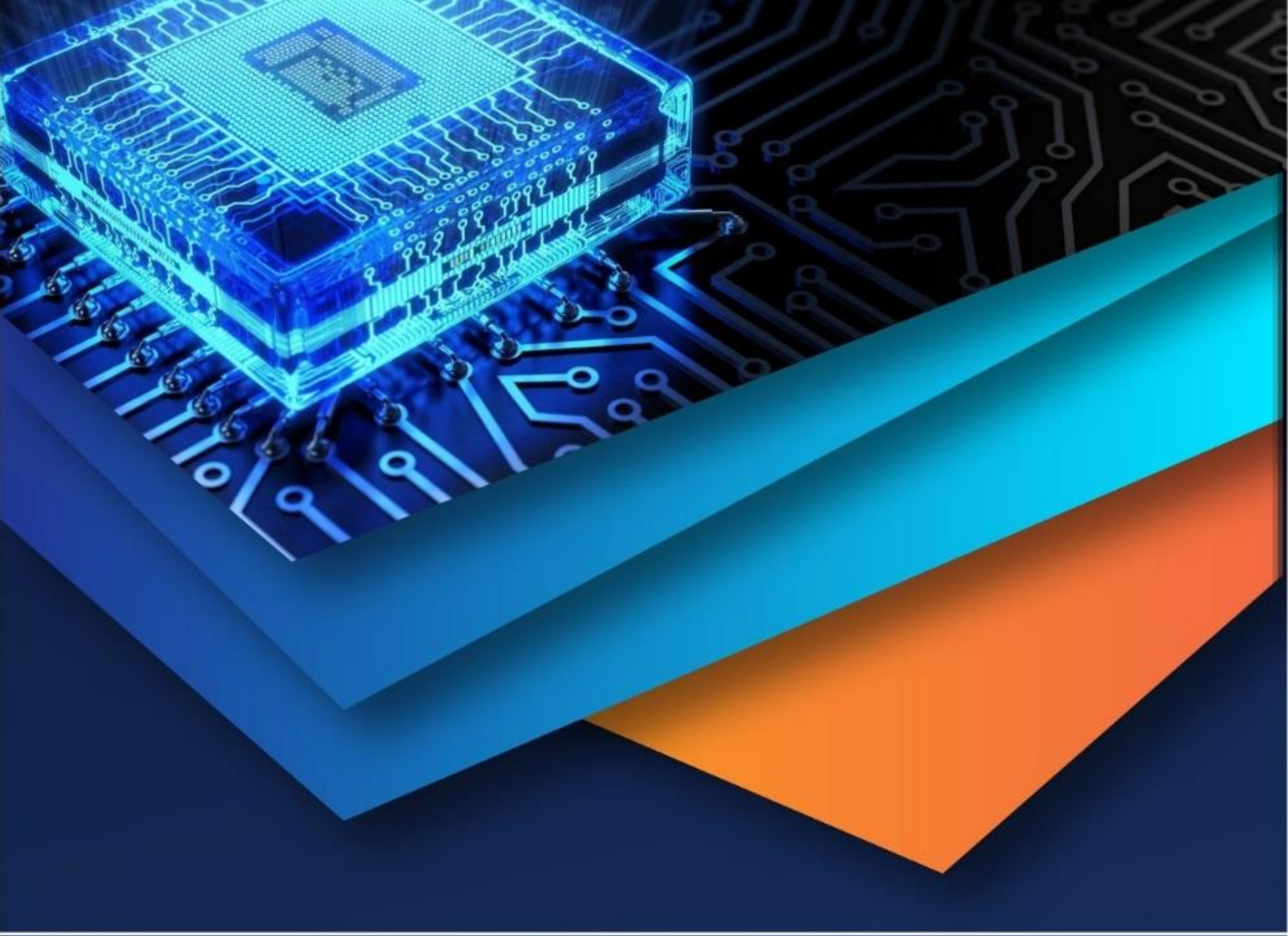
[23] Dawnc.P.Ambrose And Ravindra Naik, “Studies On The Mechanical Drying Of Curry Leaf”, Internat. J. Proc. & Post Harvest Technol., vol. 5, no. 1,pp.8-11, June, 2014.

[24] Suhaimi Misha, Sohif Mat, Mohd Hafidz Ruslan, Kamaruzzaman Sopian, And Elias Salleh, “The Prediction Of Drying Uniformity In Tray Dryer System Using Cfd Simulation”, International Journal Of Machine Learning And Computing, vol. 3, no. 5, pp.419-424,October 2013.

[25] Mahesh Kumar, “Forced Convection Greenhouse Papad Drying: An Experimental Study”, Journal Of Engineering Science And Technology,vol. 8, no. 2,pp.177-189,2013.

[26] Berhanu Tsegaye, Ali Mohammed, Tesfaye Shimber, Yehenew Getachew And Essubalew Getachew”, Research Journal Of Agriculture And Environmental Management., vol. 3,no.11, pp. 547-554, November, 2014.

[27] G.Padmanaban, P.K.Palani, S.Dharmalingam, K.Raja, “A Review On Solar Dryer Performance Reaction On Products”, International Journal Of Chemtech Research,vol.8, no.1, pp. 098-104, 2015.



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