

Recently Made Progress in the Shear Thickening Fluid - A Review

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This review paper explained in detail about shear thickening fluid and its application in various fields ballistic protection, body armour, shock absorber and damping devices and strengthened the impact energy absorption of aramid fabrics and polymers over the last 4 years. In this paper we explained the different application as per based on different materials. Shear thickening fluid is vital application in ballistic protection where we can save our life. Various types of materials is used as per different characteristics and bullet not enter directly when we wear aramid fabrics and polymer based cloth. This way we can avoid getting more injury.

Keywords: Shear Thickening Fluid, Body Armour, Aramid, Ballistics, Damping, System, Arduino UNO.

1. Introduction

Thickening or dilators liquid is a types of non-tenstonic fluid. In STF (shear thickening fluid)dynamic gumminess is spiked with rise rate of shear or shear deformation. Usually shear thickening fluid particles mixed in organic solvent and it consist of colloidal spread of non collecting particles. Yet it is not essential for shear thickening fluid. A general example is add nano clay in polythene glycol and fumed silica. Here nano clay is additive elements in shear thickening fluid. Recently shear thickening fluids used in various fields such as polymer dispersion based fluid in protective application, Biologically relevant agents, multiphase STF fluid used in improve ballistic performance, use silica particle based coated p-aramid fabrics STF fluid in flexible corporeal armour development, STF(Shear thickening fluid) used in damping devices where is control high vibration when it is filled in damper.

2. Classification based on Application of STF

2.1. Based on soft body armor

2.2. Based on damping application

2.3. Based on ballistic protection

2.1. Based on soft body armour : As per rheology theory shear thickening fluid used in soft body armor and it improves the impregnation with STF fluid. As per rheology based property STF treated fabrics used in ballistic body armor application and it results indicate that the utilize of small particle size spread phase in STF fluid formulation was calculated to be inexpensive. The ballistic display results shows that STF fluid with a high filling fraction that thicken intermittent are very strong differentiate to the successive STF fluids [1].

According to Qianyun He et.al, For improving impact resistance Shear stiffening gel is used in combination with a thickening shear liquid. The shear thickening-gel in the Kevlar/STF/STG not only secured shear thickening fluid merely too developed the shock strength of the fabric due to its better shear-stiffening characteristics. In this paper author is performed different experiments with different test as the wire extraction test and the impact test on the split Hopkinson pressure bar, the rod penetration test and the knife cutting test were performed to verify the growth- effect. Kevlar or shear thickening fluid or shear thickening gel dependent less weight than Kevlar with resistance to massy impact began with the synergetic effect in the middle of the shear thickening fluid, Shear- thickening-gel with Kevlar. Hence, the Kevlar or STF or STG Exhibit great potential in flexible body armor. From this paper it was concluded that the Kevlar or shear thickening fluid or mixtures of shear thickening gel have been processed for high protection performance apart from improving stability, STF fluid helped STG (shear thickening-gel) with each other for enhancing the impact resistance of the fabric. Shear thickening-gel is actually incorporated in the distance of the filaments, and increase friction when sliding the yarn. In usual, less-weight shear-thickening materials rised the Kevlar fabric shows a massive impact resistance and they are required to have STG exhibit great potential in flexible body armor [2].

As per A. Majumdar et.al, use aramid fabrics of p with 3 dissimilar level of thread densities. STF was synthesized using silica nanoparticle (100nm) and PEG(polyethylene-glycol). The fabrics were coated with sixty percentages STF to repair their durability in opposition to inferior-velocity bullets i.e. 165 meter per second. However, the absorption of impact energy increased as the density of the thread in the fabric increased. After covering with STF, panels with 4 layers of fabric stopped each bullet fired. It was feasible to decrease the size of panel through twenty three percentages afterwards the shear thickening fluid treatment while confirming the bullet stoppage. From this paper it was concluded that

Ballistic assessment of p- aramid fabrics with three dissimilar thread densities are complete. A panel composed of three layers of clean fabric with thirty to thirty per inch of thread density was unable to stop the bullet. i.e.165 meter per second. After based on silica-particle treatment of STF fluid, a significant grow in the consumption of impact energy was perceived. Although, few of the bullets entered through the fabric panel implying the inability of this structure to promise complete security compared to the bullets. For panels with 4 clean fabric layers, the shock energy absorption is increased with the increase in thread density. The panel made of fabric having wire density of 35 to 35 per inch absorbed the highest energy although it failed to stop any bullet. All panels with four layers of fabric coated with shear thickening fluid were able to stop the bullets. It was possible to reduce the size of the panel by twenty-three percent, while confirming the stopping of the bullets using the synergistic effect of the fabric structure and thickening of the shear fluid [3].

As per Bala Subrahmanya Harish Manukonda et. al, This survey make use of rheological theory of STF fluid SPG(silica polyethylene glycol) spread of varying substance arrangements in expression of packing-fraction, molecule dimensions with constant period-viscosity to evaluate their presentation and get the supreme Shear thickening fluid matter arrangement for ballistic-body-armor approach depend on the drawing basis initiated herein. Ballistic-presentation evaluation outcomes appeared that the STF fluids with elevated packing-fractions whichever stiffen brokenly, its mostly successful differentiated to the constantly STF(shear thickening fluids) fluids. Additionally, utilization of small scale particle dimension scattered-phase in shear thickening fluid expression was calculated to be reasonable. Besides, utilization of less molecular weight dispersion medium was recommended as it permits for a wider working temperature field in shear thickening fluid. Furthermore, the technological matters related with-the evolution , practical approach of shear thickening fluid soft body armour was addressed. By this work it-was culminated that a big packing-fraction, less molecule dimension, less molecular weight dispersion medium comprise the supreme shear thickening fluid arrangement for ballistic approach [4].

As per Dakshitha weera singhe et. al, Soft armor be composed of many sided high level presentation fabrics materials a prevalent desire for private preservation. Pervasive work performed in endmost little decagon proposal, STFs retouch the influence strength of woven-fabrics material. STF(Shear thickening-fluid) soaked fabrics material have-been showed as notional applicant for fabricating convenient, big presentation soft-body armor, present product focus to confer a full analysis of the present procedures of modeling STF(shear thickening-fluid) infused fabrics material work with a Impassable inspection of this methods utilized. This research paper is lead up to oversight of STF fluid dealing with concerned appliance, accompanied by a conversion of contemporary addresses in numeral modeling of-fabrics material [5].

2.2. Based on damping application : According to Minghai Wei et.al, As per rheological property STF-Fluid is a modish-matter it very rapidly through excitation changes. Finally, they talk through the force-displacement, velocity curves on basis of design parameter and it results shows that STF(shear thickening-fluid) shear-rate is rised then damping-force is increased while the threshold point and it also results shows that vibration with peak frequency or vast amplitude, the STF-fluid is easy to have high-rise shear-rate, so outcome in a large tremble command ability for the STF-fluid restraint. From this paper it was concluded that when the stimulation repetition was huge, the damping force of the STF-fluid damper began to reduce following the shear-rate increased a highest point. Additional it depends on annular-gap. Therefore, as the annular-gap is a basic specification for the configuration of an STF-Fluid restraint, new awareness to the connection in the middle of these rousing situations with annular-gap is essential, appeals of the shear thickening -fluid restraint in engineering scope with huge repetition, huge dimensions, and raised velocity-excitations[6].

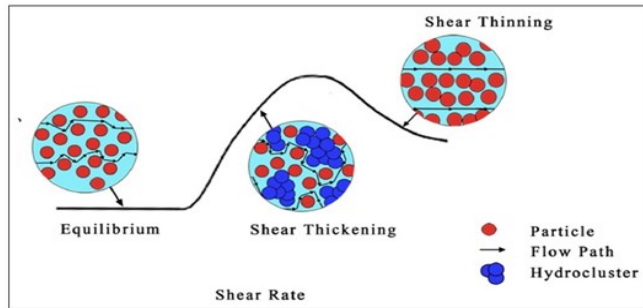


Fig-1 Schematic of shear thickening fluid

As per Selim gurgun et. al, STF-fluid is a modish matter- for tremble segregation in anatomical fellows because of visco-elastic characters. Present task, we prepared a story optimism at pouring a shear thickening-fluid into recaptured-polystyrene (XPS) scum central of an Al(Aluminum) layer-sandwich structure to extract benefit of shear thickening fluid rheology-throughout tremble packing. As per outcomes, shear thickening fluid incorporation in the sandwich formations guides to valued evolution in tremble depletion resources now those rising inversion shows disintegration in the-damping conduct. This can be finished that from the practical outcomes, Shear thickening fluid unification guides to a valued correction in-the tremble depletion characters of-the sandwich-formation. Owing to shear-thickening fabrication, tensify devolution inside the combinations acquires powerful-herewith, sandwich- formations extract benefit of this individual experience in-the tremble soaking. This thing shows prospective outcomes for forthcoming shear thickening fluid uses. Since shear thickening fluid is profitable to, the tremble depletion characters of-sandwich forms, complaint tremble disolation can be planned with-this clever liquid. Shear thickening fluid packed sandwich-systems may be used even as low systematic parts in aircraft-with increased tremble moistening dealing [7].

As per Kun lin et. al, This research paper discuss the drawing of a book oneself adaptive whole ruler restraint-with STF-fluid and it is use to- the extinguishing related to inexpedient rope oscillation. Moveable tests-are executed to research, things related to shear thickening fluid damper underneath a sequence of Lissajous curve at dissimilar repetitions nevertheless stable range. Outcomes present that, for a cable-STF-Fluid restraint system, the shear thickening fluid damper produces a mixed execution of-rubbing and adhesive restraint. It characteristics related to also rubbing or adhesive restraint protrude at apart phases-of-the degrade procedure. This proportion besides shows so as, in normal, shear thickening fluid damper is extra productive on suppression of the hold on rope tremble by balancing to the cable fixed a adhesive restraint [8].

As per Selim gurgun et. al, Present concern, the tremble features related to CFRP(carbon-fiber-reinforced-polymer) channels-were tested. To fabricate the absence of tremble separation dealing of carbon-fiber-reinforced-polymer channels, a native shear thickening fluid was poured into-the channels. hereby, thickening-rheology of modish liquid was profited in-the shear thickening fluid or CFRP formation. The outcomes appeared that the shear thickening fluid unification into the carbon-fiber-reinforced-polymer channels notably increases the native repetition related to the formation also giving foremost moistening ratio in-the shear thickening fluid or CFRP systems. As per outcomes, the shear thickening fluid unification into the CFRP tubes notably increases the natural frequency of the structures as well as providing a supreme damping ratio in the shear thickening fluid or CFRP setup. Moreover, the damping ratio corresponds well with-the rheological-dealing so as moistening predominance is grown just as shear-thickening effort obtains powerful in-the deferments. After all the carbon-fiber-reinforced-polymer formation are considerably used in-the undone lofty-vehicles acting

as-drones, such matters are-concerned to vibratory loads throughout their-flight tasks. Hereupon, absence of tremble-isolation departments related to-fiber-reinforced-polymer developments may be offset by shear thickening fluids[9].

2.3. Based on ballistic protection: As per Author T.F. Santos et.al, The present work studied the flexibility adherence and impact resistance results beside the effect of silane-coupling-agent in non-Newtonian-fluid. Outcomes related to skewer presentation for Kevlar-specimen infused with silane-agent appeared outcomes obviously high rise than more specimens removed, akin outcomes-are nearby related with-the creation related to siloxane-bonds because of the coupling-agent .The Kevlar-specimens infused-with shear thickening fluid together with coupling-silane produced foremost pliability and a remarkable rise on-the depletion kinetic(penetration-depth) balancing to more together with resistance-sticking of non-Newtonian-fluid below specimen. So, virtually this-things endured-unalterable in connection to Kevlar specimens-with shear thickening fluid together with Kevlar-control. From this paper it was concluded that the silane- coupling-agent provide additional power rise in shear-thickening feedback. This tells development in the collision energy absorption, remarkable rise in sticking, encourage a rise in-the no. of alchemical-bonds, also, supreme top, specify powerful bonds related to siloxane, thus decreasing piercing bottom, raising the pliability in connection to-the more specimens .Kevlar-control together with-Kevlar shear thickening fluid. It shows that, the utilization of Silane-Coupling-agent encourage larger development presentation related to ballistic piercing resistance related to individual defensive compounds consoles [10].

According to Author Selim Gürgen et. al ,multiphase shear thickening fluid is more effective as compare to single phase shear-thickening-fluid. Single phase shear-thickening-fluid is applied in body protection but when we use many phases shear thickening fluid ballistic performance is improved. In this work, multi-phase shear thickening fluids were produced appending dissimilar quantity related to silicon-carbide(SiC) addition toward silica together with polyethylene-glycol(PEG) based-adjourment.As per rheologic theory many-phase shear thickening fluids was scrutinized via rheologic quantification. Ballistic effects on many-phases shear thickening fluids handled fabric cloth were achieve utilizing lead-core-bullets with-the collision speed-of three hundred three thirty meter per second. Nevertheless, the mass-productivity related to fabrics-has-a deficit related to presentation for-heavy-rise celerity collision situations [11].

“According to Mansi Singh, As per steady-state and dynamic-state-rheology theory STFs possessions related to fumed-silica-PEG i.e. polyethylene-glycol with STF-fluid related to dissimilar applications together with-an- naturally improved clay together with Nanomer-one point two eight E is added and investigated. Distinction in- rheology if in place of-nanoclay, an uniform weight percentage related to extra fumed-silica-is assembled to twenty percentage fumed-silica-(PEG-200) shear-thickening-fluid i.e. Polythene glycol 200 shear thickening fluid , has been well read. At twenty five degree centigrade, in occurrence of inclusion of-nano clay-the rise in critical-viscosity is shorter besides noticed for the identicle surplus number of fumed-silica. Absorbingly, an-adverse output is looked at supreme temp. i.e. forty five and fifty five degree centigrade. Furthermore, Distinction in-steady-state together with dynamic-state-viscosity-values reduction-on-inclusion related to nano-clay. It’s recorded that a rise in-application of clay enhancement the use of dynamic-parameters. Now for shear thickening fluid related at most fumed-silica-molecules the uses are continuous disregarding related to the shift in-application. Further emphatically, simplicity related to clarifying -elasticity, durability together with steadiness of rheological-outcomes related to shear thickening fluids rises to-a valued expanse on inclusion related to fairly low cost nano-additives. From this paper it was concluded that The current study displays the growth of relatively low cost shear-thickening-fluid related to fumed-silica polythene glycol with-nanomer-clay-as supplement spread at nano-scale. Clay-is comparatively inexpensive apart from silica together with nay eco friendly. These elements will persist one of the main benefits for applying clay-based supplements over-silica together with another molecules in STF in forthcoming. Here the steady-shear-tests, it can be finished so as the inclusion related to clay at inferior concentrations does not shift critical-shear-rate and one-of-the benefits related to clay-is-that sublimate strains-are generally assisted for much-longer-times as it gets hold of time for countless

harm appliance because of effect to evolve. Besides emphatically, clay builds shear thickening fluid inferior sensitive-to variation in-temp. Clay-as nano filler offers the equal value related to critical-viscosity in the pair steady state together with dynamic state. In resist to just fumed-silica shear thickening fluid, multiplex-viscosity and both-moduli rises as-frequency together with concentration rises for clay-as-nano supplement. Here nano-clay as an extra rises the two viscous together with elastic character. Most emphatically, clay as a supplement presents more stadiness together with reproducible or relevant results. It-was-also found so as the nano molecule structure materials and it-is-not merely the total percentage of rigid molecules in shear thickening fluid that dictate it's-rheology. Hereby, the necessity together benefit of applying nano clay-as-filler-is plainly looked. It may be concluded so as the quantity of clay should be selected judiciously to obtain the required shear-thickening behavior. It-will-be pleasant to work the impact in inclusion related to different nano clays. Hereby this book perusal, absorbing clay as nano-fillers, will-lead-to-more investigation attempts on that side"[12].

According to Ms. Sapna K. Kungarani et. al, An absorbing issue of nanoscience investigation as aerospace approach is-to making a latest-thin, resilient, less weight together with cheap matter so as have-an equal superior ballistic characters besides the current Kevlar-fabrics. Main purpose related to body-protection(armor) investigation is-to evolve a inferior value, less weight, apparel cloth structure-with elevated influence-resistance. It present applied in body-armors, especially those-for-army utilization, are studied also bulky, restricting the fickleness together with versatility related to the-wearer together with lastly guiding to enhanced fatalities. Body-armor levels demand so as collision would-be ceased below influence ,infiltration bottom towards a supporting matter to the-armor would-not increase one point seven three inches. These research paper outcomes proved so as ballistic perforation-resistance related to Kevlar-fabric is increased next to compensating related to the fabric-with-colloidal STFs(shear- thickening-fluids). Infused shear thickening fluid or fabric composites appear to confer better ballistic shelter as differentiated with-easy piles related to clean-fabric together with shear thickening fluid [13].

According to Susmita Naik et.al, Kevlar and aramid fibre is applied on a huge scale in protection, biomedical and automobile and aerospace industries. This research concerned to it is the evolution and examination of composites reinforced with Kevlar fibre for ballistic us. This thing shows a ballistic influence on Kevlar composites. Conversation on research related to Kevlar fibre reinforced composites has been carried through with a focus on structural and growth, application in different engineering and affiliated sectors, foil mechanisms after ballistic influence and methods applied in analysis. It has been noticed that the research in this cirque has got great momentum since the discovery of supreme modulus and strength fibers in the 1960s. Elementary work was oriented regarding the basic, chemical and physical formation analysis along with the assessment of mechanical, thermal and influence properties which ultimately culminated in the research regarding the growth of ballistic matter Kevlar[14].

As per Author Selim Gürgen et. al, This work shows an original view of shear thickening fluid infused ballistic -fabrics material next to joining silicon-carbide molecules toward position. Here, silicon-carbide molecules-were compiled toward Si (silica) based shear thickening fluid together with Twaron-fabrics were infused with this novel adjournment. The-impact-of silicon carbide molecules in-the shear thickening fluid-was-inquired with-rheological -examining and outcomes present so as silicon carbide molecules have positive impact-to-rise the viscosity-outline related to adjournment. As per outcomes, silicon carbide particles increase the protection presentation of the shear thickening fluid picked up ballistic fabrics while defragmenting the flexibility. Rheological inspections presented that silicon carbide molecules are dominant-to- rise the viscosity outline related to shear thickening fluid. By this result of-the-drop-tower-examining. This is feasible-to-educate so as silicon carbide molecules emphatically impact- the-aegis presentation of the shear thickening fluid treated fabrics. Final, the findings prove-that-this-outlook would be helpful-to-rise the pliability related to the defensive fabrics-without agreeing-the-aegis presentation [15].

2. Conclusion

This article reviews that shear thickening fluid is used with various materials and studied many applications in various fields. Different Organic fluids and Nano supplement composites are being applied in the present. To increase the performance of the engine we add different additives with petrol, diesel, and biodiesel. In this review, most recent developments in STF technology were discussed. There is a growing attention and need to understand the characteristics and behaviours of STF materials, to find and improve their applications by choosing the proper materials and synthesis approaches. The probability of shear thickening fluid in such colloidal dispersions like fuels etc. has to be well read to decrease or improve the effects of the same. There is a region for more actual time applications of colloidal STF i.e. shear thickening fluids. Due to the specific characteristics of STF, these materials can be utilized in different engineering applications such as mechanical dampers, aircraft, automotive and construction industries, especially in reduction of external impacts or vibration attenuation. STF are smart materials with capabilities for vibration isolation in structural units, due to the viscoelastic behavior.

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