FRP DUST MITIGATION THROUGH ENGINEERING CONTROL MEASURES

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ABSTRACT

The aim of the project is to carry out a study and design on FRP (fiber reinforced plastic) dust, making a risk assessment, tooling, designing and recommend actions to eliminate or minimize the effect of FRP inside the industries.

FRPs generate abrasive and electrically conductive dust particles that can furthermore cause explosive dust. FRPs generate abrasive and electrically conductive dust particles that can furthermore cause explosive dust-air mixtures in the enclosed workspace of the machine tool. In order to protect the machine operator and the machine tool, powerful extraction systems (engine power > 5 kW) are usually installed and operated with a constant flow rate, resulting in a significant increase of the machine tool's overall energy requirement. This paper introduces a novel approach for a demand-oriented control of the flow rate to increase the energy efficiency of dust extraction systems. The objective of this project is that to control the FRP flow rate in the industries.

This project deals with the evaluation of the potential hazards related to the mankind. This project also deals with the hazardous management of the FRP dust. Recommendations shall be made to eliminate or control it for all the hazards identified during the hazard assessment. The recommendations should include the specific actions required to correct the problem.

Keyword – *Risk Assessment, Extraction Systems, Hazard Assessment etc….*

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1. INTRODUCTION

FRPs are becoming increasingly in wind blade industry, aerospace industry & many auto mobile industries. FRPs generate abrasive and electrically conductive dust particles that can furthermore cause explosive dust. Fiber-reinforced plastics (FRPs) are characterized by their heterogeneous and anisotropic material properties. Even specifically adjustable strength or oxidation resistance capabilities are feasible with these composite materials. Due to the fast development in the domain of communication and an ongoing trend of digitization and digitalization, manufacturing enterprises are facing important challenges in today's market environments: a continuing tendency towards reduction of product development.

In addition, there is an increasing demand of customization, being at the same time in a global competition with competitors all over the world. This trend, which is inducing the development from macro to machining of FRPs, is common. However, a main issue of dry machining of FRPs is the dust formation. Haddad conducted a comprehensive investigation on the formation of dust during the milling of CFRP. Next, the main challenge in modelling and analysis is now not only to cope with single products, a limited product range or existing product families, but also to be able to analyse and to compare products to define new product families. It can be observed that classical existing product families are regrouped in function of clients or features. Hence the dust extraction systems are indispensable in order to protect human resource and machines.

1.1 ORGANIZATIONPROFILE

The company founded in 1968 and has been providing composite wind blades since 2001. Our knowledge and experience of composite materials and manufacturing originates with our predecessor company, Tillotson Pearson Inc., a leading manufacturer of high-performance sail and powerboats along with a wide range of composite structures used in other industrial applications.

We are a leading wind-blade manufacturer and the only independent wind blade manufacturer with a global footprint. We accounted for approximately 32% of all sold onshore wind blades on a MW-basis globally excluding China in 2020. We reached a record high this year with nearly $1.7 billion in net sales and more than 10,600 wind blades produced. We enable many of the industry's leading wind turbine original equipment manufacturers (OEMs), who have historically relied on in-house production, to outsource the manufacturing of a portion of their wind blades, thus expanding their global wind blade capacity.

We are headquartered in Scottsdale, Arizona, and we have expanded our global footprint to include domestic facilities in Newton, Iowa; Warren, Rhode Island; and Santa Teresa, New Mexico and international facilities in Daeng, China; Taicang Port, China; Yangzhou, Jiangsu, China; Kolding, Denmark; Chennai, India; Juarez, Mexico; Matamoros, Mexico; and Izmir, Turkey.

Our advanced manufacturing facilities are strategically located around the world to serve the growing global wind market in a cost-effective manner. We also leverage our advanced composite technology and innovation to supply unique, high-strength, lightweight and durable composite product solutions to the transportation market, including passenger automotive, bus, truck, and delivery vehicle applications. The wind blades that we manufacture support the decarbonisation of energy production, provide significant reductions in greenhouse gas (GHG) emissions, and help mitigate climate change.

Fig -1: Tpi Composites

TPI has strategically built a strong global footprint that takes advantage of proximity to large existing regional markets, adjacent new markets and seaports for global export.

Headquartered in Scottsdale, Arizona, we have established a global footprint with advanced engineering centres in Warren, Rhode Island, Berlin, Germany and Kolding, Denmark; and manufacturing facilities in Warren, Rhode Island; Newton, Iowa; Taicang, China; Dafeng, China; Yangzhou, China; Chennai, India; Juarez, Mexico; Matamoros, Mexico; and Izmir, Turkey. Together we serve our customers with over 6 million square feet of manufacturing operations and over 14,000 associates including over 300 design and manufacturing process engineers, as well as craftsmen and production workers.

- **TPI China:** TPI established its Taicang Port, China facility in 2007. In 2013, our operations in China expanded with the opening of a new facility in Dafeng, China for advanced wind blade manufacturing. In 2014, TPI opened its Taicang City operation to manufacture precision molding and assembly systems for the production of wind blades. In 2019, our new state-of-the-art manufacturing hub in Yangzhou, China opened. This facility enables TPI to reliably and cost effectively serve China and global onshore and offshore wind markets via land and by water. In 2019, we transitioned the precision molding and assembly systems at our Taicang City operation into our Taicang Port location.
- **TPI Denmark:** In 2018, TPI opened its Advanced Engineering Centre in Kolding.

• **TPI India:** TPI established its newest state-of-the-art manufacturing hub in the greater Chennai region in 2020 and will be able to reliably and cost-effectively serve the India and global wind markets for multiple customers.

• **TPI Iowa:** Since 2008, our Newton, IA facility has been dedicated to advanced wind blade manufacturing to serve the North American market.

• **TPI Mexico:** Since 2014, our Ciudad Juarez, Mexico facility has been dedicated to advanced wind blade manufacturing and in 2016 and 2017, we opened two additional wind blade manufacturing facilities in Ciudad Juarez. In 2019, we opened a new precision molding and assembly systems and transportation manufacturing facility as well. Our Ciudad, Juarez Mexico manufacturing hub is capable of cost-effectively serving the U.S. and Mexico wind markets. TPI opened its Matamoros, Mexico manufacturing hub in 2018 to cost effectively serve wind markets in Mexico, Central and South America via land, rail and by water from the Port of Brownsville, Texas.

• **TPI Rhode Island:** Our operations in Warren, RI has been manufacturing precision molding and tooling assembly systems since the early 2000's and manufactures composite solutions for the transportation industry. This facility also houses our design engineering team and Advanced Transportation and Composites Centre.

• **TPI Turkey:** TPI established its first advanced wind blade plant in Izmir, Turkey in 2012. In 2015, our operations in Turkey expanded with a second plant in Izmir. Our Turkey operation is dedicated to advanced wind blade manufacturing for multiple customers primarily in the European, Middle Eastern and African markets, and it also has an advanced engineering centre.

2. LITERATURE REVIEW

The development of alternate energy source has provided growth potential for the wind industry. The global wind industry is growing fast, in terms of both number of turbines and their sizes. The modern turbines are 100 times the size of those in 1980 according to Global Wind Energy Council (GWEC). Over the same period, rotor diameters have increased eight-fold, with turbine blades surpassing 60 m in length as per reinforcedplastics.com. By the end of 2007, around 20 GW of capacity had been installed, bringing the world total to almost 94 GW. In its report Global Wind Energy Outlook 2008, GWEC predicts that wind will supply 12% of the worlds energy needs by 2020 and could supply 30% by 2050. Wind turbine blades typically consist of reinforcement fibers, such as glass fibers or carbon fibers; a polymer such as polyester or epoxy; sandwich core materials such as PVC, PET or balsa wood; and bonded joints, PU coating and lightning conductors. As the turbines grow in size, so does the amount of material needed for the blades. For a 1 kilowatt (kW) wind power plant, 10 kg of rotor blade material is needed. For a 7.5 megawatt (MW) turbine, this would translate to 75 tons of blade material. Wind turbine blades are predicted to have a lifecycle of around 20-25 years.

The wind-turbine industry is relatively young. There is only a limited amount of practical experience on the removal of wind turbines, particularly in respect of offshore wind turbines. At the moment, there are three possible routes for dismantled wind turbine blades: landfill, incineration or recycling. The first option is largely on its way out with countries seeking to reduce landfill mass. Germany has introduced a landfill disposal ban on glass fiber reinforced plastics (GRP) in June 2005, due to their high (30%) organics content such as polymer and wood. The most common route is incineration. In so-called combined heat and power (CHP) plants, the heat from incineration is used to create electricity, as well as to feed a district heating system. However, 60% of the scrap is left behind as ash after incineration. Due to the presence of inorganic loads in composites, this ash may be pollutant, and is, depending on the type and post-treatment

The alternative is recycling - either material recycling, or product recycling in the form of re-powering where old turbines are replaced by newer, more efficient ones. At the moment, however, there are few established methods for the recycling of wind turbine blades, and only 30% of fiber reinforced plastic (FRP) waste can be re-used to form new FRP, with most going to the cement industry as filler material. Several studies are in progress to find the best solution to disposal of blades after their service life. It will take some time before their results will bring out a winner for the disposal system. The most promising and mature renewable energy technology appears to be wind power and will contribute to securing energy independence and climate goals in the future, and could turn a serious energy supply problem into an opportunity in the form of commercial benefits. To meet challenges of the energy sector, the number and size of wind turbines has increased strongly in recent years. This development is expected to expand significantly, especially with the installation and operation of very large numbers of wind turbines in offshore wind parks. These will effectively serve as large power plants that produce electric power directly to the grid.

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These will effectively serve as large power plants that produce electric power directly to the grid. As per Ole Thybo Thomsen, wind turbine blades are being manufactured using polymer matrix composite materials (PMCs), in a combination of monolithic (single skin) and sandwich structures. A sandwich structure is a special form of laminated composite material composed of two thin, stiff and strong face sheets (PMCs in this context) separated by a relatively thick, compliant and lightweight core material. The resulting assembly provides a structural element with very high bending stiffness, strength and buckling resistance as well as very low weight. Today’s wind turbine designs are mainly based on glass fibre reinforced composites (GFRPs), but for very large blades carbon fibre reinforced composites (CFRPs) are being introduced in addition to GFRP by several manufacturers in order to reduce the weight. Over the last 25 years wind turbines have become significantly larger, the largest modern wind turbines have rated power outputs of 5 MW or more and rotor diameters of more than 125 m. larger wind turbines have larger energy output per unit rotor area due to increased mean wind velocity with height.

Though larger wind turbines are more expensive to install and operate than smaller ones, the total production cost/kilowatt hour of electricity produced has generally decreased with increasing wind turbine size. Hence, wind turbines with a rated power output in the range of 8-10 MW and a rotor diameter from 180-200 m will be developed and installed within the next 10-15 years. But current design methods and available components and materials do not allow this amount of up-scaling of blade size (or other turbine components). Also, gravity loads on wind turbine blades increase as the rotor disk diameter increases. It is to be expected that these loads will become more dominant than the wind loads, which again will lead to a significant increase in the weight and cost of the rotor system.
The "optimal" wind turbine dimensions (or selection of design parameters) are not known at the present time, and it’s unlikely that a global or universally meaningful optimal design solution exists, but it is safe to say that the

"best/optimal" design will depend on the material, design and operational characteristics of any given win d turbine concept. Several research projects involving wind turbine manufacturers, service providers, universities and research organizations are addressing the technological barriers associated with the design.

3. FRP DUST AND MAN KIND

FRP has a high hardness and is much lighter than steel. It is used as a fuel tank and pipe on jet aircraft to reduce the weight of the aircraft. The astronauts who boarded the moon, the miniature oxygen cylinders they carried on their bodies, were also made of fibreglass. FRP is easy to process, stainless steel is not bad, no need for paint. China has widely used FRP to manufacture a variety of small motorboats, lifeboats, yachts, and automobile manufacturing industries, saving a lot of steel.

The main component of FRP dust is styrene. Styrene is a kind of kind, which is very harmful to the human body. Because of its very small size, it is particularly easy to inhale from the respiratory tract and affect the human lung. A large amount of dust causes macrophage death. The lung tissue fibrosis is also called silicosis. The flying debris is mainly powdered glass fiber dust, which can cause skin damage when exposed to the skin, causing itching. Therefore, you must bring a mask at work and pay attention to labor protection.

The production of FRP will cause harm to the human body. It is necessary to pay attention to the dust as far as possible. In the working environment, it is necessary to pay attention to self-protection. The environment should be kept ventilated and the medical examination should be carried out regularly. If a fibreglass reinforced plastic panel was cut inside your home and appeared to produce a lot of dust, I suggest that rather than spending the $1500. U.S. or so that would be the cost of a truly competent and reliable and thorough building inspection and testing, spend your time and money and effort on a thorough, or if you prefer, professional cleaning of the home, including areas more distant from the cutting source but to which small or fine dust particles may have travelled.

3.1 WHERE TO CLEAN UP FRP DUST

Just which areas need additional cleaning really depends on how far the cutting dust spread through the building - by direct air transport or potentially by movement through a warm air heat or cool air conditioning system if such were in operation and not well filtered. Certainly remote building areas closed off by doorways or other means during this problem are not as likely to have high levels of this irritating dust.

3.2 HOW TO CLEAN UP FRP DUST

This clean-up typically involves HEPA vacuuming and damp wiping of all indoor surfaces and contents sufficient to remove most of the irritating dust. If there is central air conditioning or heating, it might be appropriate to clean the ductwork.

3.3 ARE THERE HEALTH CONCERNS FROM FRP DUST EXPOSURE.

Here is what Texture Plus says about their faux stone, brick, bamboo, etc. FRP panels:
Texture Plus is completely safe for both children and adults. There is no Material Safety Data Sheet (MSDS) required with our simulated siding. Additionally, our panels are produced with all water-based chemistry, with no VOC and do not “off gas” any formaldehyde. Fiberglass Reinforced Plastic products are in the chemical family of Polymerized Thermoset Polyesters of which some manufacturers such as Formals do indeed provide MSDS data. Formulas agree that their products are not hazardous in normal use, stating:

These products are sold as “manufactured articles” and do not represent a hazard under normal use - see Section 15, Regulatory Information. Hazards listed are associated with modifications made to the manufactured articles. Exposure to dust from cutting, grinding or otherwise altering these products may irritate the skin, eyes, nose, throat or upper respiratory tract. Here are explicit details from the Formulas product MSDS
Inhalation: Breathing dust generated from machining this product or handling may cause nose, throat or lung irritation including coughing or choking depending on the degree of exposure. Eye Contact: Eye contact with airborne dust may cause immediate or delayed irritation or inflammation. Eye exposure may require immediate first aid treatment and medical attention to prevent damage to the eye. In sum, the industry does not indicate significant health concerns associated with working with FRP products. Beyond cleaning, questions about persistent respiratory or health worries are a matter you should discuss with your physician.

3.4 LOOK FOR THE MSDS FOR THE SPECIFIC FRP PRODUCT THAT YOU ARE USING

For more detail you can take a further look at the FRP additional example MSDS (material data safety sheet examples below or better, obtain the product name for the specific FRP that was cut inside your home and thus you can obtain from the manufacturer the MSDS for that specific product). In the typical example MSDSs that we surveyed to research your question, the data asserts that about inhalation the MSDS states

Inhalation: Not considered a problem under normal use. Dust generated during machining can cause short-term irritation of the mouth, nose, throat or upper respiratory tract, eye contact: Not considered a problem under normal use. Contact with dust generated during machining can cause short-term irritation.

4. FRP DUST PARAMETER

Careful analysis of risks performed by the manufacturer and stored in the technical file has made it possible to eliminate most of the risks associated with dust extraction system operation. The manufacturer advises carefully following the instructions, procedures and advice contained in this manual as well as applicable safety regulations, including the use of the protection devices, both those integrated in the cleaner and individual.

Outstanding risks associated with the system could be: Electrical maintenance risks caused by the need to work under power. Pursuant to Presidential Decree 81/08, only trained personnel should work on the machine with the power supply connected and this must have double earth insulation.

Risk of improper use in the presence of explosive and flammable substances. The system must not be used in environments containing substances in the form of liquids that could vaporize at room temperature and flammable dusts and gas.

Having identified the various outstanding risks, the manufacturer has affixed to the machine operator a number of hazard labels in compliance with regulations relating to the graphic symbols to be used. The user must immediately replace any safety plates that become illegible due to damage.

FRP Fiberglass Reinforced Plastic Product Dust Control Standards [1]		
Chemical Component	**OSHA PELs (Permissible Exposure Limits for the workplace)**	**ACGIH TLV's (Threshold Limit Values)**
Particulate dust	TWA: 15.0 mg/m3 (total dust)	TWA: 5.0 mg/m3 (inhalable fraction)
Particulate dust	TWA: 5.0 mg/m3 (respirable fraction)	TWA: 1 fiber/cm3 (respirable fraction)

Table 4.1 FRP dust control standard

4.1 RISK ASSESSMENT

Risk Value	Risk Assessment Results
R > 401	**Intolerable Risk**:Risk is too high; necessary action to be taken immediately/or facilities,buildings,environment shutdown should be considered
201<R<400	**Based Risk:** short term improvement (within a few months)
71<R<200	**Significant Risk:** Should be improved in the long run(during the year)
21<R<70	**Possible Risk:** Should be applied under supervision
R<20	**Insignificant Risk:** Acceptable/Precaution is not priority

Table 4.2 – Risk assessment result

5. PROBLEM RECTIFICATION

These cases have emerged in composites companies are the normal one. Most of the problems occurred due to the contamination causes by the gas or liquid inside the pump. Internal corrosion caused by loose or worn seals. Mechanical failure caused by wear and tear or improper maintenance. There may be suction line damages, folding or coupling miss alignments. Also due to the less diameter of the suction line there may be a suction failure. The material needed to be changed from SS to the FRP material.

5.1 FAILURE DUE TO IMPROPER UTILISATION

Improper utilisation of the suction hose and machine are also one of the major reason of improper dust collection. Combustible dusts such as plastic and FRP dust require a deflagration system to reduce the chances of an explosion inside the dust collector and mitigate damage to the facility if an explosion should occur. These systems may include an explosion vent to release built-up pressure in the collector, an isolation valve to prevent pressure waves from propagating back into the facility, and a rotary airlock to keep collected dust safely contained in the hopper.

Fig. 5.1- Working without improper suction

The dust collector should be equipped with an internal fire suppression system for added protection against fires. A static-reducing filter media should be used to reduce the risk of self-ignition inside the dust collector and reduce clinging to the media. If plastics become heated during machining or grinding, molten plastic can accumulate on filters, causing them to cake and leading to early failure. A longer ductwork run can reduce these problems. Thermal processes such as melting and compounding will require different solutions for control of dust, odors and VOCs. If you are using thermal processes, contact us for more information.

Fig.5.2- Working with improper suction

In addition to choosing the right filter media, it is important to have an effective filter pulsing system to pulse off plastic dust clinging to the filters. A robust pulsing system combined with static-reducing filter media will extend the life of the filters.

5.4 FAILURES IN THESUCTION MACHINE

The primary difference between plastic dust and most other types of dust is that plastic dust carries an electrostatic charge. As microplastics and fines rub against each other in the airstream, they produce static electricity. Each plastic particle becomes slightly charged. The charged particles of plastic are attracted to the filter media, which makes them difficult to pulse off and leads to excessive filter loading. Static charge also creates a risk of sparks, which can lead to self-ignition of a combustible dust explosion.

Fig. 5.3- Image of the portable suction machine nil fisk

Plastic dusts are highly combustible. That means they can generate an explosion when allowed to concentrate in the air or inside a dust collection machine. Special care must be taken when collecting combustible dusts to minimize the risks of an explosion inside the dust collector. Plastic dusts are especially dangerous because of their potential for self-ignition due to their static charge. When plastic dust builds up inside conveyor systems or other enclosed spaces, the combination of static electricity and confined combustible dust can be deadly.

6. CONCLUSION

The current project work was carried out to observe and the rectification of the safety health and environment and also the dust collection mitigation process. **This project rectification done over 3 important aspects which were:**
Rectification in suction line
Rectification in tool.
Rectification in improper utilization.
Rectification in the suction machine.

Observation of handling found that due to good training and safety culture follows in my site help the workers to work safely. Training period for the worker improved the safety culture inside the site and help the worker to learn and understand safe procedures. All the necessary standards were maintained that reduced the probable injury that would have caused during activities. Maintenance of machinery and equipment is interrelated to safety. Proper Maintenance promotes health environment and safety at work place.

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