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RESEARCH ARTICLE OPEN ACCESS

Investigation on Suspected Corona Virus and Harmful Bacteria in Sand Moulding Foundries - Case Study

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Abstract

Vast research has been carried out on the atmospheric pollution created by mould gas and dust in foundries. In early 2020, outbreak of Corona virus in almost all countries of the world has urged the material scientists to search further presence of Corona virus and other bacteria on the surface of different materials. Surfaces of some of the materials on which COVID 19 can live are plastic, stainless steel, cardboard, Glass, Ceramics, Cu, Al and fixtures made of them. This paper presents a study about this viral and bacterial pollution in foundries. Samples from sand moulding foundries were taken cultured in different media and suggestions are put forth for their control in foundry atmosphere.

Keywords: COVID-19, bacteria, culturing, detection on metallic surfaces, prevention

Nomenclature

Bacteria

Antibiotic – A germ killing substance prescribed as a medicine (or sometimes as a feed additive to promote the growth of livestock). It does not work against viruses.
Antimicrobial – A substance used to kill or inhibit the growth of microbes. This includes naturally derived chemicals, such as many antibiotic medicines. It also includes synthetic chemical products, such as triclosan and triclocarban. Manufacturers have added some antimicrobials – especially triclosan – to a range of sponges, soaps and other household products to deter the growth of germs.
Bacterium (Plural bacteria) A single celled organism forming one of the three domains of life. These dwell nearly everywhere on earth, from the bottom of the sea to inside animals.
Gene – A segment of DNA that codes, or holds instructions, for producing a protein. Offspring inherit genes from their parents. Genes influence how an organism looks and behaves.
Immune – Able to ward off a particular infection or show no impacts from a particular poison. More generally, the term may signal that something cannot be hard by a particular drug, disease or chemical.
Infection – A disease that can be transmitted between organisms.
Microbe – short for microorganism.
Microorganisms – A living thing that is too small to see with the unaided eye, including bacteria, some fungi and many other organisms such as amoebas. Most consist of a single cell.

Sand definitions

Silica sand – Silica sand grains of high purity 99.8+%SiO_2
Bank sand – Sands taken from the banks of lakes and pits having >5% clay sued for synthetic sands and core sands.
Lake sand – Sub angular sand taken from the bottoms of the lakes free from AFS clay (45-50, 50-60, 60-70 AFS fineness)
System sand – Any sand employed in mechanical sand preparation and handling system
Heap sand – Sand collected in the form of heap on the foundry floor, ready for moulding
Bonding sand – Natural clay containing sand ready for moulding
Sharp sand – Any sand free from bond, such as lake sands
Sand additive - Any material added to the moulding sand for imparting properties
Loam – A sand comprising 50% sand grains and 50% silt and clayey particles. Used for heavy castings.
Clay: Fine-grained particles of soil that stick together and can be molded when wet. When fired under intense heat, clay can become hard and brittle. That's why its used to fashion pottery and bricks.

1. INTRODUCTION

Like any other industry, the atmosphere of foundry is not free from pollution. Principal forms of industrial pollutions existing in atmosphere of foundry are classified as gaseous, thermal, radioactive and sonic pollutions, which are created by gases from furnaces, moulds cores and those evolved during metallurgical treatments e.g. flux addition, inoculation, refining, degassing etc. thermal radiations omitted by hot bath of furnace, X-ray and radio-active elements used in N.D.T. and high level noise given by electric furnace during manufacturing of steel [1].

In some old small foundries which are not equipped with modern facilities of moulding & mixing, core making, the workers mix the sand ingredients such as SiO_2 sand, clay, bentonite, water and number of other special additives with hands and prepare the mould with old foundry tools. The raw materials such as natural bonding sands generally come from the river and lake beds. The mould sand once used for moulding and casting is heaped outside the foundries and instead of reclaiming, it is reused. All these factors increase the risk to the safety of the personnel working in a foundry.

According to the Punjab Occupational Safety and Health Act, 2019 (IV of 2019) it is the prime duty of the employer to take all possible and reasonably practical measures to ensure safety and health of the employees at work place and make arrangements to control and prevent physical, chemical, biological, radiological, ergonomics and psycho-social or any other hazards to the employees and other persons at the workplace [16].

Vast research has been carried out on the atmospheric pollution created by mould gas and dust, but very few papers have been produced on some bacterial infection which may exist in the atmosphere of foundries. In early 2020, outbreak of Corona virus (fig. 1, a-b) in almost all countries of the world has urged the foundrymen to research further on the atmosphere of foundry and all the materials used for moulding and casting to investigate the presence of Corona virus and other bacteria. This paper presents a study about viral pollution which may exist in the atmosphere of foundries.

2. MATERIALS AND METHODS

2.1 Materials

a) **Natural Bonding Sand:** Natural clay containing sand ready for moulding

b) **Used Moulding Sand:** Used sand + Water = 4% + Molasses = 2%

c) **Sodium Silicate Sand:** Sod. Silicate = 8% (Blow of CO_2 Hardening time = 10hrs)

d) **Fine mill scale (FeO):** special additive for improving hot strength of sand mould

e) **Biomass – Dry Cow dung:** 2% added for improving permeability of mould

f) **Manure – Dry Horse dung**: 2% added for improving permeability of mould

Sodium Silicate Sands mould preparation

Sodium silicate ($Na_2O.mSiO_2.nH_2O$) is also used as special additive in moulding material. When water from it, is dried, it forms a gel which envelops the sand grains. On heating at 200-260^oC, it dries and dissociates in 100min. On blowing CO_2 at 1-3 atm through the sand mould based on sodium silicate, the following reaction takes place.

$$Na_2O.mSiO_2.nH_2O+CO_2 = Na_2CO_3.qH_2O+m(SiO_2+pH_2O)$$

where m.p+q=n

Table – 1 tabulates casting properties of the silica moulding sands and special additives examined

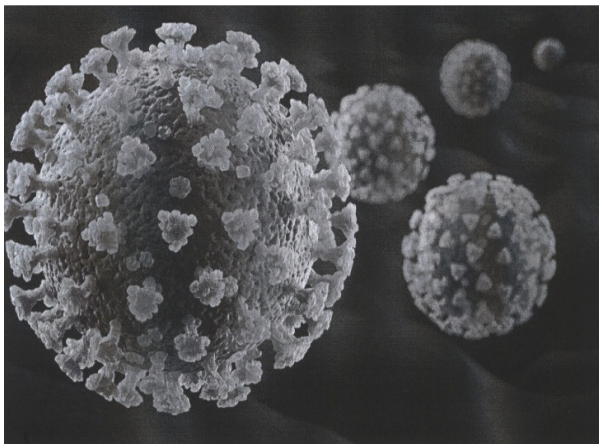


Fig. 1 (a) Digital generated image of macro view of the corona virus from the 2020

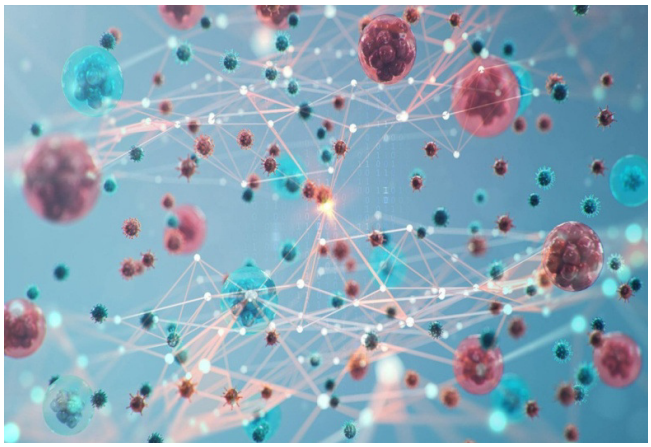


Fig. 1(b) Image of novel corona virus by Artificial Intelligence (AI) technologies

2.2 Method

Procedure for identification of micro organisms in silica sand

The details of techniques for the staining process are as follows:-

Stain the film 2 minute with Huckers gentin violet prepared as follows:

1 ml saturated alcoholic solution, gentin violet or crystal violet (4 grams dye in 20 ml of 95% ethyl alcohol)

10 ml. of 1% ammonium oxalate

Wash with water and apply Gram's iodine, 1 minute. Gram's iodine is prepared as follows:

Iodine	1gm
Potassium iodide	2gm
Distilled water	300 ml

Pour off excess fluid and wash with acetone (10 parts) and 95% alcohol (70 parts) until the smearcases to lose colour Wash with water Counter stain with 2% aqueous solution of rennin Wash with water, blot dry and examine.

Table – 1 Casting properties of the silica moulding sands and special additives examined

Type of Moulding Sand/ special additives	Composition	Alloy for which it can be used	Role in improvement in properties
Natural Bonding Sand	Natural clay containing sand ready for moulding	For all ferrous and non ferrous alloys	Main ingredient
Used Moulding Sand (prepared for moulding)	Used sand + Water = 4% + Molasses = 2%	For all ferrous and non ferrous alloys	Main ingredient
Sodium Silicate Sand	Sod. Silicate = 8% (Blow of CO_2 Hardening time = 10hrs)	Ferrous casting	Having good permeability, adequate compression strength
Special Additives			
Fine mill scale (FeO)	Small amount	Ferrous casting	Increases hot strength
Biomass – Dry Cow dung	> 2%	All metals and alloys	Increases permeability Improves green/ dry strength & collapsibility
Manure – Dry Horse dung	> 2%		Increases permeability Improves green/ dry strength & collapsibility

3. RESULTS

The results of microbiological investigations are tabulated in tables- 2-4.

Table - 2 Harmful Bacteria detected in some of the essential materials used in sand casting foundries, rolling and forging mills.

Table - 3 Cultural report on ingredients of synthetic moulding sand (Silica sand, clay, water, molasses).

Table – 4 Examination of harmful bacteria and suspected corona virus on fabricated products

Table - 2 Harmful Bacteria detected in some of the essential materials used in sand casting foundries, rolling and forging mills

S. No.	Metal Industry	Shops	Materials	Microbiological Examination at 25°C, RH: 40%							Microbiological Examination (Escherichia Coli family)[2]
				Total plate count[1]	Total coliforms (MPN/g)	Fecal coliforms (MPN/g)	E-coli (MPN/g)	Salmonella spp/25g	Staph aureus (cfu/g)	Yeast & mould count	
1	Steel Casting	Pattern making shop	Wood	4×10^2 / cfu / sq in	N.D.	N.D.	N.D.	N.D.	N.D.	0.05×10^2/ sq.in	N.T
		Mould shop	Natural bonding sand	4×10^3 (cfu/g)	N.D.	N.D.	N.D.	N.D.	N.D.	<10/g	N.T.
			Sodium Silicate Sand Sod. Silicate = 8% Blow of CO_2 Hardening time = 10hrs	9×10^3 (cfu/g)	N.D.	N.D.	N.D.	N.D.	N.D.	<10/g	N.T.
			Special additives[3] Biomass – Dry Cow dung Manure – Dry Horse dung	*Pathogenic bacteria, Listeria monocytogenes, Klebsiella pneumonia*[4,5] *Yersinia, enterocolitica, salmonella, Escherchia coli, Aeromona Clostridium tentn*[6]							N.T.
			Used sand	Total plate count cfu/ml = 1×10^8 Growth of E-coli is not found on Maconkey Agar							--
			Waste sand[7]	*Phylogenetic* analysis *actinobacteria* 46%, *proteobacteria* 29%, *bacteroidetes* 5%							--
2	Rolling	Sheet and bars shop	Mill scale (FeO)	9.9×10^3 (cfu/g)	N.D.	N.D.	N.D.	N.D.	N.D.	<10	Negative for bacteria growth
3	Steel Forge	Sledge Hammer shop	Mill scale (FeO)	9.9×10^3 (cfu/g)	N.D.	N.D.	N.D.	N.D.	N.D.	<10	Negative for bacteria growth
4	Machining	Turning shop	Lathe machine refuse	Total plate count, cfu/ml = 15.2×10^5 Growth of E-coli is not found on Maconkey Agar							Negative for bacteria growth

N.T. = Not tested, N.D. = Not detected (1) cfu = colony forming units (2) *E-coli, Salmonella, Streptococcus, Staphylococcus, Mould / Fungus, Clostridia spp.* Nutrient Agar used as basic media for bacterial growth. (3) Only those additives were examined who are suspected to contain bacteria. (4) Beneficiary bacteria: *Lactobacillus plantarum, Lactobacillus casei, Lactobacillus acidophilus, B. subtilis, Enterococcus diacetylactis*, *Bifido bacterium* may also exist (5) see Ref. 8 (6) see Ref. 7 (7) Comp: sandy loam (50% clay, 50% sand) Silt + 30% waste foundry sand, see Ref. 25.

Table - 3 Cultural report on ingredients of synthetic moulding sand (Silica sand = 90%, clay = 4%, water = 4%, molasses = 2%)

Silica Sand

Culture	Seen after one day
Culture of Sand on N.A. (Nutrient Agar)	Two type of colonies seen, big & small opaque coloured.
Culture of Sand on M.A. (Maconkey Agar)	Sterile
Culture of Sand on S.A. (Saberod Agar)	Sterile
Culture of Sand on N.B. (Nutrient Broth)	Little Turbidity seen

Molasses

Culture of Molasses on N.A. (Nutrient Agar)	3 big colonies seen, opaque & yellow coloured.
Culture of Molasses on M.A. (Maconkey Agar)	Sterile (no growth)
Culture of Molasses on S.A. (Saberod Agar)	Heavy Fungus growth seen
Culture of Molasses on N.B. (Nutrient Broth)	Heavy turbidity was seen

Reculture

Reculture	Seen after two days
Reculture on S.A. from N.B. of Sand Reculture on S.A. from N.B. of Molasses	Sterile Fungus isolated
Morphological report of Sand	Organisms were given negative cocies cocied form observed, not dangerous for human health
T.B. report of sand	Negative

Clay

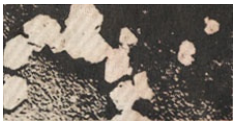
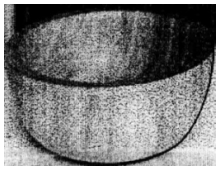
Clay mineral type	Composition type	SEM images	Shape	pH	Bacterial growth
Montmorillonite	$(OH)_4Al_4Si_8O_{20}nH_2O$	 38000×	Flakes	8-10	Favourable
Illite	$(OH)_4K_9(Al_4Fe_4Mg_4 Mg_6)(Si_{8-9,}Al_9)O_{20}$	 45000×	Irregular flakes	Moderate	Moderate
Kaolinite	$(OH)_8Al_4Si_4O_{10}$ Ex:60% kaolinite, 30% illite, 10% quartz, etc.	 30000 ×	Hexagonal crystals	Very low	Slow

Table – 4 Examination of harmful bacteria and suspected corona virus on fabricated products

S. No.	Product - Utensil Bowl[1]	Material	Manufacturing process	Microbiological Examination[2,3]	Suspected corona virus	
					Survival time	Mechanism of inactivation of virus on the metallic surface
1		γ- Brass Cu-20%Zn	Sand Casting (Vacuum mould)	at 24°C, RH 37 • Less than 1 cfu/sq. in • Yeast and mould count less than 1/sq.in.	4-8 hours At: 21°C RH 30-40	• Rapid inactivation of human coronavirus occurs on brass at 21°C. • Exposure to Cu fragmentates the viral genomes and virus morphology. • Cu alloys have antibacterial and antifungal activity against pathogens. Zn present in alloys has a slight antiviral effect. Cu ion release and generation of reactive O2 species (ROS) are involved in inactivation HuCoV-229E. • Cu-Ni also effective at inactivating HuCoV-229-E. (90% Cu-Ni produces inactivation equivalent to that demonstrated by brass with 70% Cu).
2		Stainless steel 18Cr8Ni	Deep Drawing	• 3.5 cfu/sq.in. • Yeast and mould count less than 1 / sq.in	2-3days. At: 21°C RH 30-40 (S. Begley 2020) (E Mack 2020)	Stainless steel forms fine passive film of Cr (III) oxide, (Cr2O3 which prevents surface corrosion and avoids from spreading it in metal's internal structure. In old stainless steel utensils, when this layer ruptures, oxide spinals of Mn, Ni, Cr with FeO are formed, on which the corona virus can survive for little time. Porous surfaces are much less likely to hold viable amount of virus [Mackay I.M., Arden K, 2020]
3		Silver	Fabrication	• 9 cfu/sq.in. • Yeast and mould count less than 1/sq.in	5 days	• Silver (Ag) is germicidal and is widely used as antimicrobial material, but it is relatively weaker contact killer as compared to the SS and Cu. • Silver is stable under biosphere condition; oxides and Ag+ only form at acidic pH and the most oxidizing biosphere conditions. • Ag2S (silver sulfide) easily forms on the silver surface even when traces of hydrogen sulfides are present in the air.
4		Wood (Tamarix articulata)	Carpentry	• 0.30×10^3 cfu/sq.in • Yeast and mould count[4] 4.5 /sq.in	2 days At: 21°C RH 65%	• Virus can survive on wood log and can take two days to leave, rhinorrhoea (S. Bagley 2020). • According to other observation wood surfaces are virus proof because of microstructure of wood and the presence of antimicrobial substances. • To avoid the risk, the surface disinfection is recommended (Domig K, Wimmer R, 2020).

(1) Bowl diameter: 4 ½ in., height: 1 ¾ in., curvature: 2 ¼ in., Inner surface: 28.28 sq. in. (2) Only pathogenic bacteria, *Total coliforms, Fecal coliforms, E-coli, Salmonella spp., Staph. aureus,* Yeast & mould count were examined by A.O.A.C. (American Org. of Analytical Chemistry) method. (3) Bowl was swabbed with 50ml water, only, from interior (4) Bacteria suspected.

4. DISCUSSION

4.1 Moulding Sand Ingredients

4.1.1 Silica Sand

Temporary moulds are composed of granular material, with high refractoriness, as a basic material e.g. silica sand, in which different bonding materials and special additives are added to develop specific properties. Product obtained by homogenous mixing of this material in the required ratio, is termed as 'moulding material'. Granular particles of silica sand, SiO_2, principally comprises 50-95% of the total material of a moulding mixture. They differ as per their physical chemical properties e.g. average grain size, their shape and distribution, their chemical composition and their refractoriness & thermal stability (see fig.2).

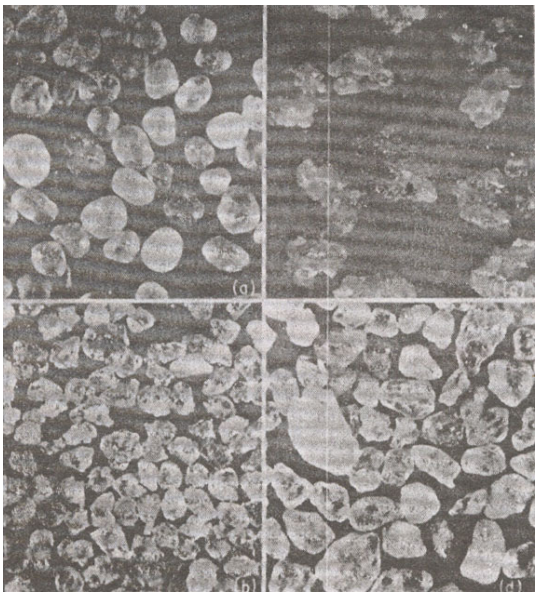


Fig. 2 Sand grain shapes (a) rounded sand grains (b) angular sand grains (c) compounded sand grains (d) sub angular sand grains (From AFS Foundry Sand Handbook)

Culture report of silica sand, on Nutrient Agar, Maconkey Agar, Saberod Agar and Nutrient Broth is tabulated in table-2 and no organisms harmful for human health were found.

4.1.2 Clay

Clay minerals are hydrous aluminosilicates and are the finest fraction of the inorganic component of soils. Different clay minerals vary in their particle size, chemical composition, surface charge properties, cation exchange capacity, and water retention properties. The principal clay minerals found in soils are members of the kaolinite, montmorillonite, and illite groups.

Moist clay is the bond or binder of moulding sand. The bonding forces involved in holding particles of clay together may be accounted for by several theories: electrostatic bonding, surface tension forces, and interparticle friction bond. The mechanism of electrostatic bonding of clays may be described as a network of dipolar forces operating at the sand-clay and clay-clay interfaces. This network of forces is initiated by the preferential adsorption of positive ions and negative ions on combined water and clay (hydrated) surfaces (see fig. 3).

Electrostatic attraction: Bacteria possess a net negative surface charge at normal physiological pH values. Evidence has been presented for the role of electrostatic phenomena in the attraction of colloidal clays to bacterial surfaces. Positively charged edges of colloidal clay particles are attracted to negatively charged sites on the bacterial surface. In those bacteria possessing some positively charged surface ionogenic groups, the predominantly negatively charged faces of clay particles are attracted to the bacterial surface [20] (see fig. 4).

Binding film formed by bentonite: Particles of montmorillonite are constituted in rows of fragmented channels. Due to fragmentation, on the corners and peaks and on the surfaces, which are exposed, a number of anions with free valences are produced and due to this, these particles bear the negative potential. Together particle of montmorillonite, it may be termed as 'macro anion'. When particles of the montmorillonite come in contact with water (electrolyte), it develops adsorption of cations on the surface of macro anions. The cations adsorbed from the liquid will form an ionic pool or '1st diffused layer'. Cations adsorbed form ionic bond which have a tendency of hydration and attract the molecules of polarized water (dipoles). In this way, 'IInd

diffused layer' is formed in between water layer and particle of bentonite, which envelops the particles of montmorilinite. The thickness of the layer is 3.10^{-5} cm [9]. Molecules of water from this layer are retained by great force, due to this reason; the water from this layer is very viscous. Structure formed by ions and cations is called 'micelle'.

Microhabitats within soils are notable for their remarkable diversity and complexity. Soils may be broadly classified in terms of textural classes to give some indication of the variability in the types and sizes of the major particulate components of the soils (table 3). With decreasing particle size there is an increase in particle number and in the surface area per gram of soil. It is clear that the interfacial area enlarges with an increase in the proportion of the clay size fraction and consequently, the opportunities for interactions between microorganisms and soil particles should increase [20].

Microorganisms have been found to associate with clay particles of a size that may escape conventional filtration plants and enter potable water supplies. (Poliovirus (Sabin type 1) conxsackievirus A9, f_2 bacteriophage and E.coli are associated with clay / bentonite particles [24].

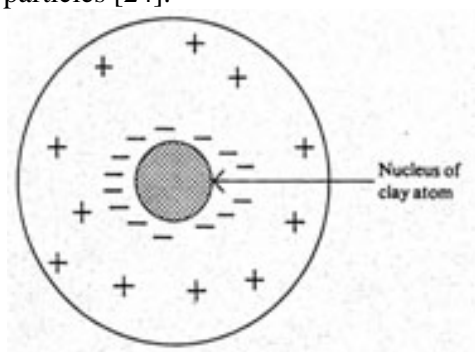


Fig.3 A clay dipole. Surrounding the particle of clay are negatively charged hydroxyl ions positioned at varying distances from the particle. Outside this layer are positively charged ions (usually hydrogen ions) also located at varying distances from the particle; hence the term double diffuse layer. This layer is rigidly attached tothe surface of the particle and is considered to behave as a solid (Courtesy American Foundrymen's Society)

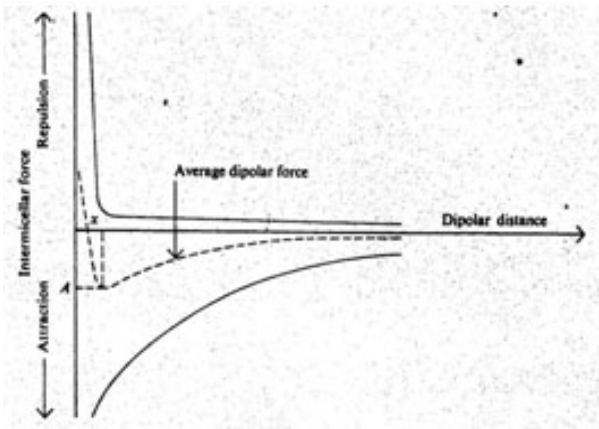


Fig.4 The forces of attraction and repulsion as a function of dipolar distance. The critical dipolar spacing is defined as x unit and the maximum bond is A. (Courtesy American Foundrymen's Society)

4.1.3 Molasses

Molasses is the residue of sugar industry. It is in the form of viscous liquid, density 1.3-1.35 kg/dm^2 and consists of 45-50% sugar and almost 30% other residues of sugar, salts of potassium, 20-25% water. Property of the binding is imparted by the sugar present in the molasses (see fig. 5). It is a common additive and added in the moulding mixture in little percentage (almost 2%). It increases dry strength and edge hardness of the sand mould and is used for all the metal and alloys. Cores are also made from the sand containing 2-3% molasses and baking is carried out at 160-180°C. Core made from molasses are hard from exterior and soft from interior and therefore they can be used for alloys having greater coefficient of contraction.

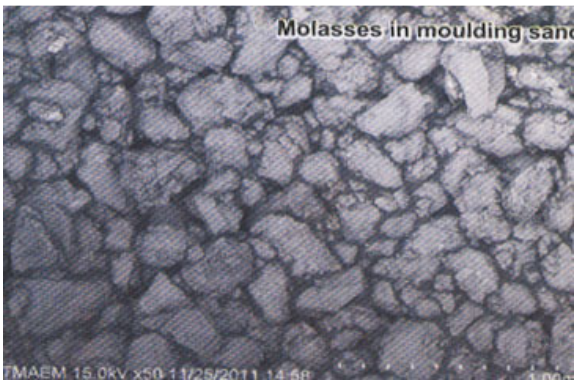


Fig.5 Moulding sand mixture containing 2% molasses

Being hygroscopic, if cores made from molasses are retained for long time, fermentation of the molasses present in cores takes place and as a result the cores lose their bonding properties. Molasses is also prone to the microbes. The culture reports of molasses shows the appearance of heavy fungus with Saberod Agar and heavy turbidity with Nutrient Broth (table-3).

4.1.4 Bacteria in waste foundry sands

In an article "Characterization and composition of bacterial communities in soils blended with spent foundry sand" [Ref. 18] authors have carried out Phylogenetic analysis of bacterial isolates (total blends) and showed that they were dominated by Actinobacteria (46%), Proteobacteria (29%), and Bac members belonging to Bacteroidetes (5%) [18].

Waste foundry sands are contaminated with certain heavy metals such as Al and Ni. The microbes *Pseudomonas aeruginosa*, *bacillus* and nutrient broth are used in the treatment of heavy metals present in casting sand [17]. In this way they are made environmental friendly for further use. Bacterial methods involving the use of bacteria such as *Bacillus* have proved to be effective in the treatment of heavy metals such as aluminum and nickel present by reducing their concentration from as much as 50% up to 90%.

4.2 Fabricated Products

Copper

In new researches [27, 30], it has been demonstrated by different researchers that human corona virus was rapidly inactivated on the range of copper alloys within few minutes to few hours. Cu(I) and Cu(II) moieties were responsible for the inactivation, which was enhanced by reactive oxygen species generation on alloy surfaces, resulting in even faster inactivation. Copper ion release and generation of reactive oxygen species (ROS) are vehemently involved in inactivation of HuCoV-229E on copper and copper alloy surface. Inactivation of corona virus on copper and copper alloys surfaces results in fragmentation of the viral genome, ensuring that inactivation is irreversible. Virus that had been exposed to copper and brass surfaces demonstrated reduced copy numbers of this fragment with increasing contact times. Transmission Electron Microscope (TEM) studies confirms that exposure to copper surfaces results in morphological changes to human corona virus particles.

The mechanism of bacterial death on copper surfaces is complex, involving direct action of copper ion and also the generation of destructive oxygen radicals, resulting in "metabolic suicide". Cu(I) reacts with molecular oxygen to generate superoxide (Eq. 1) and subsequently, hydrogen peroxide (Eq. 2) which could also produce hydroxyl radicals (Eq.3) as follows:

$$2Cu^{+} + 2O_2(aq) \rightarrow 2Cu^{2+} + 2O_2^{-} \quad (1)$$
$$2O_2 + 2H^{+} \rightarrow H_2O_2 + O_2 \quad (2)$$
$$Cu^{+} + H_2O_2 \rightarrow Cu^{2} + OH^{-} + OH \quad (3)$$

According to the results obtained by Sarah L, Warnes and others [27], the Cu(I) chelator BCS protected corona virus on brass surfaces, suggesting that Cu^{+} migrating from the metal is important in toxicity and supporting the reaction (Eq.3) generating hydroxyl radicals. The reason is, brasses were more effective at inactivating corona virus than copper nickels alloys due to the increased Cu(I) release and subsequent ROS generation. However zinc present in brasses had only mild antiviral activity (Fig. 6 shows microstructures of brass at high Mag.)

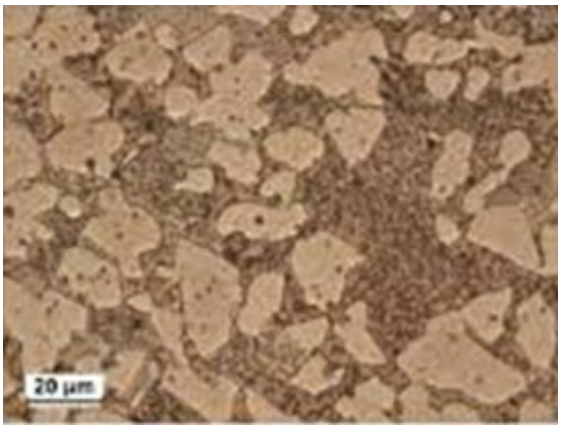
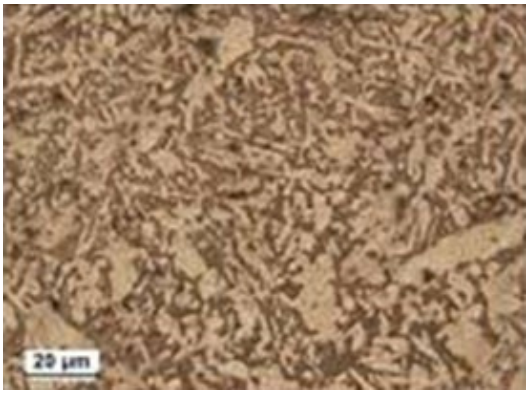


Fig. 6 Microstructures of Brass



Stainless Steel

There was a significant difference in appearance between purified HuCoV-229E exposed to stainless steel and that exposed to copper surfaces. On stainless steel, uniform visions were visible following a 10-min exposure, but on copper, clumps of damaged virus particles as well as a few intact particles could be seen. The content of damage increased upon further exposure to copper.

Stainless steel forms fine passive film of Cr (III) oxide, (Cr_2O_3) which prevents surface corrosion and avoids from spreading it in metal's internal structure. On hard, shining surface of stainless steel corona virus stayed for longer time. In old stainless steel utensils, when this layer ruptures, oxide spinals of Mn, Ni, Cr with FeO are formed (see fig. 7), on which the corona virus can survive for little time. Porous surfaces are much less likely to hold viable amount of virus [Mackay I.M., Arden K, 2020]

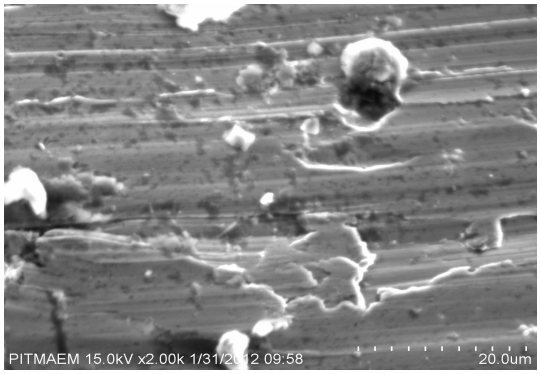


Fig. 7 Stainless Steel: Complex oxide spinal in thin film, on surface, 2000 X

Silver

Silver (Ag) is germicidal and is widely used as antimicrobial material, but it is relatively weaker contact killer as compared to the stainless steel and Cu. Silver is stable under biosphere condition; oxides and Ag+ only form at acidic pH and the most oxidizing biosphere conditions. Ag_2S (silver sulfide) easily forms on the silver surface even when traces of hydrogen sulfides are present in the air.

Bacteria on Iron Objects

Considerable attention has also been given to the influence of bacteria upon iron. The growth of Crenothrix may cause much trouble in waterworks. A variety, Chlamydothrix (Gallionella) ferruginea (Mig.) appears to play an important part in the formation of rust.

Neufeld gives particulars of three varieties: Crenothrix polyspora, which separates iron; Cr . Ochracea, which separates aluminium and some iron; and Cr. Manganifera, which separates manganese.

Jackson gives micro-photographs of these varieties. Microscopically the masses of Crenothrix are seen enclosed in a gelatinous sheath, in which is imbedded the precipitated metallic hydrate. It is anaerobic and its action is favoured by absence of light. In the absence of dissolved oxygen, the bacillus appears to take its iron from the pipes. Cr. Polyspora is found however to separate the iron not from the ferrous carbonate ($FeCO_3$) but from iron organically combined.

Recently scientific investigations carried out to study microstructure and surface morphology of evolution of thin films on the metallic surfaces has clarified the different stages in formation of oxide films on the iron objects [6]. These compose: nucleation, crystal growth, coalescence, filling the channels, growth if continuous film, thickening of film by deposition of layers, and finally powdering due to loosely adhering layers. Condensation starts by nucleation and sites of nuclei are connected in many cases to active centers (such as defects, impurities etc) in substrate surface. Primary crystals grow independently of each other. Then coalescence takes place when growing adjacent grains approach and touch each other. Channels formed in primary coalescence (or incomplete coalescence) are filled by secondary coalescence (or complete coalescence). This ultimately forms the continuous film. As the film thickens due to the deposition of more material, different layers in the thick film could not adhere properly and are powdered.

Magnetic Materials: Magnetic materials were also tested for suspected bacteria and corona virus. It was found free from pathogenic bacteria, *Total coliforms, Fecal coliforms, E-coli, Salmonella spp., Staph. aureus,* Yeast & mould count. Cfu was found 100 / sq.in. and yeast mould count was observed <10 / sq.in. The action of magnetic lines on bacteria and corona virus should be studied thoroughly.

Enameled Electrical Steel: Enameled transformer electric steel (composition C = 0.01%, Mn = 0.5%, P = 0.1%, S = 0.01%, Al = 0.1% and Si = 2.6 to 3.5%, resistivity (ρ) = 47.2×10^{-8} Ω.m. total loop area = 98.21 erg, Coercivity (H_{Ci}) = 4.13, Magnetization saturation (Ms) = 15.83 emu, Retentivity (Mr) = 79.11 E^{-3} emu, Squareness (Mr/Ms)= $4.99E^{-3}$) was tested for suspected bacteria and corona virus. It was found free from pathogenic bacteria, *Total coliforms, Fecal coliforms, E-coli, Salmonella spp., Staph. aureus,* Yeast & mould count. Cfu was found 7.2× 10/ sq.in. and yeast mould count was observed <10 / sq.in.

Sacred stones

During *Rami,* in pilgrimage, the *Shaitan* is beaten (*Rami*) by stones in Mina. This stone and other sacred stones from *Hira* cave, *Thaur* cave, *Jabl-ul-Rehmat* and mountain *Uhud at Madina* are subjected to microbiological study by A.O.A.C. (American Org. of Analytical Chemistry) method. These were found free of pathogenic bacteria, *Total coliforms, Fecal coliforms, E-coli, Salmonella spp., Staph. aureus,* Yeast & mould count and corona virus (COVID-19).

5. CONCLUSIONS

1. Like any other manufacturing industry, the workshop environment of foundry is not completely free from pollution. Present research is conducted to detect pathogenic bacteria *Total coliforms, Fecal coliforms, E-coli, Salmonella spp., Staph. aureus,* Yeast & mould count on some of the essential raw materials used in the sand foundries and products manufactured.
2. A sand moulding foundry generally comprises pattern, moulding, core, fettling, salvaging and reshuffling shops. In all these shops some or other materials and tools are utilized to carry out different jobs:

a) **Pattern shop**, wooden piece is cut in the shape of the casting to be used as a 'pattern'.
Virus can survive on wood log and can take two days to leave (S. Bagley 2020). According to other observation wood surfaces are virus proof because of microstructure of wood and the presence of antimicrobial substances. To avoid the risk, the surface disinfection is recommended (Domig K, Wimmer R, 2020).

b) **Mould shop,** the mixture of silica, clay, bentonite, water and molasses is generally used for packing sand in the cope and drag and preparing the mould cavity for pouring the liquid metal. Culture report of silica sand, on Nutrient Agar, Maconkey Agar, Saberod Agar and Nutrient Broth indicates that none of the organisms, harmful for human health was present.

Microorganisms (Poliovirus) have been found to associate with clay particles of a size that may escape conventional filtration plants. Molasses is also prone to the microbes. The culture report of molasses shows the appearance of heavy fungus with Saberod Agar and heavy turbidity with Nutrient Broth.

c) **Special additives** added in the moulding material to develop different casting properties and to eliminate casting defects, such as biomass – cow dung contains *Lactobacillus plantarum, Lactobacillus casei, Lactobacillus acidophilus, B. subtilis, Enterococcus diacetylactis, Bifido bacterium* [8] and horse dung *Yersinia, enterocolitica, salmonella, Escherchia coli, Aeromona Clostridium tentn* [7].

d) **Waste foundry** sand (composition: sandy loam and silt + 30% waste foundry sand), *Phylogenetic* analysis shows *actinobacteria* 46%, *proteobacteria* 29%, *bacteroidetes* 5%

3. In new researches it has been demonstrated that corona virus is rapidly inactivated on the fabricated products of copper, stainless steel, silver, cadmium, enameled magnetic materials and stones & ceramics.

a) On range of **copper and copper alloys** such as brass, Cu-Ni corona virus inactivates within few minutes. Copper ion release and generation of reactive oxygen species (ROS) are vehemently involved in inactivation of HuCoV-229E. The transmission electron microscope (TEM) studies confirms that exposure to copper surfaces results in morphological change of human corona virus particles.

b) **Stainless steel:** Corona virus survives for more time on hard plain surfaces of stainless steel. Stainless steel forms fine passive film of Cr (III) oxide, (Cr_2O_3) which prevents surface corrosion and avoids from spreading it in metal's internal structure. In used and worn-out stainless steel utensils, when this layer ruptures, oxide spinals of Mn, Ni, Cr with FeO are formed, on which the corona virus can survive for little time. Porous surfaces are much less likely to hold viable amount of virus [Mackay I.M., Arden K, 2020]

c) Silver (Ag) is germicidal and is widely used as antimicrobial material, but it is relatively weaker contact killer as compared to the stainless steel and copper. Silver is stable under biosphere condition; oxides and Ag+ only form at acidic pH and the most oxidizing biosphere conditions.

d) **Magnetic Materials:** Magnetic material were also tested for suspected bacteria and corona virus. It was found free from pathogenic bacteria. Cfu was found <10 sq.in. and yeast mould count was observed <10 sq.in. The action of magnetic lines on bacteria and corona virus may be studied thoroughly.

e) **Sacred stones:** During *Rami,* in pilgrimage, the *Shaitan* is beaten (*Rami*) by stones in Mina. This stone and other sacred stones from *Hira* cave, *Thaur* cave, *Jabl-ul-Rehmat* and mountain *Uhud at Madina* are subjected to microbiological study. These were found free of pathogenic bacteria and corona virus (COVID-19).

4. In order to avoid the risk of corona virus for the labour working in these shops, it is necessary to take following measures for labour safety:

a) In **pattern shop**, the pattern maker touches the log from which the pattern is made. The surface of wooden log is may be polluted with microbes. The pattern maker must wear the mask and every tool being used by him should be sanitized.

b) In **mould shop,** every labour who works on the mould line should wear the mask and gloves and sanitize everything which they use. The best measure to avoid the risk of bacteria and viruses of these ingredients, is to use moulding machines, such as jolt machines, squeezing machines and automatic

conveyer belts for transportation of moulds.

c) In **fettling shop**, the casting is subjected to sand or grit blasting for surface cleaning. The labour working in this zone should wear mask, helmets and sanitize their hands and everything which touches the casting.

5. In modern foundries, all above mentioned jobs are carried out automatically. These automatic foundries are now in-use in all most all the countries. These employ very few workers; consequently they need less care for labour's protection. Therefore a contaminant free and virus free healthy atmosphere in working zone of foundry can effectively be obtained in automatic foundries. Despite the ongoing automation of foundry processes, especially small and medium sized enterprises still perform multiple operations in a manual manner.

6. ACKNOWLEDGEMENTS

I am grateful to Dr. Iqbal, Director General (Research) Punjab, Veterinary Research Institute, Lahore, Pakistan for extending cooperation in detecting the suspected viral infection in moulding materials samples. The cooperation extended by Prof. Dr. M. Suhail, Dy. Dean, Federal Postgraduate Medical Institute (FPGMI), Lahore, Pakistan is also highly appreciable. I am also thankful to Mr. Rao Zahid Mehmood, Dy. Secretary, Labour Deptt., Punjab and Syed Ahmed Awan, Centre for Improvement of Working Condition and Environment (SAACIWCE), Lahore, Pakistan. Special thanks are for PCSIR, Lahore for microbiological studies.

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