DEVELOPMENT OF COMPACTION SYSTEMS FOR RADIOACTIVE ASSORTED WASTE AND HEPA FILTERS, AN INDIAN PERSPECTIVE

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ABSTRACT

Indian nuclear establishments having multiple facilities generate substantial quantities of radioactive solid-waste per year. Bulk of this waste comprises of assorted waste and filters. Indian waste management program employs compaction and incineration as the two major techniques for their volume reduction. Incineration gives a very good volume reduction factor of around 50. However incineration systems are complex, capital oriented, and high man-Rem consuming due to requirements of ash fixation facility, elaborate off-gas treatment facility, high temperature safeguards and appreciable energy consumption. Only a limited spectrum of waste is amenable to incineration due to various limitations. In comparison, compaction gives a moderate volume reduction of around 5. However these systems are simple, economical, operating at ambient temperatures and consuming nominal man-Rem expenditure.

Compaction is a technique of void volume reduction under application of external force. Higher the applied force, higher is the effectiveness of compaction in terms of better volume reduction factor and lower spring-back. First generation compaction systems presently employed by Indian nuclear establishments are in-drum compaction systems suitable for low level beta, gamma waste. Being in-drum compaction systems these can not employ more than 35 tons compaction force. Their suitability for compaction of elastic materials like rubber/PVC is limited. These do not have alpha tight containment and totally remote non-contact operations. It makes them unsuitable for compaction of alpha waste and intermediate level waste. They also do not have engineered provisions of drum pelletization and filter compaction.

A second-generation compaction system overcoming the limitation of present systems, has become a necessity due to ever increasing waste volumes. Efforts are put in to indigenously develop a multi-purpose compaction system, meeting all the demands of compaction. It uses a compaction ram of 200 ton, operating inside a reusable sleeve, enabling application of complete compaction tonnage. Operations in totally airtight chambers, complete remote working and engineered provisions for drum pelletization make it suitable for compaction of complete spectrum of low and intermediate level beta, gamma as well as alpha waste. These have also provisions for denting the metallic frame

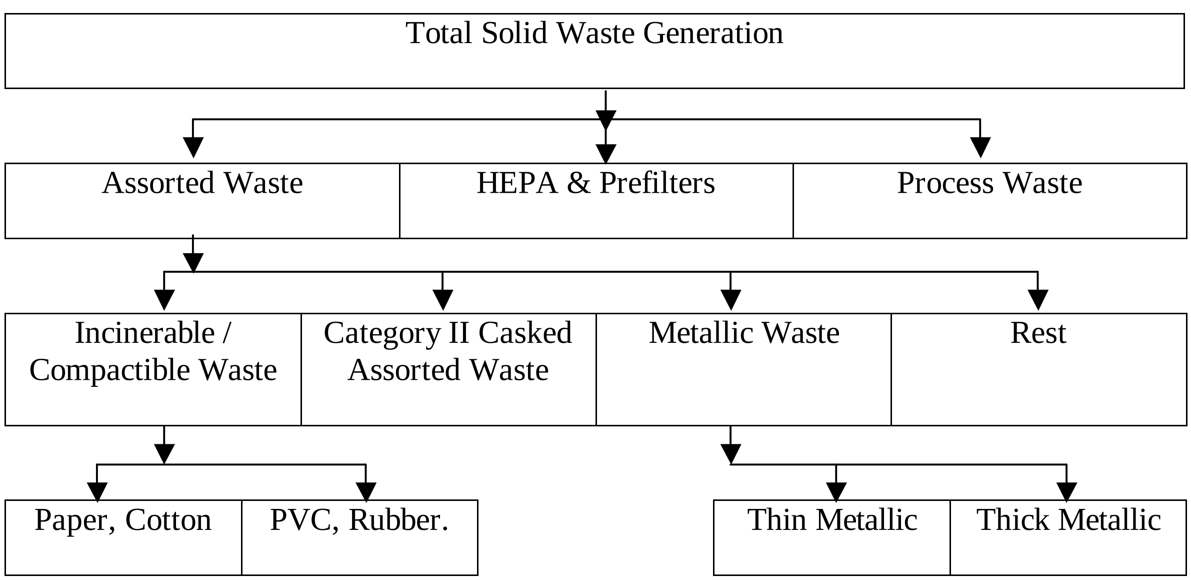
of HEPA filters, and then compacting the filter to ensure minimum release of activity during filter compaction. With the development of this system, waste compaction needs felt during the operating life span of Indian nuclear facilities, are expected to be met satisfactorily.

INTRODUCTION

India is having a full scale nuclear program spanning a complete nuclear fuel cycle right from mining, fuel fabrication, nuclear power generation, fuel reprocessing to waste immobilization. Facilities for all these activities are spread all over India. In addition to these India has also a full grown nuclear research and development organization which operates through numerous laboratories spread across India. Sizable quantities of radioactive solid-waste are generated from the operations of these various nuclear facilities such as nuclear power plants, nuclear reactors and laboratories, fuel fabrication and reprocessing plants, as well as waste management facilities. The management of this waste has to be done in a manner, to provide adequate protection to the plant personnel

TABLE - I

Solid Waste Generation
At Multi-facility Nuclear Site in India



and to the members of the public, that the exposures are within the limits prescribed by the regulatory authorities.

Types of low level and intermediate level radioactive solid-waste generated at various nuclear facilities are shown in table I. It consists of assorted waste, HEPA & Pre-filters and process waste. Assorted waste, also referred as `Dry Active waste` (DAW) essentially consists of paper trash, cotton waste, mops and apparels, PVC and rubber protective wears, metallic scrap, concrete chipping, glass laboratory wares, discarded wood etc. Process waste essentially consists of filter sludge and spent resin which are immobilized in a suitable matrix of cement / polymer before disposal. Non process waste comprising of category I, II & IV assorted waste and filters forms the bulk of the waste produced at a nuclear facility. In order to reduce the space requirement for its disposal at Near Surface Disposal Facility and also to avoid transportation of large waste volumes, these wastes are subjected to a suitable volume reduction technique of either incineration or compaction. Most of these wastes are amenable to volume reduction by either of these techniques. Incinerable waste is mostly compactible but the vice-versa is not true. Hence a larger spectrum of waste is amenable to compaction as compared to incineration. Table II indicates the specifications of waste categories as per Indian classification.

TABLE - II

Solid Waste Categories As Per Indian Classification

Category	Surface Dose	Type of Activity
I	0-200 mR/hr.	beta,gamma
II	200 mR/hr.-2 R/hr.	beta,gamma
III(A)	2-50 R/hr.	beta,gamma
III(B)	> 50 R/hr.	beta,gamma
IV	Alpha Waste	Predominantly alpha

INCINERATION

Incineration is a well-established technique, which results in a large volume reduction factor of the order of 50. Most of the radioactivity is retained in ashes, which are chemically inert solid byproduct of this system. Since ashes are dispersible in air these need to be immobilized by fixing in cement matrix. Only a limited spectrum of waste is amenable to incineration. Hence an efficient segregation system, to separate out burnable and non-burnable constituents, needs to accompany an incineration system. Segregation as well as management of secondary waste generation in the form of ashes involves multiple handling of waste, which results in higher man-Rem expenditure. Incinerator off-gases have appreciable carryover of radioactivity. Hence elaborate off-gas treatment facility needs to be provided. This facility also needs to be compatible with the corrosive properties of off-gases depending upon the waste constituents. Off-gas cleaning plants also cause secondary waste generation in the form of scrubbing chemicals / filters etc.

which need to be managed further. For efficient operation of incinerator specific attention needs to be paid towards avoiding the occurrence of un-burnt particles. Incinerator systems, by their very nature, are high temperature systems necessitating adequate safeguards. Due to these factors, incineration systems become complex and highly capital intensive. These are also high-energy consumption systems, which add up to the operating cost.

Incinerators, presently in use in India, are basically low level Beta, Gamma (category I) waste incinerators exclusively suitable for cellulose waste. These incinerator systems have mostly all contact operations, without any major provisions of shielding, in a non alpha tight environment. Hence these can not take care of intermediate level Beta, Gamma (category II) and alpha (category IV) wastes. These are also unsuitable for incineration of PVC and rubber. Combustion of halogenated plastics (e.g., PVC) and sulfur compounds (e.g., rubber) forms corrosive acid gases. These acid gases need a wet scrubber to control their release into environment, within limits prescribed by regulations. However `wet` operations represent a severe corrosion hazard within the system. Due to this a much more complex ` wet` off-gas treatment system, in terms of its design and materials of construction, becomes necessary for taking care of acid gases. However present day incinerators have provision of simple `dry` off-gas cooling and filtration, which is inadequate for controlling the release of acid gases to the environment. Hence these require essentially complete elimination of PVC and rubber from incinerator feed.

COMPACTION

Compaction is a volume reduction process for removing excess air from the waste. It results in a moderate volume reduction factor of the order of 5. However it is an economical technique due to moderate capital cost and low operation and maintenance cost. Operations being room temperature ones are simple and the fire risk is relatively negligible. There is no multiple handling of the waste. Generation of air-borne activity is also minimal. Hence man-Rem expenditure during operation is very low.

For combustible radioactive waste, incineration is the most logical treatment process. However a large volume of waste is either noncombustible or is not amenable to incineration due to design limitations of present day incinerators available in India. Most of this waste is compactible in a suitably designed compaction system.

WASTES AMENABLE TO COMPACTION

Following wastes are exclusively amenable to compaction if a properly designed compaction system is available.

- PVC and rubber waste of category I, II & IV.
- All assorted waste of category IV.
- Category I and IV, HEPA and Pre-filters of ventilation system.
- Thin metallic waste of category I, II & IV
- Casked assorted waste of category II

MECHANISM OF COMPACTION

Compaction mechanism performs through the reduction of void volume of waste materials under the application of external force, by rearrangement of the materials, initiating the brittle fractures and by introducing plastic flow of the materials, to fill up the voids as well as to maintain the compacted state, thus avoiding the spring-back which is the opening up of the compacted mass when external force ceases to be applied. Higher the external force higher is the effectiveness of compaction. Compaction mechanism has a limited aim of reduction of void volumes and the retention of the same. It does not aspire for compression of material at molecular level, as it requires a disproportionately large compressive force without any proportionate compaction benefits.

Ductile materials and brittle materials behave differently under the action of compaction force. These are discussed below in brief.

Compaction of ductile materials:

Ductile materials, when compacted, undergo a plastic deformation. This is partially recovered when the compaction force is released. Due to this the compacted mass tends to open up. The amount by which the compacted mass opens up is the spring-back. Increase in compaction force helps in reducing the spring-back by inducing increased plastic flow of the material.

Compaction of brittle materials:

Brittle materials, when compacted, break into smaller particles, which occupy the interstitial spaces of the bigger particles, resulting in volume reduction. Rearrangement of the particles due to force exerted by the compaction ram, also delivers similar results. Different arrangements of particles result in different void fractions. Simple cubic packing has a void fraction of 0.48. Random close packed arrangement is denser with a void fraction of 0.35. Hexagonal close packed is the densest with the void fraction of only 0.20. There is no spring-back associated with this kind of compaction.

In actual practice due to heterogeneous nature of the radioactive waste, its compaction follows both the compaction mechanisms discussed above.

PRESENT COMPACTION SCENERIO IN INDIA

Presently compaction systems of the capacity ranging from 50 to 200 tons are being utilized at various nuclear establishments in India, which can be termed as first generation compaction systems. These are essentially In-drum Compaction systems suitable for category I waste. Waste is placed in a drum which moves to a compaction station where a hydraulic ram platen enters the drum to compact the waste giving a volume reduction of around 5 without any pre-compaction. Compaction station is enclosed in a casing with door, which is provided with a exhaust system to create negative pressure inside the casing. Exhaust is sucked through the HEPA Filters to prevent particulate activity from escaping to the environment. Waste charging / recharging and drum capping are carried out manually. It caters to the compaction needs of category I waste consisting of paper, cotton, PVC, rubber, thin metallic etc. However these are most suitable for the compaction of category I cellulose waste which is the major component of assorted waste generated by the power reactors.

INADEQUACIES OF PRESENT COMPACTION SYSTEMS

A number of limitations are imposed over the utility of present compaction systems due to the very nature of their design. A brief discussion about these follows.

For category I cellulose waste, incineration is the ideal choice of waste management. Compaction of this waste is only a second preferred choice. Hence compaction of this waste is resorted to, only in case of non-availability of incineration system. It seriously hampers the utility of these compaction systems.

These are In-drum Compaction systems. As compaction is carried out inside a drum, lateral component of the vertical compaction force has to be resisted by the drum walls. Drums are generally mass manufactured 200 litre carbon steel drums having shells manufactured from 18 SWG carbon steel sheets with a double lap joint for the seam. As the compaction force increases there is a proportionate rise in the lateral component being resisted by the shell and its seam. It is observed that at around 35 ton compaction force the drum seam starts opening up as it is no more able to resist the lateral component. Hence any excess capacity of the ram over and above 35 tons can not be utilized for In-drum Compaction, as there is no provision to prevent lateral forces generated during compaction from acting on the drum walls. This limitation on the compaction force results in an inadequate control over the spring-back of the waste compact. This necessitates the drum lid to resist the spring-back, which on occasions fails to do so successfully.

Materials like rubber, PVC etc. are also compacted by these In-drum Compaction systems. However due to their high elasticity very little permanent deformation takes place, at the 35 ton compaction force employed by In-drum Compaction mode. Due to elastic nature of deformation the compacted mass tends to have an uncontrolled spring-back. It has been observed that at times even spring-back arrestors are unable to resist it. Cases of drum lid being pried open due to this are reported on occasions. Hence these systems have limited suitability for the compaction of elastic materials like rubber, PVC etc.

Thin metallic waste is compacted in these systems by In-drum Compaction mode. However it involves additional waste handling due to manual charging and recharging of the drum. As these systems are designed for most of the contact operations, it results in increased man-Rem expenditure.

Experience of operating these systems has shown that assorted waste, though supposedly \`dry\`, often exudes water during compaction due to presence of absorbents, cleaning mops, wetted waste etc. However there is no provision for spill-free containment and management of this contaminated water. This leads to spread of contamination to areas located around the compaction bed.

Presently available systems can not take care of compaction of category IV waste, as the handling of waste as well as capping of the drum is a manual operation, thus bringing the operator in close proximity of waste. These manual interventions are in open, which can cause personnel contamination and spread of alpha activity. Compaction operations are carried out under negative pressure in an enclosure, which is not leak-tight. Hence possibility of air activity leaking out to the environment under unforeseen circumstances can not be ruled out. Alpha waste compaction needs absolute containment of the air displaced during compaction. It also needs totally non-contact operations, which in turn means totally remote operations. As the present systems do not provide these facilities, these systems are found inadequate for alpha waste compaction.

These systems are also found inadequate for category II waste compaction, as all operations excluding compaction are manual contact operations. As no remote operations are available compaction of category II waste will result in unacceptably high man-Rem expenditure.

These systems do not have properly engineered facility required for compaction of HEPA filters, which can ensure compaction of filter without any appreciable release of activity from the filter. Hence HEPA filters are presently not compacted in India.

Systems available presently, also do not have suitably engineered facility for drum pelletization, which can compact the waste alongwith its container and convert it into a pellet.

DEVELOPMENT OF MULTIPURPOSE COMPACTION SYSTEM

India's growing nuclear program has led to the generation of higher quantities of solid waste, which include alpha waste, HEPA and pre-filters, intermediate level assorted waste, PVC and rubbers, as well as thin metallic components. As need is felt to manage these wastes in a safe manner on tech-economically sound basis, a second generation compaction system incorporating improved design features has become a necessity. From this point of view, efforts are being put in to indigenously develop a multi-purpose compaction system, which is versatile enough to meet all the demands of compaction of waste, raised by the operating facilities.

In view of the limitations of presently available systems, we have undertaken the development of a multipurpose compaction system with the objective of compaction of category I, II & IV assorted waste consisting of cellulose waste, PVC/rubber, thin walled metallic waste as well as HEPA filters.

Multi-purpose compaction system is provided with a 200 metric ton hydraulic ram unit for compaction. It has a capacity of 5 m^3 per day, achieving a volume reduction factor of around 5 for most of the waste generated during the operating life of a nuclear facility.

Compaction is carried out in a reusable compaction sleeve which resists the lateral forces generated during compaction, thus preventing them from acting on the walls of the waste drum. It moves up and down to facilitate loading, unloading and capping of the drum. Due to introduction of the compaction sleeve full capacity of the 200 ton ram can be utilized, thus ensuring minimum spring-back of the waste compact.

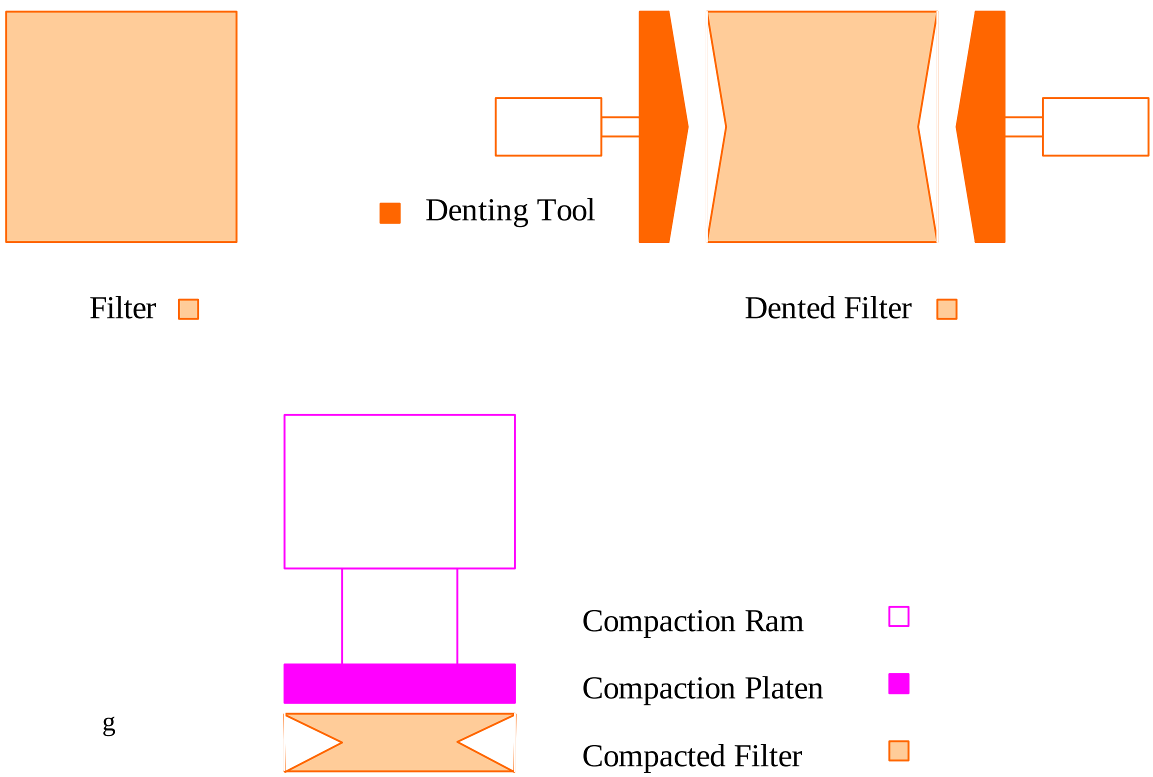
To suit compaction of category IV waste all operations are carried out in a compaction chamber, which provides absolute containment with zero leakage of contaminated air released during compaction. Compaction chamber is provided with intervention chambers for feeding waste, drums and drum lids. These intervention chambers have double door system to prevent spread of alpha contamination. Compaction chamber is provided with ventilation system consisting of supply fan and exhaust fans for treatment of air released during compaction. Air is sucked through HEPA filters to control discharge of activity into the environment. Complete ventilation system is provided with proper interlocks to ensure that compaction is carried out only under leak tight condition of enclosure and positively under negative pressure inside the enclosure.

System is provided with the complete remote operations of drum transport, waste feeding, waste compaction, lid placement and capping, and waste compact encasing for personnel protection and to prevent spread of contamination. Waste compact drum is remotely capped and sealed with suitable gaskets to make airtight containment of waste compact. All remote operations also facilitate in compaction of category II waste due to man-Rem expenditure control.

Suitably engineered facility for pelletization is provided to facilitate compaction of elastic materials like rubber, PVC etc, contained in a carbon steel drum, by compacting the drum in a sleeve which causes plastic flow of drum walls to form a permanently set waste compact, i. e. a pellet. Permanent plastic deformation of the drum walls restrains the rubber / PVC waste inside the pellet and prevents its spring-back.

To prevent spread of liquid contamination, the system is provided with built-in provisions for containment of water exuded during compaction and for decontamination of compaction bed.

Multi-purpose compaction system also has provision for compaction of HEPA filters. Most widely used HEPA filters are constructed from a continuous length of sheet of pleated, high efficiency glass fibre filter medium to form a filter pack with corrugated aluminium separators inserted in between. The filter pack is housed within a epoxy coated carbon steel filter frame and sealed to its side frame members with Polyvinyl acetate (PVA) based sealant to prevent the escape of unfiltered air. The filter is provided with soft neoprene gaskets on one or both the faces of the filter. A universally standardized filter has face dimensions of 609 mm x 609 mm with a depth of 292 mm, which can handle 1700 m^3/h of air at a pressure drop of 25 mm of water column. Through developmental efforts (1) it has been established that HEPA filters can be successfully compacted, without release of any appreciable amount of activity from the filter medium, if metallic frame is dented from the sides first and then filter is compacted with about 40 tons force. This folds the filter frame as well as the glass fibre filter medium into a compact mass. It gives a volume reduction factor of around 5. Hence there is a provision for denting the filter with the help of a denting tool and its subsequent compaction by compaction ram. Studies on effectiveness of 200 tons force for filter compaction shall be carried out on development of this multi-purpose compaction system.



FILTER DENTING & COMPACTION

FIGURE - 1

COMPACTION MODES

This system performs in 3 compaction modes.

In-drum Compaction:

A compaction sleeve is provided which enters the drum. Waste is placed in the sleeve and compacted. Proper design of the sleeve facilitates in utilizing the complete compaction force of 200 tons. Full utilization of the ram capacity results in higher volume reduction factor and lower spring-back. On completion of compaction, sleeve is lifted up, leaving waste compact contained inside the drum.

This mode is suitable for the compaction of category I and IV cellulose waste.

Drum Pelletization:

A compaction sleeve encloses the waste drum to be pelletized, from outside. Hydraulic ram enters the sleeve and compresses the waste drum inside the sleeve to form a pellet. Compaction sleeve is lifted up and pellet is grabbed and placed in a drum.

This mode is suitable for the compaction of drums containing full load of rubber /PVC, thin metallic scrap and category II assorted waste.

Filter Compaction:

HEPA filter with steel frame and glass fibre medium is placed in a denting chamber and steel frame is dented by about 50 mm from both sides. . Dented filter is placed in a compaction sleeve and compacted by a hydraulic ram. A circumferential water atomizer sprays a fine mist of water around the edges of the filter compaction platen thus preventing the activity from getting airborne during compaction. Lifting the sleeve releases the filter in the drum.

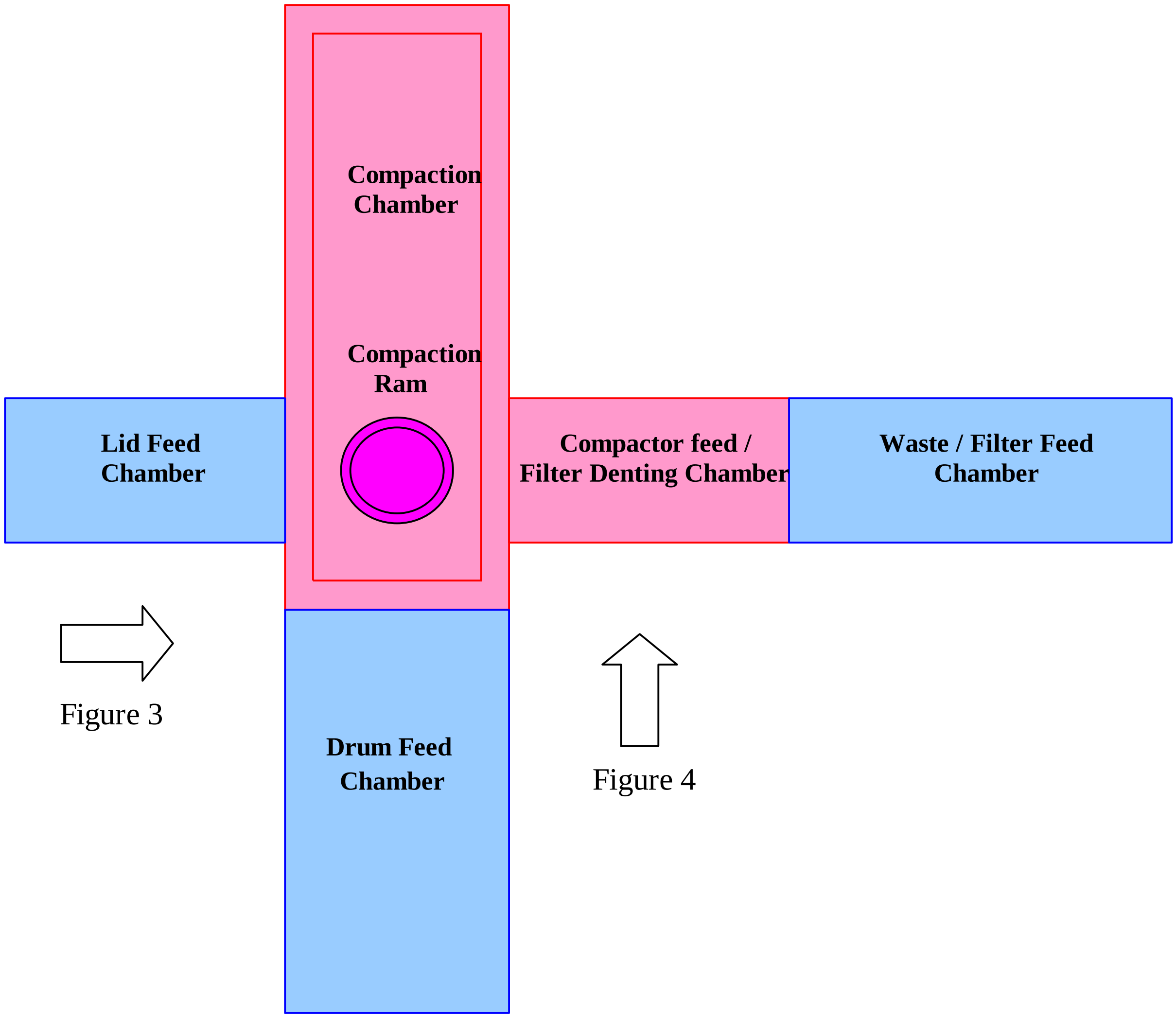
This mode is suitable for compaction of HEPA filters as well as pre-filters having metallic frames and dimensions similar to HEPA filters.

SYSTEM DESCRIPTION

A general configuration of the system is indicated in figure no. 2. A schematic representation of sectional side view and sectional front view are presented by figure nos. 3 and 4 respectively. System consists of following subsystems / major components.

Empty Drum Charging Mechanism:

A drum feed conveyor is located inside a drum feed chamber, on which empty drum is remotely lowered. By conveyor operation drum is brought to drum pickup station. It is grabbed and lifted remotely to facilitate its placement on compaction bed. Compaction bed is mounted on a hydraulically operated sliding table. It is provided with a detachable self indexing guide which facilitates the placement of drum on bed top maintaining concentricity with respect to the bed centre. Sliding table has a provision to raise and lower it, in order to transfer the compaction load directly to the foundation.



TOP VIEW – COMPACTION SYSTEM

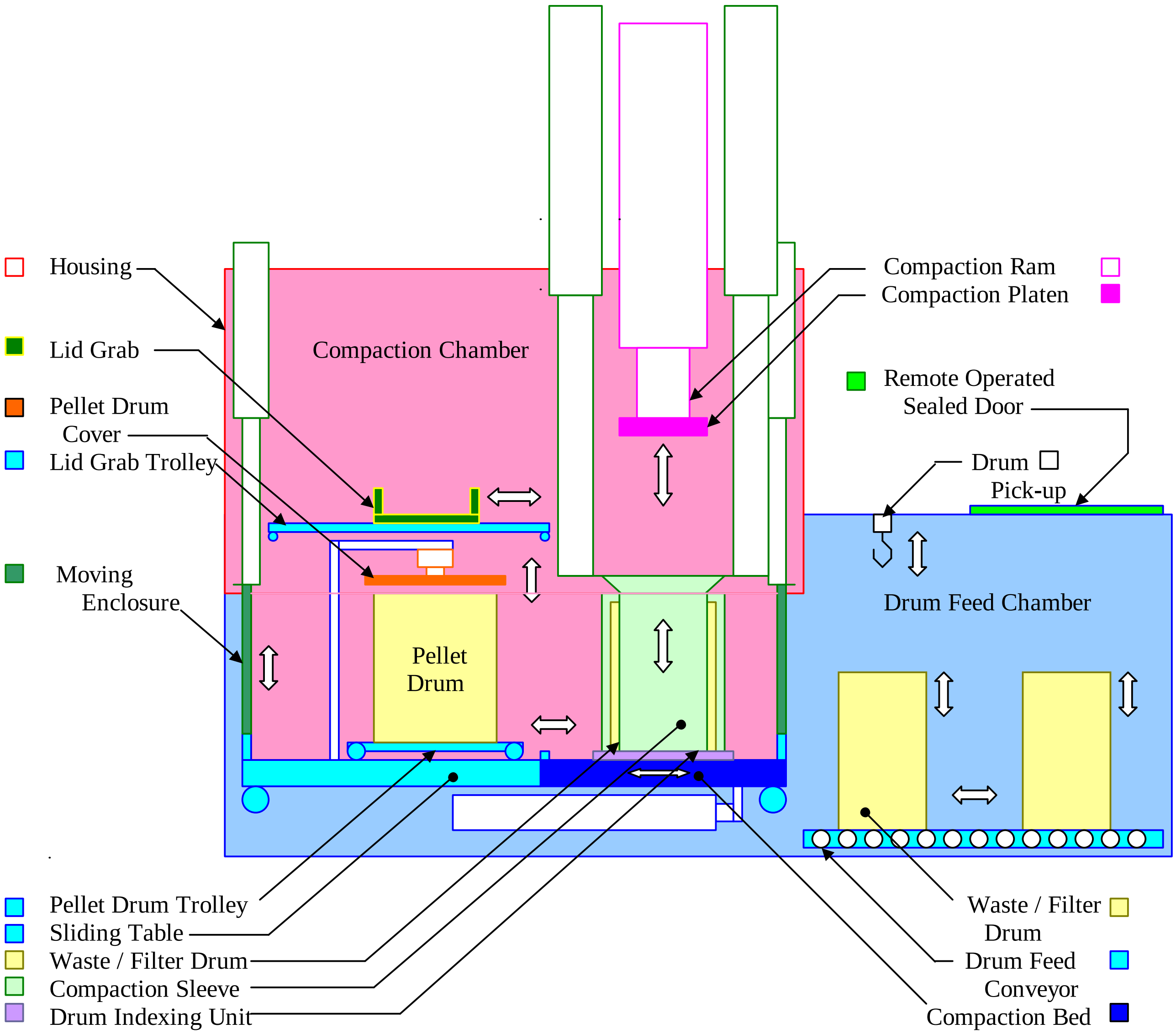
FIGURE - 2

Moving Enclosure:

An enclosure, which can be raised and lowered, is provided inside the housing. In lowered position it rests on the sliding table top with suitable sealing arrangement with respect to sliding table as well as with the housing, so that compaction chamber becomes absolutely air tight to work under negative pressure. Moving enclosure is lifted and sliding table is pushed out. Empty drum is lowered onto the compaction bed. Sliding table is brought in and moving enclosure is lowered to sit on the sliding table tightly.

Compaction Sleeve:

Three sleeves, one each for In-drum Compaction, Filter Compaction and Drum Pelletization are provided, which are installed as per the operating mode.



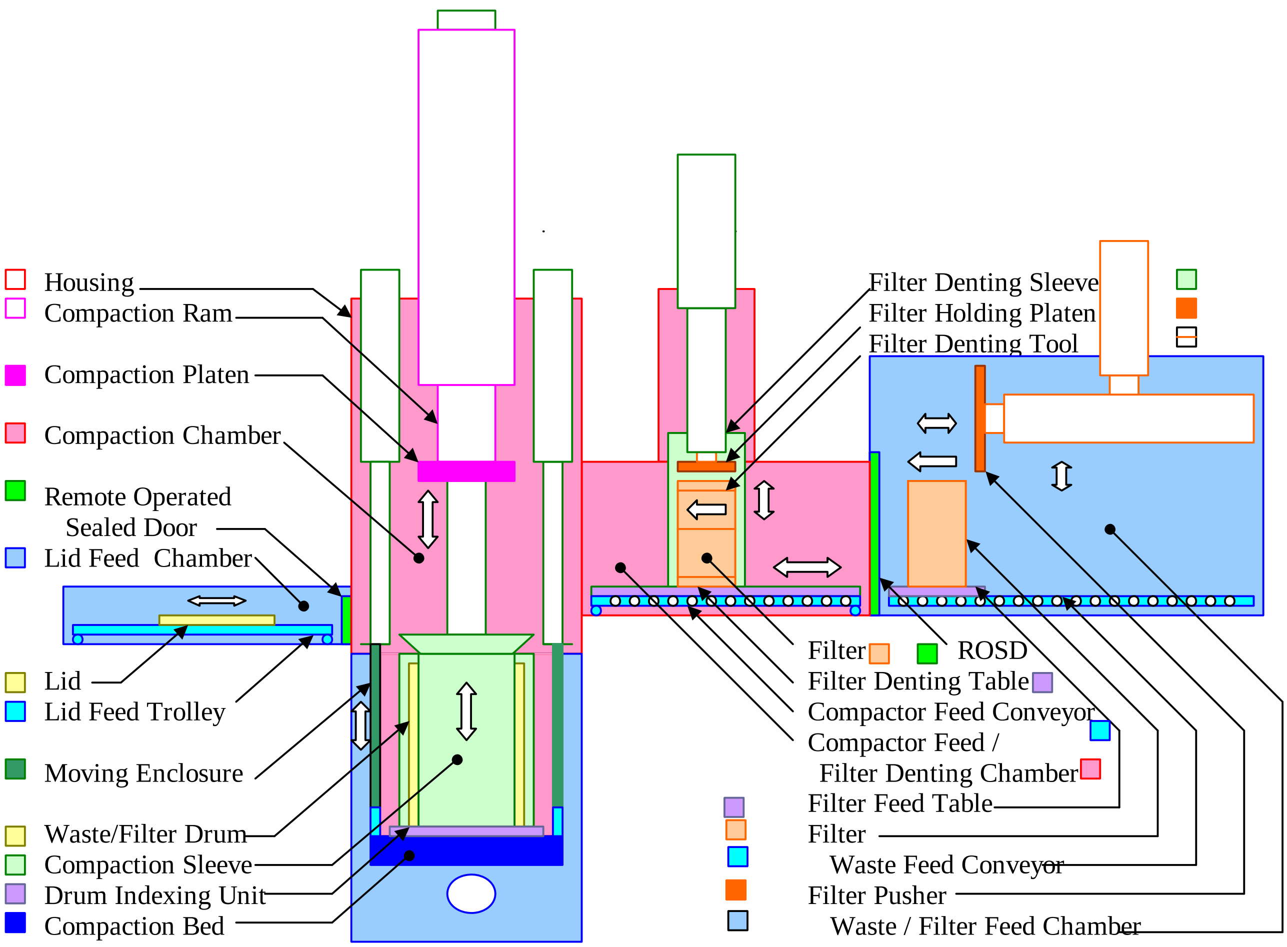
SECTIONAL SIDE VIEW – DRUM FEEDING & COMPACTION

FIGURE - 3

- For In-drum Compaction, a sleeve which goes inside the drum, is provided. Waste is placed and compacted inside this. It is dual walled to enclose the drum from outside, thus preventing external drum contamination.
- Filter compaction sleeve is rectangular in geometry. It is also dual walled to enclose the drum from the outside. It is lowered into the filter container to receive the dented filter for compaction.
- Drum pelletization sleeve encloses the waste drum from outside and compaction ram goes inside the sleeve to compact the drum into a pellet.

Waste Feed chamber:

Waste producers, at the source itself, carry out basic segregation of assorted solid waste and waste is packed in polythene bags and collected in 200 litre drums. Compactible



SECTIONAL FRONT VIEW – WASTE / FILTER FEEDING & LID FEEDING

FIGURE - 4

waste packets are manually transferred to the waste feed chamber attached to the compaction chamber for remote feeding of solid-waste into the compactor. Waste is loaded onto a waste fed conveyor comprising of a motorized belt conveyor. Capacity of the feeding system is such that required quantity of waste feed can be collected. Compactor feed chamber is opened. Compactor feed conveyor is pushed backward and coupled with waste feed conveyor. Waste feed conveyor is operated to feed waste to the compaction feed conveyor.

Compaction Feed Chamber:

It is an extension of compaction chamber. It contains a compactor feed conveyor, which consists of a motorized belt conveyor mounted on a hydraulically operated trolley. On receipt of waste from waste feed conveyor, compactor feed conveyor is pushed forward and operated to place waste inside the drum.

Filter Feed Chamber:

Waste feed chamber doubles up as a filter feed chamber. Filter feed table is installed on waste feed conveyor where filter is placed manually. A filter pusher is provided for pushing the filter onto the filter-denting table. It is lowered and operated for pushing the filter.

Filter Denting Chamber:

Compactor feed chamber also doubles up as a filter denting chamber. A removable filter-denting table is mounted on the compactor feed conveyor for the purpose of filter denting. Compactor feed conveyor is pushed back to couple the filter-denting table with the filter-feeding table. Filter pusher pushes the filter onto the filter-denting table. Filter denting table is brought in denting position. Two hydraulically operated denting tools are located inside the denting chamber on two sides of the filter. A filter-denting sleeve and a filter holding platen are mounted on a telescopic hydraulic dual ram. Filter denting sleeve is lowered over the filter and filter is dented from two sides by operating the denting tools. Denting tools are withdrawn and filter-holding platen is lowered to hold the filter in position. Filter denting sleeve is raised to free the filter. Compactor feed conveyor is pushed forward inside the compaction chamber. Filter is lifted by filter grab and placed inside the filter compaction sleeve for compaction.

Compaction Ram Unit:

Hydraulically operated ram system is provided to exert on the waste a vertical compressive force upto 200 tons, through a compaction platen. Ram unit has a provision to adjust the stroke length and compressive load as per requirement. Programmable Logic Controller (PLC) based digital display unit is provided to display the ram position and compressive force during compaction with ultimate limit switches to prevent over travel and overloading.

Platens:

Three detachable platens are provided for In-drum Compaction, Drum Pelletization and Filter Compaction. All the three platens carry expandable jaws for attaching the lid grab. Platen for Drum Pelletization carries a hydraulic pellet grab for placing the pellets in the pellet drum. Platen for Filter Compaction carries a filter grab and circumferential water atomizer to prevent activity from getting airborne during filter compaction.

Remote Capping:

It consists of lid feeding, lid grabbing and lid sealing systems. A lid grab trolley is provided inside the housing for carrying a lid grab. It slides below the compaction ram and the lid grab is attached to compaction platen with the help of expandable jaws. Lid grab is provided with dual grabbing system consisting of electromagnets as well as vacuum cups, to prevent lid detachment due to any single failure. A lid feed chamber houses a lid feed trolley, which can slide into the compaction chamber. This trolley carries the lid and feeds it to the lid grab attached to the ram. Ram places the lid on the drum and pushes it down to lock the lid with the help of auto clamps provided on the lid, simultaneously sealing the drum with the help of sealing rings provided inside the lid to make the drum airtight.

Housing:

All the components of the system such as sleeve, ram, compaction bed, moving enclosure etc are housed in a metallic enclosure to contain air activity and also to facilitate the operations at the negative pressure. Housing is provided with the transparent windows to view the operations. Complete compaction system inclusive of housing and various feeding chambers is provided with remote operated sealed doors to ensure the air-tightness of the enclosures.

Spring-back Arrestor:

Compaction is carried out in a sleeve at a compaction force upto 200 tons with adequate curing period. This results in permanent setting of the waste compact. After withdrawal of the sleeve an annular gap is created between the waste compact and the drum. This annular gap provides space for lateral expansion of the waste compact. These provisions mostly control any serious spring-back.

If needed, a spring-back arrestor in the form of a suitably designed metallic disc, is placed on lid trolley and fed to the compaction chamber in the same manner as lid and installed in the drum before capping the drum.

Pellet Encasement:

Sliding table is provided with a pellet drum trolley for loading and unloading a pellet drum. It is also provided with hydraulically operated pellet drum cover as a transient sealing arrangement to keep the partly filled pellet drum closed during loading of subsequent batches of waste drum for pelletization.

Decontamination Provision:

Compaction bed is having a skirt all around its periphery to contain the contaminated water exuded during compaction. A set of spray nozzles is installed around the 4 sides of compaction bed, for flushing the compaction bed, by spraying water / decontamination solutions without any splashing. Sets of sump, pump and piping are provided for feeding, collection and discharge of these flushing solutions.

VENTILATION SYSTEM

Compactor housing alongwith moving enclosure and sliding table coupled with their sealing arrangement form the compaction chamber. Compaction chamber and all the feed chambers are always maintained under negative pressure of 25 mm of water column, so that particulate released during compaction do not escape to the environment. During waste feeding and compaction process radioactive particles can get airborne. In order to prevent their settling and straying around, suitably designed forced ventilation through a supply fan is provided in compaction chamber. Negative pressure is maintained by providing exhaust to all the chambers through an exhaust fan. An additional exhaust fan is provided as operating standby with auto changeover facility. Exhaust fans suck through a bank of pre-filters and HEPA filters to clean the air before releasing it to the environment. HEPA filters have a particulate filtration efficiency of 99.97 % down to 0.3 micron, and have a total operating pressure drop of 25 and 100 mm of water column in clean and choked conditions respectively. Ventilation system is so designed that flow of air in compaction chamber is always from bottom to top towards exhaust port to prevent settling of radioactive particles and contamination of external surface of the drum. Adequate air velocity in compaction chamber is maintained to achieve the same. Flow of air from feed chambers is always towards the compaction chamber to prevent escape of radioactivity from compaction chamber to the feed chambers.

Following logic is incorporated, to ensure the negative pressure inside the complete system and regulated flow of air towards the exhaust port of the compaction chamber.

- Auto changeover from one exhaust fan to other in case of failure of one.
- Auto – ON for second exhaust fan in case of drop of system negative pressure.
- Auto – OFF for supply fan for further drop of system negative pressure with audio-visual alarm.
- Auto cutoff of supply air to compaction chamber whenever feed chamber doors are opened.
- Continuous monitoring of differential pressure across the filters.

CONTROL SYSTEM

- PLC based sequence controlled operations.
- Interlocks of movements of ram, trolleys, doors and ventilation system.
- Audiovisual annunciation of all interlocks.
- Visual indication of status of all operations.
- An infrared / ultrasonic system with digital display to indicate the height of waste fed into the drum and the height of waste compact.
- Auto stop of waste feed at desired presets.
- Manual override for all auto operations.
- Indication of negative pressure inside the compaction and feeding chambers.
- Indications of pressure drop across air filtration system.
- Housing air-monitoring system.

SAFETY ASPECTS

- Auto tripping of ram movement against over-loading and over-travel.
- Emergency stop and return for the ram.
- Logic controlled auto operations of ram, trolleys and doors.
- Total shutdown in case of fan failure or seals failure indicated by drop in negative pressure in the enclosures.
- Auto-tripping of the movements of moving enclosure, sleeve, trolleys and doors against overloading.
- Visual monitoring to the extent possible.
- Dual grabbing system for lid grab based on electromagnets as well as vacuum cups.

COST ESTIMATES

Estimated manufacturing cost of the multipurpose compaction system in India excluding development expenses is expected around 100,000 U.S. Dollars i.e. around 4.5 million Indian Rupees.

PRESENT STATUS OF DEVELOPMENT

We are in the process of procurement of a developmental prototype of multi-purpose compaction system through indigenous hydraulic press manufacturing industry. Few Indian manufacturers have shown keen interest in this system. Tenders have been opened and bid evaluation is under progress. It is expected to take about one year for delivery of the system after the placement of purchase order.

CONCLUSION

Development and implementation of multi-purpose compaction system is expected to fulfil the compaction needs of all the non-process wastes generated during the operating lifetime of Indian nuclear facilities. With the advancing age of these nuclear facilities, these shall become due for decommissioning in very near future. This shall result in generation of large quantities of heavy metallic waste due to discarded equipment. Hence further efforts need to be put in towards the development of super compactors of around 2000 tons capacity which will be able to meet the demands of compaction raised by decommissioning of the nuclear facilities.

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