A
Seminar report
On

Cryogenic Grinding

Submitted in partial fulfillment of the requirement for the award of degree
Of Mechanical

SUBMITTED TO:

www.studymafia.org

SUBMITTED BY:

www.studymafia.org

www.studymafia.org

Preface

I have made this report file on the topic **Cryogenic Grinding**; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to ……..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

www.studymafia.org

Acknowledgement

I would like to thank respected Mr…….. and Mr. ……..for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my parents who patiently helped me as i went through my work and helped to modify and eliminate some of the irrelevant or un-necessary stuffs.

Thirdly, I would like to thank my friends who helped me to make my work more organized and well-stacked till the end.

Next, I would thank Microsoft for developing such a wonderful tool like MS Word. It helped my work a lot to remain error-free.

Last but clearly not the least, I would thank The Almighty for giving me strength to complete my report on time.

www.studymafia.org

CONTENTS

1. Introduction
2. Application of Cryogenics
3. Cryogenic Grinding Process
4. Cryogenic Grinding Technology
5. Advantages of Cryogenics
6. Application of Cryogenic Grinding
7. Problems with Conventional Grinding
8. Advantages of Cryogrinding with Liquid Nitrogen
9. Working of Cryogrinding Plant
10. Future Prospects
11. References

www.studymafia.org

Introduction

The term “Cryogenics” originates from Greek word which means creation or production by means of cold. As prices for energy and raw materials rise and concern for the environment makes safe waste disposal difficult and Costly, resource recovery becomes a vital matter for today’s business. Cryogenic grinding technology can efficiently grind most tough materials and can also facilitate Cryogenic recycling of tough composite materials and multi component scrap. The heart of this technology is the CRYO-GRIND SYSTEM. It employs a cryogenic process to embrittle and grind materials to achieve consistent particle size for a wide range of products. The cryogenic process also has a unique capability for recycling difficult to separate composite materials.

Cryogenic grinding is a method of powdering herbs at sub-zero temperatures ranging from 0 to minus 70°F. The herbs are frozen with liquid nitrogen as they are being ground. This process does not damage or alter the chemical composition of the plant in any way. Normal grinding processes which do not use a cooling system can reach up to 200°F. These high temperatures can reduce volatile components and heat-sensitive constituents in herbs. The cryogenic grinding process starts with air-dried herbs, rather than freeze-dried herbs.

Solid materials are ground or pulverized by way of hammer mills, attrition mills, granulators or other equipment. A smaller particle size is usually needed to enhance the further processing of the solid, as in mixing with other materials. A finer particle also helps in melting of rubber and plastics for molding. However, many materials are either very soft or very tough at room temperatures. By cooling to cryogenic temperatures with liquid nitrogen, these may be embrittled and easily fractured into small particles.

www.studymafia.org

A scientifically controlled study using four herbs was conducted at Frontier Herbs in the Fall of 1996, comparing cryogenic grinding methods with normal grinding methods. The herbs tested included feverfew, goldenseal, valerian and echinacea. In all cases the cryogenically ground herb contained greater amounts of the constituents tested. Feverfew herb showed the greatest difference, with the cryogenically ground herb containing 21.8% higher levels of parthenolide, the primary active constituent. Valerian root showed an 18.7% increase in valerenic acid when cryogenically ground. Goldenseal root showed a 16.4% increase in berberine and 10.7% increase in hydrastine. Lastly, Echinacea purpurea root showed a 12.1% increase in total phenolic content in the cryogenically ground root. Test results were obtained by HPLC (high performance liquid chromatography) methods.

Cryogenic grinding was shown to significantly affect active constituent levels in herbs. Test results showed an average increase of 15.6% in constituents tested in four medicinal herbs when they were ground cryogenically. The range was 10.7% to 21.8%, indicating that some herbs are affected more than others by the temperatures at which they're ground.

www.studymafia.org

APPLICATION OF CRYOGENICS

The major areas in which cryogenics find its applications are : -

1. Gas Industry – in air separation. The volume of production of nitrogen and Oxygen by cryogenic separation of air is the important of the separation of air, refrigeration and separation. In the separation column, the difference in the boiling points of the constituents of air is used to separate them out.
2. As the source of gas. For example, the breathing oxygen needed for the pilots of the fighter aircraft is supplied by vaporizing liquid oxygen on board. In this way is a weight reduction of 65% and space reduction of 85%.
3. In space research – as rocket propellant and for space simulation. The most important advantage of cryogenic fuels is that these have very high specific impulse when compared to other fuels (specific impulse is kgs of thrust produced per kg of propellant per sec). The value is approximately 500 for cryogenic fuels whereas it is about 250 for alcohol oxygen mixture.
4. In biology – for preservation and in treatment of diseases.
5. In food industry – for food handling and processing
6. In electronics – both semiconductor and superconductor electronics for better signal to noise ratio speed etc
7. In miscellaneous applications such as cryogenic grinding , freezing pipelines for repairs, shrink fitting, fire fighting, etc
8. In medicine – Magnetic Resonance Imaging, Magnetic Resonance Spectroscopy (MRS), Magneto Cardio Graphy (MCG), etc.
9. In nuclear and high – energy physics
10. Metal fabrication

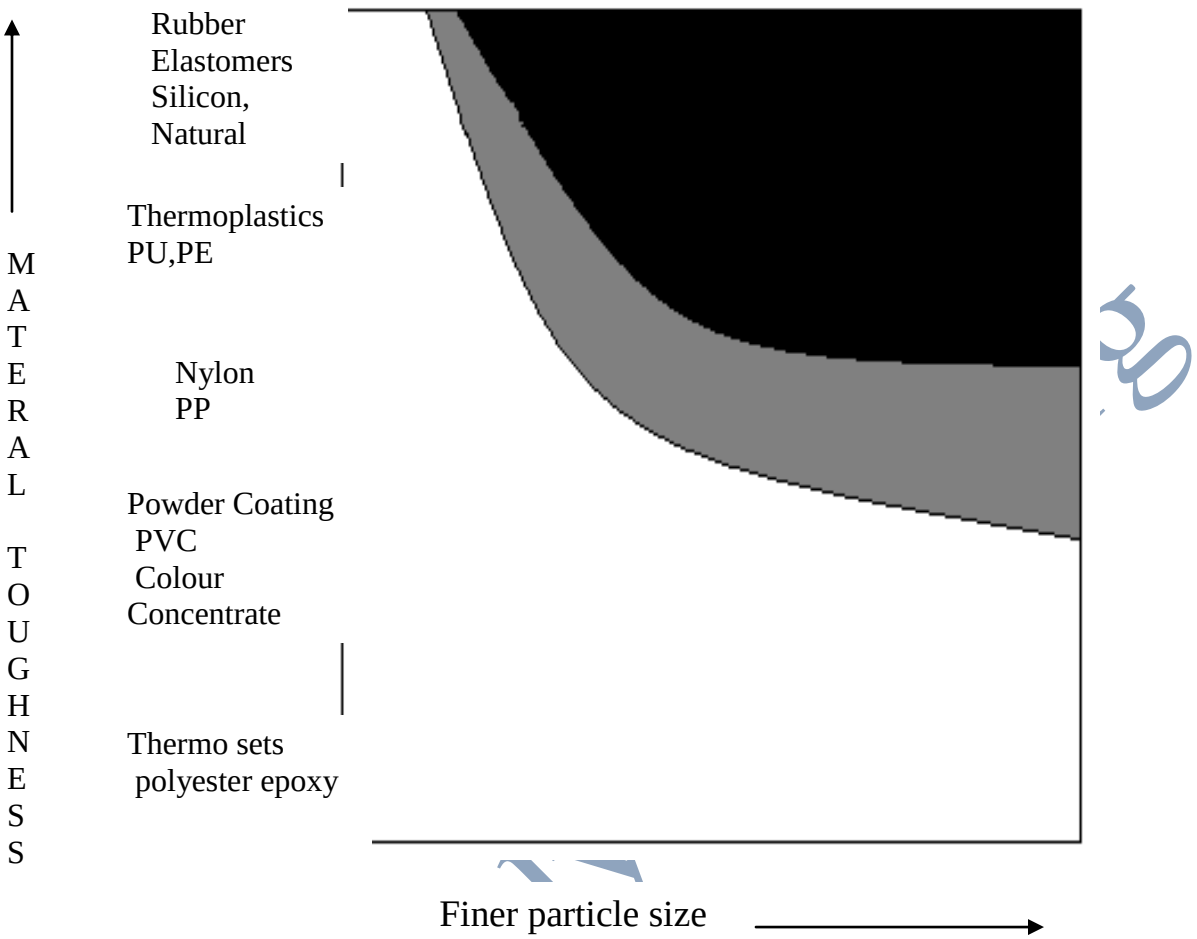
www.studymafia.org

CRYOGENIC GRINDING PROCESS

Since almost all materials embrittle when exposed to cold temperatures, cryogenic size reduction utilizes the cold energy available from liquid nitrogen to cool, embrittle and inert materials prior to and or during the grinding process. All materials which due to their specific properties at ambient temperatures are elastic, have low melting points, contain volatile or oily substances, have low combustion temperatures and are sensitive to oxygen, are ideal candidates for cryogenic size reduction.

Physical properties of liquid nitrogen is produced by the separation of air into its components in an air separation plant and is distributed in vacuum insulated transport vessels to the end user where it is stored in a vacuum insulated storage vessel till it is used. At atmospheric pressure liquid nitrogen is at a temperature of –320 deg F and possesses a latent energy content of 94 BTU/LB resulting in a total cooling energy content of 179.6 BTU/LB. Nitrogen is anon-flammable, non toxic and inert gas which makes up 78.09% of the air we breathe. It has the characteristics of an inert gas, except at highly elevated temperatures, and does not form any compound under normal temperatures and pressure. Drawn from the liquid phase, nitrogen generally has a purity of 99.998 % with a dew point less than – 100 deg F and is very dry.

www.studymafia.org



Rapid embritlement of tough materials

Liquid Nitrogen at 77.6 K is used to embrittle a material prior to size reduction. Once brittle the material is much easier to grind. When CRYO-GRIND system is used to recycle composite or multi component materials, two separate phenomena occur. First, since each component generally would have a different coefficient of thermal contraction, high thermal stresses are created at the interface between the components due to rapid cryogenic cooling. Second, because each component material embrittles at different temperatures, it allows selective embritlement, which further enhances separation effectiveness. The most brittle components will undergo greater size reduction. Through careful control of thermal stress and embritlement with operating temperature, cleaner separation and recovery of individual components are achieved.

Cryogenic Grinding System

When using the system, measurable and repeatable results are obtained for lab or productions calculations. Mills range in size from 7-1/2 HP to 200 HP. With our cryogenic grinding unit an understanding develops with interaction of equipment components and operating parameters. Factors such as consistent feed rate, precise temperature measurement, mill operating parameters and pressure control are critical to the evaluation of cryogenic grinding and cryogenic grinding systems.

Cryogenic Grinding System

www.studymafia.org

CRYOGENIC GRINDING TECHNOLOGY

For pulverizing many materials, cryogenic grinding technology increases productivity and lowers power costs. Many elastic or "soft" materials are very difficult to pulverize, requiring long cycle times and high energy consumption. This combination decreased productivity and increased costs unnecessarily. Cryogenic grinding involves cooling a material below its embrittlement temperature with a cryogenic fluid, typically liquid nitrogen or, in certain applications, carbon dioxide. After cooling, the material is fed into an impact mill where it is reduced in size primarily by brittle fracture. This process has several benefits:

- Ability to process relatively "soft" or elastic materials that cannot otherwise be ground
- Increased throughput
- Reduced power consumption
- Smaller size particles
- Minimal loss of volatile components
- Lower capital investment

Probably the greatest benefit provided by cryogenic grinding is the ability to grind "soft" or elastic materials that otherwise could not be ground, or could be ground only with long cycle times and high energy use. By embrittling the material, fine powder or crumb can be obtained easily and with a minimum expenditure of energy. Because embrittled material grinds easily, the throughput for a given mill is substantially increased and less power is used per pound of material ground.

Cryogenic grinding also reduces the material to particle sizes difficult or

www.studymafia.org

impossible to attain with ambient temperature grinding. The dry, cold, inert atmosphere in which the grinding occurs minimizes reaction with the material and reduces the loss of volatile components. When processing composite materials, cryogenic grinding usually makes it easy to separate the various materials.

Cryogenic grinding is used for grinding spices, thermoplastics, elastomers, color concentrates, and similar materials. It is also used to recover a variety of scrap materials, such as factory scrap rubber and scrap tires, and to separate the components in composite materials.

www.studymafia.org

ADVANTAGES OF CRYOGRINDING

1. Higher production rate
2. Lower energy consumption
3. Finer particle size
4. More uniform particle distribution
5. Lower grinding cost
6. No heat generation which is good while grinding spices, pharmaceuticals and scrap plastics
7. Provides an inert atmosphere thus eliminating the possibility of oxidation

www.studymafia.org

APPLICATIONS OF CRYOGENIC GRINDING

CryoGrinding of steel

The large amount of thermal energy generated during machining and grinding at high speed and feed rate raises the temperature at the cutting zones excessively. This elevated temperature level under large cutting stresses accelerates plastic deformation and wear of cutting edges leading to increased cutting forces and premature tool failure. Cooling with conventional cutting fluids in the form of jet or mist is unable to solve the problem. In such cases cryogenic cooling by agents like liquid nitrogen will improve the situation. In the case of cryogenic grinding, the liquid nitrogen from a reservoir under air pressure comes out a jet from a nozzle to the spot where cooling is desired. The jet impinges on the work surface at the grinding point from a suitable distance and angle. The amount of temperature reduction due to cryocooling will increase the grinding depth. Because of the extreme cooling action, the life of the grinding wheel\s will be increased.

Thermoplastics

To which Nylon, PVC, Polyethylene, and polypropylene belong are commonly used in powdered form, for but not limited to, a variety of applications such as adhesives, powdered coatings, fillers, resins and plastics sintering and molding. These powders generally can only be produced in high production rates and fine particle sizes utilizing cryogenic size reduction.

www.studymafia.org

Thermo sets

To which natural and synthetic rubbers belong are important recyclable materials. Under cryogenic size reduction these materials can economically and at high production rates be ground into fine powders, used as filler, be recycled.

Adhesives & Waxes

These materials at ambient temperature are generally pliable and sticky and when ground would form excessive deposits in the mill building up heat, increasing energy requirement and eventually shutting down the size reduction process. Under cryogenic temperatures these products become brittle and can be pulverized with much less energy and without forming deposits.

Explosives

Explosives explode when their ignition temperature, in the presence of oxygen, is achieved. Cryogenic size reduction performs two tasks when grinding explosives; it reduces the temperature of the material well below its ignition temperature and removes the oxygen from the system thereby eliminating the possibility of combustion. The product to be ground is filled into the volumetric screw feeder where it is metered at a specific rate into the cryogenic pre-cooler. In the cryogenic pre-cooler liquid nitrogen is injected and combines with the product thereby cooling and embrittling the product. The product is then transported, along with the cold gas generated by the evaporation of the liquid nitrogen, to the grinding mill where it is pulverized. The pulverized product then goes through a classifier where it is

www.studymafia.org

separated into various particle sizes and packaged. Should oversize material exist this can be fed back into the volumetric feeder and recycled into the system. The cold gas from the mill is recycled through the filter or bag-house and makeup air back into the mill. Excessive cold gas is vented out. In addition the cold dry nitrogen gas keeps both the classifier and bag-house free of moisture and inert, preventing the possibility of dust explosions and buildup of product.

Spices

Spices like Pepper, cinnamon, chilly, Ginger, Cumin seed, Nutmeg, Glove etc., have a characteristic taste and aroma. These characteristic qualities are essential in them to have their value as 'spice'. These qualities exist in them due to the presence of etheric oils within. The etheric oils have their boiling points ranging down to 50^{o}C. During conventional grinding, due to the heat produced by friction, the temperature of ground spices shoots up to about 90^{o}C, where by most of the etheric oils oil off resulting in inferior quality of the ground product. This inferior quality is evident by the reduced taste and aroma.

www.studymafia.org

PROBLEMS WITH CONVENTION GRINDING

Loss of etheric oil

The applied energy gets dissipated in the form of heat (>99%) and hence the temperature in the grinding zone rises to more than 90oC resulting in loss of etheric oils whose boiling point vary from 50oC to 320oC. This results in the inferior quality of the ground product.

Clogging and gumming of the mill

Spices like nutmeg, clove, cinnamon, etc.., contain high level of fat while capsicum, chilli, etc, contain high moisture content. These cause clogging and gumming of mill thus affecting the throughput and quality of the ground product. High moisture content materials often stick to the parts of the mill.

Oxidation and related degradation:

Due to intimate cyclone effect of the air in the vicinity of grinding zone, aromatic substances in materials oxidize and become rancid. In addition the formation of fresh and exposed surfaces due to grinding, accelerates the process of oxidation.

www.studymafia.org

ADVANTAGES OF CRYOGRINDING WITH LIQUID NITROGEN

Higher retention of etheric oils

Due to lower operating temperatures, the etheric oils will be retained in the product almost to the original level. Hence the ground product will obviously be better in taste and aroma, with the improved value as 'spice'.

Prevention of oxidation and rancidity

The heat developed during grinding will be absorbed by liquid nitrogen which in turn will be converted to vapour. These vapours expel any air in the mill and produce an inert atmosphere during grinding. This eliminates the possibility of oxidation. To add to this, an inexpensive, dry and inert atmosphere for storage and package of ground product is created.

Increased throughput and power saving

Due to usage of liquid nitrogen, the raw material becomes brittle. This in turn keeps the oil and moisture content in the crystallized condition during grinding and avoids clogging. At the same time when the material is brittle, less power is required to crush. Thus cooling with liquid nitrogen increases the throughput due to reduction in specific energy requirement.

Finer particle size

www.studymafia.org

CryoGrinding results in finer particle sizes of the ground spices. This eliminates speckling problems and reduces the settling rate of spice powders in liquid preparation.

Reduction in microbial load

By cooling with liquid nitrogen, some bacteria's which some others may become dormant. Thus, when the ground product is warmed to the room temperature (in the inert atmosphere of nitrogen) one expects considerable reduction in microbial load.

Possibility of fine grinding of difficult spices

By use of low temperatures, the raw materials become brittle which causes fibers to shatter. Thus fibrous spices like ginger can be ground easily to finer particle size. High oil content spices like nutmeg can be ground easily. CryoGrinding can be employed for grinding green spices like chilies with no pre-drying and also with the retention of its original colour.

www.studymafia.org

WORKING OF CRYOGRINDING PLANT

The spice to be ground is cleaned manually and fed in to the hopper. From the outlet of the hopper the spice enters in to the vibratory feeder, which is positioned with a small inclination towards the entry of the helical screw conveyor. The vibratory feeder has a provision to control the feed rate.

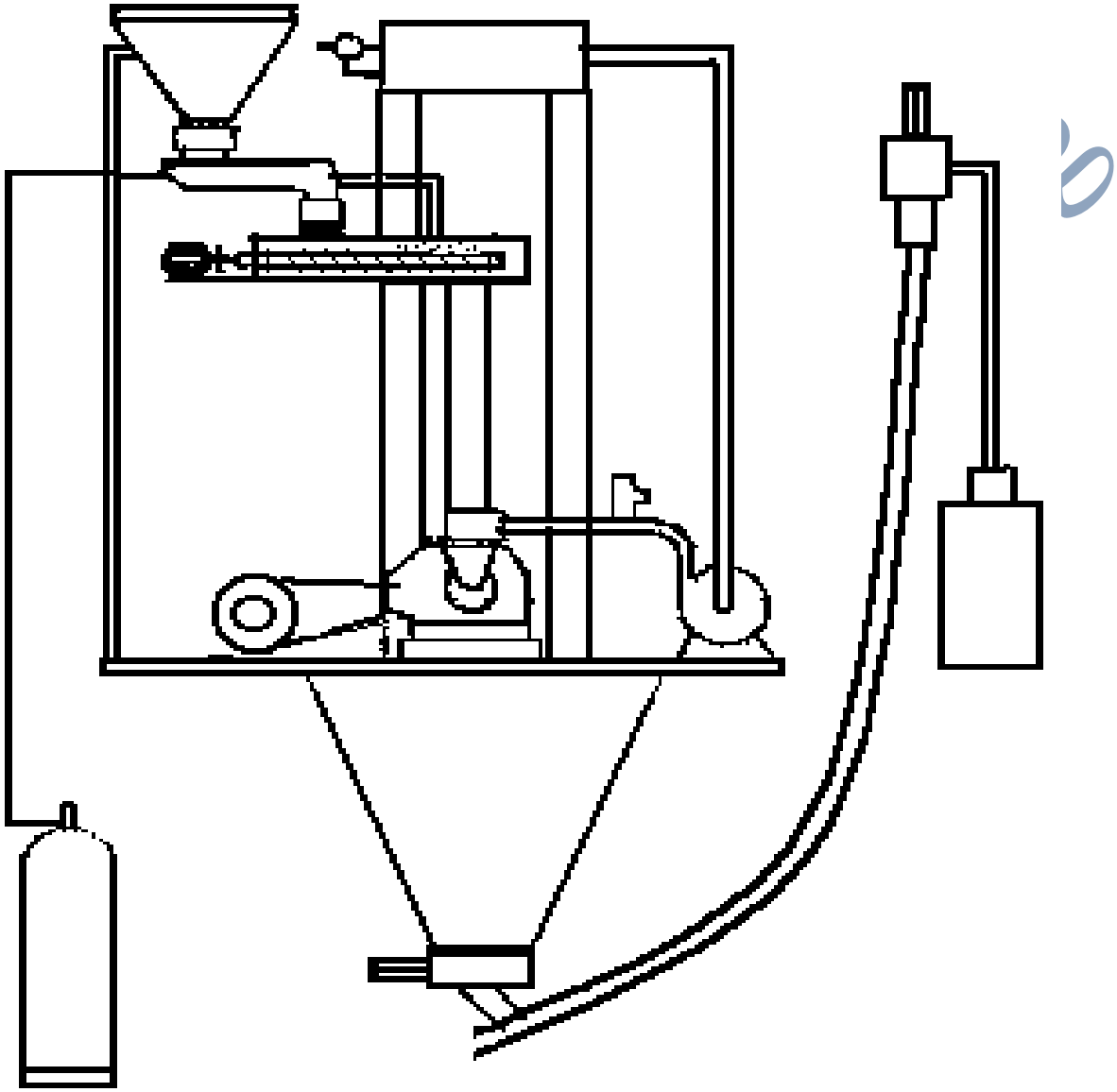
The helical screw conveyor has a total length of a metre where the fed material travels horizontally to the grinding mill. The screw conveyor is driven by a 0.75 KW drive with reduction gear and inverter control. Liquid nitrogen from a storage container is sprayed into the screw conveyor. The time of stay of spice in the conveyor can be adjusted by varying the speed of the drives. A censor monitors the temperature of the ground spice and the liquid nitrogen spray is optimized using automatic feed back control.

The grinding mill is driven by a 5.5 KW, 3 – phase,50 Hz motor. The mill is connected with the motor by a flat belt between the motor pulley and the mill pulley. Inside the mill, stud disc is mounted on the shaft. The circularly projecting studs fit between the similar projecting studs from the rear of the front door. The spice to be ground gets locked between the studs of the rotating disc and studs of the stationary disc. When the mill is running, the spice gets crushed between the studs and comes out through an optional sieve as a ground product.

To the bottom of the mill a collecting bin is housed where the ground product gets collected. The bottom of this tapering collecting bin, a rotary valve is mounted which is driven by a 0.37 KW motor. The rotary valve has 8 compartments mounted radially in the same plane. The product, which comes out of the rotary valve, is lifted to the storage container by the Hapman Helix conveyor. This is driven by a 0.37 KW motor.

www.studymafia.org

The vaporized nitrogen from the mill is sucked by a centrifugal blower and through the filter assembly if fed back to the mill.



FUTURE PROSPECTS

As the cost of raw materials and energy is increasing day by day, it is very necessary to use optimum quantity and at the same time getting the required quality. By using CryoGrinding technology these aspects can be met efficiently.

By using this we can also recycle tough and composite materials. It has many significant advantages over conventional grinding. This also leads to value addition to the product. CryoGrinding is economically viable, if liquid nitrogen costs are not formidable.

By adopting CryoGrinding technology the leading spice industries of our country will earn considerable foreign exchange by exporting more value added processed spices, in place of exporting whole spices. The technique can be easily extended to processing of PVC and industrial waste plastics in view of recycling of non-biodegradable materials.

www.studymafia.org

References

- www.google.com
- www.wikipedia.com
- www.studymafia.org

www.studymafia.org