

# Processed Text

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thermosetandthermoplasticpolymers epoxy andnon epoxypolymers 2 initsmostbasicform  
whentwoormorecomponentsarecom low viscosity resin used create thermoplastic polymer  
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thismakesitmoredifficulttorecycleinexchange generally used boost matrix toughness rigidity wider range  
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replacementoftraditionalmaterials suchaswoodandmetal midfibersareoftenemployedinfrpcarbon 1  
duetotheirhigh theirlightnessandmechanicalstrengthincombinationwiththeir  
specificmechanicalproperties carbon fiberreinforcedpolymersin cheaprelativeproductioncosts  
particulararefrequentlyutilisedinavarietyofindustries suchas  
materialsthatuseorganicpolymersasthematrixandfibersas aerospace aviation auto infrastructure etc 4  
last ten thereinforcementarecalledaspolymermatrixcomposites pmc year demand carbon fiber  
reinforced polymer nearly fiber reinforced plastic frp many pmc variant tripled rising 60 170 kiloton  
according figure based type polymer used including amorphous growth rate anticipated demand  
material expected slow next 20 year although stillachancethatthedemandforcarbon  
fiberreinforcedpolymers correspondingauthor increase globally investigating individual fibre polymer e  
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trashproductionandrecyclingpotential lionmetrictonnesofthe8300millionmetrictonnesofpolymers

produced 1950 2015 recycled enormous an aircraft manufacturer determines how long it will last  
 amount of waste produced by fiber reinforced polymer composites  
 number of pressurization cycles is used to determine an aircraft  
 made it imperative to develop effective recycling strategies 4 lifecycle  
 the duration of a flight during which an aircraft is kept  
 depth research and development have been put into polymer pressure known pressurization cycle airplane  
 matrix composites pmcs which are employed in a range of tech 5 70 year old typical aircraft 20 nological  
 field including aerospace aerospace industry year lifetime with a certain amount of flight cycles and hours  
 demand of composites is increasing due to its lightweight  
 airplanes are transferred to the aircraft boneyard after their useful uses less fuel and which in  
 turns saves money for the fuel advanced life retired airplanes are kept at aircraft boneyard as storage  
 lightweight substitutes for heavier materials are made possible by 2010 material employed air transport  
 ability polymers as matrix element high load industry composite partly due dramatic increase bearing  
 property reinforcing phase large passenger air use composite raw good production started plane  
 increasingly using fiber reinforced polymer frps back 1970 assessing aircraft lifespan  
 frp composites have developed into a different range of materials around 20 25 year reclaiming reworking  
 composite which can offer considerable benefits in terms of density and fatigue  
 trash that has collected in the aviation sector over the years would give characteristic traditional metallic  
 material be critical in three to five decades 5 thermoset composites are lighter than similar metal constructions  
 composite material account 18 7 resource aeronautical industry noticed growth usage  
 used by aerospace companies to construct aircraft structures them in aircraft particularly in airliners  
 frp composites now make this figure is expected to rise in the coming years a significant user  
 up the majority of the structural mass of a number of commercial composite aviation sector 6 composite  
 widely aircraft including boeing 787 airbus a350 xwb used in the marine pipelines and tanks wind energy  
 construction space industry composites play a crucial role in the development and other sectors  
 which increase the quantity of waste produced and production of space habitats like the international space station  
 and the requirement for recycling because the thermoset resin in the station as well as rockets satellite  
 and other spacecraft despite the often used composite 62 largely constituted fact pmcs particular frps  
 widely used epoxy resin the recycling and reuse of these kind of epoxy based composite aerospace industry  
 exceptional thermoset composite is critical 75 strength weight ratio potential their use is unquestionably con  
 strained in ability to deform plastically result 1 2 recycling waste composite materials absorb energy damage  
 generation lead to failure mechanisms like delamination fiber matrix debonding  
 recycling garbage is only ranked fourth among the best ways to fibre fracture inadequate plane impact  
 loading per managewaste by the european union with avoidance reduction  
 formances are also quite important reuse preferred recycling mechanical thermal  
 epoxies are the most often utilized polymers as matrix in frps chemical waste treatment technique frp may  
 generally in the aerospace industry compared to other thermosetting poly split three category although  
 technological mers polyester epoxy particularly suited  
 technique for recycling this form of garbage is the easiest the final aerospace industry due excellent  
 mechanical property product is also the least valued chemical recycling techniques can adhere substrate  
 fiber resistance moisture absorb be used to acquire the highest grade material 8 chemical tech  
 tion and resistance to corrosive conditions they also operate well niques still mostly research employed high  
 temperature high glass transition the industry 7 temperature study compare different recycling technique  
 frp 1 2 1 mechanical recycling trash in order to assess their effectiveness in light of these selected  
 the first step in recycling mechanical composite materials is to sustainability criterion literature analysis con  
 cut smaller piece maximum size 50 ducted sustainability performance evaluation carried 100mm  
 the pieces are then reduced in size to 10 50mm using examine applicability mcda type study hammer mill  
 comparable high speed grinding equipment to better understand the issues related to frp waste recycling  
 composite material is sorted into fiber rich and matrix rich com order determine best performing approach  
 based on points using cyclones and sieves 9 both sorting and the initial selected sustainability factor study  
 compare several frp cut need less energy the crushing operation consumes the major  
 waste recycling systems using multicriteria analysis ity of the energy 710  
 recycling offers a source of inexpensive high quality material

this is the most popular technique of recycling FRP waste due to help lower high cost raw material aerospace  
 to the technological ease of the process however grinding significant component recycling complicated material  
 cantly lower the value of the materials according to projections polymer matrix composite becoming  
 increasingly feasible cost carbon fiber utilized aerospace sector per kilo recycling technology advance  
 indicates aerospace gram must be 81.90 USD on average in 2018 however this price industry  
 potential uses for recycled materials are growing i.e. raw material used much crushing 7-10 future potential  
 recycling polymer matrix composite 11 when carbon fibre and glass fibre are employed as reinforcing utilised  
 aerospace sector positive recycling economic fibre mechanical polymer matrix composites are formed  
 and environmental advantages will become more evident as tech since the fibre are broken by crushing  
 thus larger particles can nology advance prompting increasing investment field  
 be used as reinforcing material for other FRP because the fibre repair furthermore  
 the regulatory climate is projected to become more  
 ticles are not completely detached from the polymer matrix after favourable to recycling increasing the industry  
 sexpansion mechanical processing they are thought to use as reinforcement in  
 another FRP because they are not as tightly connected to the polymer matrix 7-10 11  
 to alleviate adverse environmental effects of rising energy utilization fibre creation recycled fibre must used  
 2n ramawat n sharma p yambaetal materials today proceedings xxx xxx xxx  
 seen by the disparity in energy intensive recycling and production composite waste is broken up into bits  
 they are then introduced procedure 12 cement concrete product sculpting com  
 into a tank of liquid silicon sand and is liquefied at temperatures pound roofing material drainage different  
 box made ranging from 450 to 550 cid 3 using a hot air or nitrogen stream  
 mechanically processed polymer matrix composites are all exam  
 polymer matrix evaporates in a heated sand mass releasing fibres plus off FRP applications component heated  
 gas used transport solid when compared to alternative methods of recycling composite particle cyclone  
 separated gas material the mechanical process has the benefit of being techno mass separate area  
 after burner receives polymer resin logically simple both the processing of glass fibre reinforced poly gas  
 totally oxidize temperature 1000 cid 3 c mer composite carbon fibre reinforced polymer composite  
 and are then used for heat recovery 17 the temperature at which acceptable practicable term energy  
 consumption procedure carried impact quality mechanical recycling i.e. hazardous environment  
 treated fibers much like with thermal processing techniques recycling procedure 12 chemical processing  
 procedure test found tensile strength decline i.e. lower tempera need between 63 and 91 MJ/kg  
 pyrolysis requires between 3 and 10 times than it does at high temperatures 30 MJ/kg due significantly poor  
 fibre quality reuse more financially feasible after two recycling cycles 10 1 2 3 chemical recycling  
 the disadvantage of chemical processing is the requirement to 1 2 2 thermal recycling  
 apply it to recycled material depending on the chemical structure  
 garbage is cooked at temperatures ranging from 300 to 700 cid 3 c for example  
 the bulk of studies on epoxy resin matrix composites without the use of oxygen during the pyrolysis process  
 according have been completed and reinforcing fibres required diverse recycling to one study  
 the lowest heating temperature for pyrolysis of wind cling fluid time environment temperature get opti  
 turbine waste is 500 cid 3 c heating produces char and synthetic gas or gum outcome chemical recycling  
 also riskier oil as byproducts 13 although recovered fibres can be reused  
 mechanical and thermal recyclings since it involves potentially hazardous options are limited  
 and they may be badly damaged depending on arduous chemical might harm environment take  
 the heating temperature place at potentially dangerously high temperatures pressure  
 studies have shown that glass fiber reinforced polymer matrix owing consideration difficult create  
 composites may be recovered with high quality fibers at a temper industrial scale chemical FRP waste  
 recycling facility since ature 450-500 cid 3 c 14 carbon fiber economically  
 both costly and technically difficult 18 19 viable option FRP reinforcement moreover composite con low  
 temperature chemical recycling also known as solvolysis taining fibre may treated temperature ranging  
 occurs temperature i.e. 200 cid 3 c normal atmospheric 450 to 600 cid 3 c 10  
 still the information available shows that the pressure throughout the method acid or other solvents are used  
 glass fiber is mainly deteriorates during the pyrolysis process low break chemical linkage make polymer  
 ering mechanical characteristics by 50 when compared to virgin matrix in acid solvolysis pre

treatment is required to hasten the filament 15 polymer chemical chain breakdown particularly process the oil generated during the process of synthetic gas typically  
 in FRP since it is made up of several laminas and is therefore similar  $CH_4$   $H_2$   $CO$   $CO_2$  used energy recovery  
 process split 13 the chemical makeup of the recycled glass fibers pyrolysis process 13 theory also possible  
 use oil used investigation caused variation quality recover chemical component needed produce  
 polymer material amount soluble chemical recycled fiber resin for example PMMA  
 monomer may be recovered by pyrolysis in the material used for solvolysis affects their quality  $Al_2O_3$  and  
 different pyrolysis oil provide 15 20 MJ/kg combustion  $CaO$  two soluble chemical cause fiber loss 60  
 energy compared to PMMA 25 MJ/kg depending on the heating of their original weight over time 20  
 temperature various oil synthetic gas solid contribute water is heated to a temperature exceeding 374 °C  
 and crushed differently to pyrolysis the proportion of solids obtained is greater to a pressure of 22 MPa  
 other solvents such as methanol ethanol when heating at lower temperatures whereas the percentage of oil  
 propanol and acetone can be employed with glycols with catalysts and gas obtained is greater when heating at higher temperatures catalysts and  
 formula to reduce the required temperature and 5 pressure technology recovers high quality recycled  
 carbon the pyrolysis process of recycling fibers can also be used to find and glass fibers from FRP use automobile  
 sector despite numerous general temperature ranging 230 °C to 500 °C research pyrolysis large  
 scale enterprise employed investigate chemical FRP waste recycling process make thing recycled glass  
 carbon fibre moreover cesses utilizing supercritical water mixed to various liquids quality comparison exist  
 between the product recycling studies have succeeded in obtaining recycled fibres that have lost  
 recycled fibres are used in place of brand new fibers 15 0 08 weight retaining original tensile main difference  
 microwave conventional strength while others have obtained non recyclable material that  
 pyrolysis is that microwaves are utilized to heat FRP waste micro  
 are not suitable for fulfilling new material functions being used as waves heat up rapidly  
 and the heating takes place within the recycling matrix or being used as reinforcement 21 however research is  
 conducted in the lab utilizing tiny FRP samples and a broad range free atmosphere type pyrolysis heating area  
 of chemical combinations experiment setups and methodologies around material heated from inside  
 recycling supercritical solvolysis liquid methanol material lower heat loss happens regular pyrolysis  
 ethanol propanol acetone or glycol are used as well as catalysts this saves energy 16  
 microwave pyrolysis in an argon environment in the case of supercritical water solvolysis experiments that used  
 ment produced highest quality result recycled fibre  
 these fluids as the principal element in solvolysis had great results almost the same tensile strength as new fibre  
 when carbon fibres in terms of recycled fibre quality including glass and carbon fibre recovered using  
 microwave pyrolysis surface uniform 22 many studies found that the mechanical properties of recycled flat  
 strength properties of 72 module 90 fibre and fibre used to enhance fresh polymer matrix composites  
 the new fibre 16 were equal nevertheless the polymer matrices used in composite  
 for the recovery of treated carbon and glass fibres for FRP recycling  
 waste recycling are far from being commercially viable for supercritical fluidized bed gasification is ideal  
 the original polymer matrix critical solvolysis the experimental design of the study serves as 3n ramawat n  
 sharma p yamba et al material today proceedings xxx xxx proof small sample investigated ideal  
 solvolysis topsis technique order preference similarity ideal condition still sought different liquid  
 temperature solution 28 when doing MCDA these two multicriteria analysis pressure examined well  
 machinery technique combined may example used employed make recycling chemical composite  
 waste assess and compare the sustainability performance of various selected effective as feasible 23 tronic  
 waste recycling system despite fact specific piece of literature uses fuzzy numbers and topsis the basic  
 concept utilizing traditional MCDA 2 methodology and techniques methodology a concrete and simple  
 understand result is achieved through the polymer matrix composites are only minimally recycled  
 a clear and sequential set of steps in a multi criteria analysis since the local or international level  
 no effective trash recycling system MCDA result may arbitrary influenced has been built  
 despite its numerous potential uses its widespread researcher opinion sensitivity analysis also performed  
 adoption impeded lack market recovered polymer check the validity of the results matrix composite waste  
 another difficulty expensive complicated technological aspect recycling FRP facility built FRP trash may

recycled 3 results and discussion optimal recycling process also chosen due multiplicity variable influencing effective option detailed analysis carried work order term sustainability making decision challenging eco assess compare various polymer matrix composite material economic ecological social variable often three key waste recycling system literature research analysis aspect taken account approach 5 despite fact the information that is currently accessible on frp waste recycling that almost all studies related to sustainability evaluation contain alternative done introductory chapter based such a classification the most recent research on the sustainability information four recycling systems are chosen for further evaluation assessment analysed study bigger categorization using specified sustainability criterion multi criterion criterion includes also technology performance manage decision making analysis particularly analytical hierarchy method 24 process and topsis 5 the two primary categories of sustainability evaluation criteria eight sustainability criterion chosen mcda based quantitative and qualitative are separated into the aforementioned information gained from literature research on frp waste recycling basic groupings each has advantages and disadvantages quantitative systems and methodology guidelines for sustainability assessment five criteria can be measured and computed using standard measurement framework four grouping criterion economic ecological surement calculation method procedure energy use technological social impact represent four fundamental kwh kg trash amount ghg emission produced sa aspect certain frp recycling system received tco2 waste two regularly used quantitative sustainability more investigation than others and because mcda requires common measure 25 the qualitative aspects that must be quantified during comparable data criterion selection process constrained in review process based survey stakeholder knowledge already available 29 three criterion make experience and general knowledge innovativeness and public perception majority technological criterion group workplace perception are two examples of qualitative criteria qualitative criteria safety makes up the sole social criterion allow study broader variety conclusion conclusion fig 1 provides mechanical recycling techniques for which there are inadequate numerical measurements or score 0.63 making closest ideal solution pi mathematical physical unit utilised four frp waste recycling method according result quantify them yet applying qualitative criteria make the results mcda evaluation microwave pyrolysis come second arbitrary however shown scholarly publication place with a score of 0.59 followed by conventional pyrolysis with examined work often utilized sustainability score 0.45 supercritical water solvolysis score assessment technique permit inclusion criterion 0.38 the greatest choice is just 0.13 unit higher than the halfway such a multi criteria analysis 26 point perfect answer making four option far a range of sustainability evaluation approaches are used in the optimum solution additionally resulting score top scientific literature on the recycling of frp debris while identify second best performance close however mechanical in the most appropriate kind of analysis for this study it should recycling outperform supercritical water solvolysis by 40% benoted that multi criteria analysis is commonly used in research related sustainability evaluation various trash recycling technology method wide range of applications since allows selection numerous indicator type application to the important assessment of a given process as well precise determination criterion significance through the assignment of a specific significance 27 to evaluate the relevance of the criteria both the subjective analytical hierarchy method objective entropy technique applied the ahp is based on the paired comparisons concept which compares two indication rank 1 9 according to importance one indicates that the criteria are equally important whereas 9 indicates that the particular criterion is more important than the criterion it is being compared to the ahp technique may also be used to normalise and assess one sustainability however prioritise alternative simply utilised to rank the criteria in this study 5 the assessment normalization sustainability performance done using fig 1 topsis results 5 n ramawat n sharma p yamba et al material today proceedings xxx xxx xxx for all of the examined frp waste recycling processes it is far credit authorship contribution statement from the best option which can be understood by examining the patterns of criterion values some of the solutions that have been used in ramawat supervision resource investigation data compared perform much better area curation conceptualization writing original draft writing poorest result others instance mechanical recycling per review editing madhav charyatsanidhi data curation form well across six eight criterion poorly across other two mechanical recycling

out of the four options considered in this study is predicted to perform the best but its performance data availability hampered fact least effective approach other areas in conclusion although getting the highest assessment data will be made available on request score it has several shortcomings that are evident in how far it is from the perfect answer 5 declaration of competing interest microwave pyrolysis second best alternative according outcome multi criterion decision making study used the authors declare that they have no known competing financial interests or potential conflicts of interest personal relationship could appear no technologies recycling fiber reinforced plastic waste recycled to influence the work reported in this paper fiber tensile strength performance of this fiber recycling process is poorest outperform option in any of the analyzed categories reference according to findings and review of the literature sustainable approach recycling frp trash 1 f c campbell structural composite materials as m international 2010 employed the most one may argue that this outcome is indicative 2 m buggy l f arragher madden w recycling of composite materials j mater processtech 1995 of the current state of frp recycling in general most archaic 3 v goodship uk recycling issues in polymer matrix composites 2012 technique that has relatively minimal environmental and economic 4 yao qiao li sa d f ing madhusudhan r pal leka kelvin simmons l a review ical costs is mechanical recycling also it does not provide high fabrication method mechanical behavior continuous quality recovered fibre or matrix other polymer matrix composite thermoplastic polymer fiber thermoplastic polymer matrix composites 2022 5 iltina delveremarija maxat shanbayev array abildayeva kuzhamberdieva waste recycling technique greater ecological effect svetlana danija blumberga evaluation of polymer matrix composites waste noted study account indirect recycling methods effect reduced global warming potential could 6 ale feuvre garnier l jacquemin b pillian anticipating in use stock of carbon fiber reinforced polymers and related waste flows generated by the potentially result in recovering higher quality materials that could commercial aeronautical sector 2050 resource conservation be used in high technology composite applications reducing the recycling need new frp manufacturing saving material 7 nashauib p t m ativenga energy demand in mechanical recycling of glass fiber reinforced thermoset plastic composites journal of cleaner production energy used for virgin fibre and polymer resin 2016 8 wong k rudd c pickering x liu composites recycling solution for the aviation industry 2017 9 gnilakantan snutt reuse and upcycling of aerospace prepreg scrap and waste in reinforced plastic 2015 10 nvijay battacharjee rajkumar v assessment of composite waste disposal in aerospace industries procedia environmental sciences 2016 11 j howarth r m areddy m ativenga energy intensity and environmental analysis of mechanical recycling of carbon fiber composite journal of cleaner 3 1 conclusion production 2014 12 pimenta pinho recycling carbon fiber reinforced polymer while frp has several advantages over homogeneous materials structural application technology review market outlook waste management 2011 recycling frp is challenging due to its composite nature industrial 13 blazso pyrolysis for recycling waste composites goodship v 2010 scale application chemical recycling yield highest 14 yyang r boom birion recycling of composite materials chem eng process grade recovered material common 21 despite fact intensif 2012 15 srna qvi h mysore prabhakara e abarmer wdierkes rak kerman b gbrem manufacturing polymer matrix composite costly a critical review on recycling of end life carbon fiber glass fiber reinforced energy intensive process vast majority frp plastic waste composite waste using pyrolysis towards circular economy resource land filled recycling sort rubbish might reduce conservation and recycling 2018 16 gharde b kandasubramanian mechano thermal chemical recycling amount of garbage discarded in landfills as well as the requirement methodologies for the fiber reinforced plastic environmental technology for new frp manufacture as recycled fibre quality chemical com innovation 2019 ponents recovered from polymer resin matrix and perhaps energy 17 sk gopalraj karki review on the recycling waste of waste carbon fiber glass fiber reinforced composites fiber recovery properties and life cycle analysis recovered amount all improve so does the complexity of technology 2020 ogy according research frp may chemically recycled 18 j bachmann c hidalgo bricout environmental analysis innovative recover high quality fibres that can be utilized in the same applications sustainable composite potential use aviation sector lifecycle assessment review 2017 tions virgin fibre another obstacle creating worldwide 19 kumars krishnans recycling of carbon fiber with epoxy composites by industrial scale frp recycling system lack demand chemical recycling for future perspective a review 2020 recovered reinforcing fiber

based on the literature review multi 20 w dang tsudak kubouchim sembokuyah chemical recycling of glass  
 criterion decision making analysis sensitivity analysis per fiber reinforced epoxy resin cured amine  
 using nitric acid polymer 2005 formed in this paper to compare frp waste recycling methods 21 khalily f  
 sustainability assessment of solvolysis using supercritical fluids for determined mechanical recycling  
 method carbon fiber reinforced polymers waste management sustainable production sustainable specific  
 sustainability criterion used and consumption 2019 22 wu zhang w jin x efficient reclamation carbon  
 fiber epoxy paper applied study polymer matrix composite  
 composite waste through catalytic pyrolysis in molten zncl<sub>2</sub> 2019 waste recycling method needed scarcity  
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 knowledge on other possible sustainability criteria if there was a energy analysis of carbon fibre pre processing  
 processing and post processing recycling methods in resource conserv recycl 2020 greater range of  
 correct data mcd results would be less reliant 24 cyeh xuy sustainable planning of e  
 waste recycling activities using fuzzy on a small number of criteria for which information is accessible  
 multicriteria decision making journal of cleaner production 2013 5n ramawat n sharma p yamba et al  
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 economic aspect of fiber 27 h li k englund recycling carbon reinforced thermoplastic composite  
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 mechanical and tribological properties of natural fiber reinforced polymer lightweight structures  
 in global automotive lightweight materials in elg composite 2020 carbon fibre ltd 2016 29 r asyraf khan  
 syamsir b supian synthetic and natural fiber reinforced polymer matrix composites for advanced applications  
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## Top Keywords

recycling: 0.35544445286979454  
 composite: 0.31482222968467516  
 polymer: 0.20311111592559689  
 material: 0.19295556012931703  
 criterion: 0.1624888927404775  
 frp: 0.1624888927404775  
 matrix: 0.1624888927404775  
 waste: 0.1624888927404775  
 fiber: 0.15233333694419765  
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 technique: 0.0914000021665186  
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