



## مجلة

# كلية المصطفى الجامعة

مجلة علمية محكمة نصف سنوية

تعنى بالدراسات والبحوث الهندسية

العدد الرابع

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### كلمة العدد :

رغم تفشي الجائحة التي تجتاح البلد والعالم اجمع والتي تؤدي الى توقف او تباطئ سير العملية التربوية في بعض الدول والمجتمعات تسعى كلية المصطفى الجامعة بكل عزم واصرار على الاسهام في تنشيط كافة الفعاليات الحيوية ، من خلال اقامة النشاطات والندوات العلمية والرياضية ، ولا تنسى القلم بل بقي القلم في هذه الكلية مستمراً ينبض بالحياة .. والبحوث العلمية لم تنقطع كي تسهم في نشر الافكار الفلسفية العلمية والتربوية والثقافية في جميع صنوفها لكي تثبت للجميع روح الامل والتقدم ، ومن الجدير بالذكر ان كلية المصطفى الجامعة كان أولى أولوياتها العمل جاهدة على اعداد الكوادر العلمية الرصينة في مجالات تخصصاتها المتعددة ، لمواجهة احتياجات سوق العمل ، ونأمل أن يصل هذا العدد إلى أيدي الباحثين والمعنيين في موضوعاته وهو يحمل بذور تعكس الروح الجامعية الرائدة الأصيلة لغايات وأهداف ثقافية وعلمية وتربوية سامية تلتزم بها الكلية وتعمل على تأكيد بروح الإيمان والأمل لبلوغها .

كان الحرص رائد الجميع على أن يكون طابع المجلة توخي الدقة والاتقان ما استطعنا لذلك جهداً .

إن لجنة المجلة تترجو مخلصاً ان يكون هذا الجهد المتواضع وهو في مقتبل شبابه بعد باكورة أعمال نافعة تتلوها أخرى صالحة وأصيلة وانه تعالى هو الموفق ونعم النصير وبه نستعين .

ومن الله التوفيق ....

رئيس هيئة التحرير

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- ١- تخصص المجلة بنشر البحوث ذات التخصصات العلمية والهندسية .
- ٢- تعرض البحوث المقدمة للمجلة على هيئة التحرير؛ لبيان ملاءمتها ويحق لهيئة التحرير أن تعتذر عن قبول البحث .
- ٣- يتم عرض البحث مسبقاً على لجنة السلامة اللغوية ولجنة السلامة الفكرية .
- ٤- تلتزم هيئة التحرير بإرسال البحوث إلى خبراء علميين من الاختصاص نفسه عدد (٣) وفي حالة الرفض من أحدهم يرسل إلى خبير ثالث لغرض الترجيح .
- ٥- تلتزم هيئة التحرير بعدم الكشف عن أسماء المحكّمين ، لضمان سرية التحكيم ولرفع، الرصانة العلمية وكذلك تكون المعلومات الخاصة بهوية الباحث في الصفحة الأولى من البحث فقط . وأن يلتزم الباحث بعدم الإشارة إلى هويته أو مكان عمله في ثنايا البحث .
- ٦- تكون حقوق الطبع للبحث ملكاً للمجلة عند قبوله للنشر ولا يحق النقل والاقتباس عنه إلا بعد الإشارة إلى المجلة .
- ٧- لا يجوز نشر أكثر من بحث للباحث في العدد الواحد .
- ٨- تحتفظ هيئة التحرير بحق أولوية النشر للبحوث مع مراعاة التنوع في النشر بحسب المحاور المعتمدة .
- ٩- ما ينشر في المجلة من بحوث ودراسات تعبّر عن رأي أصحابها ولا تعبر بالضرورة عن وجهة نظر هيئة تحرير المجلة أو وجهة نظر الكلية .

## شروط النشر :

- ١- قبول البحوث المقدمة للنشر باللغة الانكليزية .
- ٢- يقدم الباحث ثلاث نسخ من البحث مطبوعة على (A4) ويضم ملخصاً باللغتين العربية والانكليزية وأن لا يزيد الملخص عن ١٥٠ كلمة .
- ٣- يكون الطبع ببرنامج Microsoft Word ونوع الخط Simplified Arabic بالنسبة للبحث باللغة العربية أما البحوث باللغة الانكليزية فيكون نوع الخط Times new Roman.
- ٤- يكون حجم الخط (١٤) للمتن و (١٢) للهوامش و (١٦) للعنوان الرئيس و (١٥) للعنوان الفرعي .
- ٥- أن لا يزيد عدد صفحات البحث عن (٢٥) صفحة .
- ٦- يتعهد الباحث أن يكون البحث غير مقدم للنشر مسبقاً إلى جهة أخرى .
- ٧- تقديم نسخة الكترونية من البحث على قرص (CD) بعد إجراء التعديلات المطلوبة من المحكمين .
- ٨- ترفق السيرة الذاتية للباحث مع البحث .
- ٩- يكون التوثيق العلمي للهوامش على وفق الآتي :
  - أ- كتابة الهامش في متن البحث في الصيغة الآتية (اسم الملف،السنة،الصفحة).
  - ب- كتابة الهامش اسفل الصفحة وفق الآتي : ( اسم المؤلف ، عنوان الكتاب ،دار الطبع ، بلد الطبع ، السنة ، الطبعة ، ص ) .

حقوق الطبع محفوظة لكلية المصطفى الجامعة

رقم الايداع في دار الكتب والوثائق ببغداد : ٢٢٤٨ لسنة ٢٠١٧

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# بحوث المجلة

# Testing Standards for Energy Absorber of Car Bumper

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**Abstract-** The purpose of an automobile bumper's energy absorber is to deflect the kinetic energy of a collision-causing vehicle. This is typically achieved using a variety of materials and technologies, including crushable foam, plastic, or metal honeycomb structures, and springs or other flexible elements. The purpose of an energy absorber is to reduce the amount of force that is transmitted to the occupants of a vehicle during a collision, which can help to prevent injuries and save lives.

**Keyword-** Bumper energy absorber, automobile, car crashes.

## I. Introduction

One of the industries with the greatest growth rates worldwide is the automotive sector. One of the most crucial factors in car design nowadays is safety. In cases of crashes at slower speeds, a vehicle's bumper is crucial to the protection of pedestrians. [1]. Front and rear bumpers are automotive protection made of steel, aluminum, rubber, or plastic on a passenger car. The bumper system absorbs the shock in low-speed collisions to avoid or lessen damage to the vehicle. The rearmost or frontmost portion of an automobile is called a bumper, and it serves as a means of impact protection for the occupants within during collisions. [2]

### ١,٢ Function of a bumper system.

A bumper system's purpose is to reduce injury or damage during rear and frontal crashes with pedestrians, other vehicles, and fixed objects at comparatively lower speeds by absorbing impact energy through elastic and plastic deformation. A car's bumpers, which are fastened to the front and rear sides of the vehicle, protect it. Due to their extensive deformation zones, they lessen the consequences of collisions with other vehicles and objects. The bumpers are designed and constructed in this manner in order to deform and absorb the force (kinetic energy) during a collision. [3]

However, a car's bumper systems should be built to absorb the force of slow-speed crashes and assist safeguard the interior and other pricey parts that are close by.[4]

### ١,٣ Standards of Bumpers and insurance requirements.

Most regulations stipulate that all cars must have bumpers. The height and placement of bumpers may also be legally required in accidents involving vehicles of different heights to prevent the smaller car from slipping under the larger one. More and more bumpers are being produced to decrease the damage that cars cause to pedestrians, such as by using bumper covers made of flexible materials. Nevertheless, bumpers can't prevent harm to passengers in cars in high-speed collisions. [4 ]

Conflicting requirements of a soft absorber for pedestrian safety with the following capabilities are specified by legislative and insurance test processes.

-١ Prevent visible and structural damage due to low velocity impacts

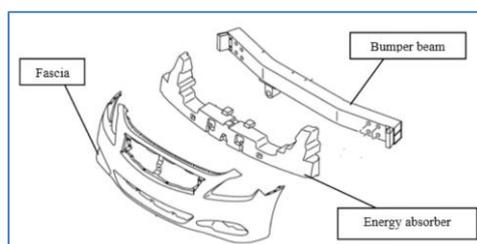
-٢ Minimize repair cost (insurance rating) due to medium velocity (15 km/hr) impacts

3- Manage load path and structural integrity for high velocity impacts to maximize occupant protection. [5]

### ١,٤ Bumper System Components.

Bumper system is composed of three main elements fascia, energy absorber and bumper beam (see Fig. 1).[1]

Fig. 1. Main parts of Bumper System [2]



١,٤,١ **The Fascia:** is generally used for reducing the aerodynamic drag force and aesthetics. It cannot sustain to impact energy,there for it is considered as a component non-structural type .

١,٤,٢ **The Energy Absorber:** is a damping part designed to damp the force created when two cars collide. Traditional energy absorbers often consist of an integrated structure made of foamed polypropylene (EPP) or thermoplastic polymer, which may require a complete overhaul as a result of a home damage.[3]

١,٤,٣ **The Bumper Beam:** is a main structure part which helps to absorbing the kinetic energy through a high-speed impact collision and in a low-speed impact collision provide resistance to bending. Bumper beam part will absorb the energy of the impact collision in a controlled manner before it transferred to the occupants.[2]

### ١,٥ **Standards to Test the Performance of Vehicle Bumpers**

There are several standards that are used to test the performance of vehicle bumpers. These standards are designed to ensure that bumpers are able to protect the vehicle and its occupants in the event of a low-speed collision. [6]

#### ١,٥,١ **FMVSS**

NHTSA (National Highway Traffic Safety Administration) issues Federal Motor Vehicle Safety Standards (FMVSS) to implement laws from Congress in united states. It has made it a top goal to decrease the number of deaths and the severity of injuries caused by forceful air bag deployment in low-speed collisions while also maintaining the advantages for adults who are generally seated, restrained, and wearing seatbelts in high severity crashes. These regulations allow to fulfil the mission to prevent and reduce vehicle crashes. One common standard for bumper testing is the FMVSS No. 208, which is used in the United States to test the performance of vehicle bumpers. This standard specifies requirements for the energy absorption and deflection of bumpers, as well as requirements for the strength and attachment of bumper components. [7]

### **Overview of Potential Candidate Test Procedures**

## ١,٥,١,١ Full Frontal Fixed Barrier:

The full-frontal Fixed Barrier Crash test (also known as the Rigid Barrier test) simulates a collision between two vehicles traveling at the same speed when they collide. Figure (1-2) displays a schematic of the test arrangement. The test is made to mimic the majority of real crashes involving a significant amount of frontal contact in the direction of impact (both car-to-car and car-to-fixed object incidents). The barrier rebound velocity for FMVSS No. 208 typically ranges up to 10% of the impact velocity for a change in velocity of up to 53 kph, though it does vary slightly from vehicle to vehicle. The impact velocity ranges from 0 to 48 kph (0 to 30 mph) for this standard. [7]

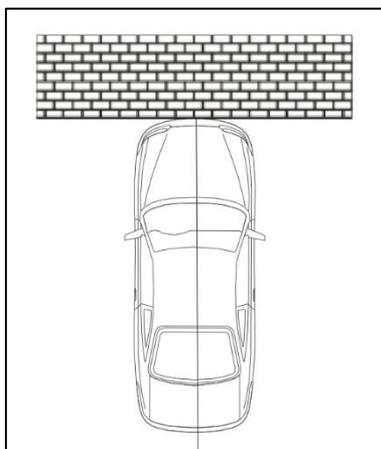


Fig. 2. Full Frontal Fixed Barrier [7]

### 1.5.1.2 Oblique Frontal Fixed Barrier

A stiff barrier test at speeds of up to 48 kph and at angles of up to 30 degrees from the line of travel are required by FMVSS No. 208's frontal barrier crash test. Figure 1-6 displays a schematic of the test arrangement. Oblique frontal fixed barrier tests offer a longer length crash pulse with a lower acceleration than full-frontal fixed barrier tests. [7]

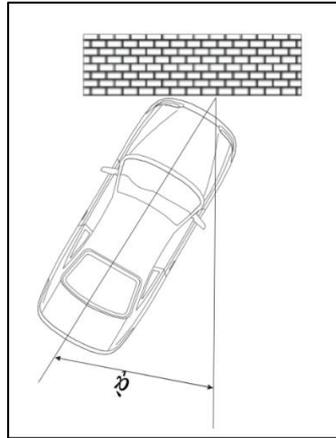


Fig. 3. Oblique Frontal Fixed Barrier (shown at 30° Impact Angle) [7]

#### **1.5.1.4 Frontal Fixed Offset Deformable Barrier:**

This test, also known as the Offset Barrier Test, involves partially engaging the front structure of the vehicle/occupant restraint system with a crushable barrier face. The offset barrier test generates what is often referred to as a "soft" crash pulse, which has a lower acceleration and a longer duration than the complete frontal fixed rigid barrier test. It is a whole systems test that assesses how the occupant restraint system and the energy-absorbing vehicle structure react to a low severity collision pulse. With reduced frontal contact and perpendicular hits with changes in speed up to about 56–60 kmph based upon a speed of impact 56 kmph, the offset barrier test is designed to simulate the majority of real-world accidents.

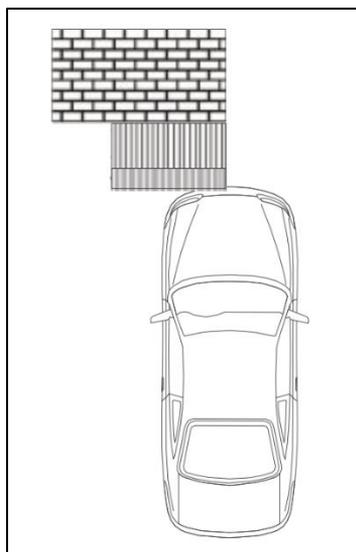


Fig. 4. Frontal 40 % Offset Deformable Barrier Test[7]

#### 1.5.1.5 Oblique Moving Deformable Barrier Test (MDB)

This test is designed to simulate extremely serious oblique accidents with extensive frontal contact and intrusion. The frontal-oblique MDB test results in a short-duration, high-deceleration crash pulse that is commonly referred to as a "stiff" pulse. The test is designed to replicate an oblique car-to-car collision with each travelling at 50 to 60 kph or with only one going at 100 to 120 kph. [7]

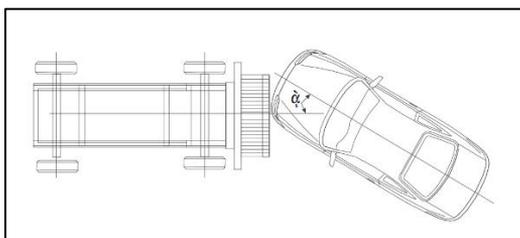
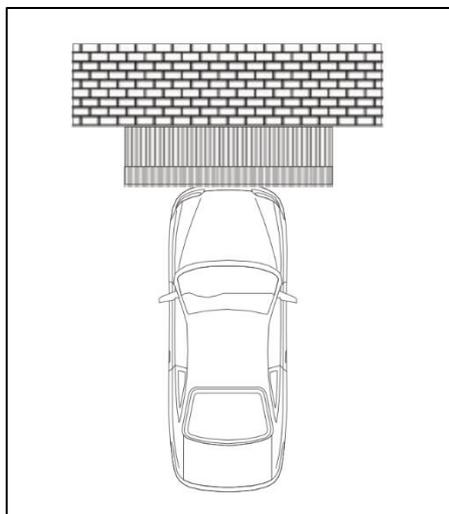


Fig. 5. Oblique Moving Deformable Barrier (MDB) Test

#### ١,٥,١,٦ Full Frontal Fixed Deformable-face Barrier (FFFDB)(

In order to fully engage the vehicle construction, the Full Frontal Fixed Deformable-face Barrier (FFFDB) test expands on the Deformable Offset Barrier Test's basic idea. A car is pressed up against an experiment's stiff, flexible wall. Fully engaged is the vehicle's front structure. Although the

rebound speed changes from car to car and is typically ten percent of the velocity of impact, it should be noted that the change in speed during this test is about the same for belted or unbelted passengers, ranging from 0 to 53 kph. [7]



**Fig. 6. Full Frontal Fixed Deformable-face Barrier (FFFDB)**

### ١,٥,٢ RCAR Bumper Test Protocol

RCAR (Research Council for Automobile Repair) is a global organization of vehicle research facilities run or controlled by insurance companies or groupings of insurance companies, with the main objective of advancing the RCAR purpose. The RCAR Bumper Test pushes automakers to design efficient bumper systems with high energy absorption beams and crash boxes that can successfully shield the car in low-speed collisions. Additionally, the bumper systems must feature broad beams that shield the car's corners from low-speed collisions. According to RCAR, good vehicle bumper beams should include the following characteristics :

Can be mounted on cars' front and back.

-have a beam height larger than 100 mm and be positioned to engage properly with the front and back bumper barriers. - be interchangeable without cutting or welding.

-maintain stability throughout impacts to avoid underride and override

-be able to carry lateral loads without twisting by being torsion-resistant.

-deflect energy and restrict harm to the bumper system alone.

-be joined to the body using components that absorb energy and are simple to replace or repair.

Protect expensive structural, welded, or bonded, and other parts from harm.

-stretch laterally to safeguard the car's corners. To determine how successfully a vehicle's bumper system shields it from harm in low-speed accidents, an international RCAR working group has devised test methodologies. These studies address three aspects of bumper function while producing damage that closely resembles the patterns seen in low-speed collisions in the real world.

١. Geometry – In order to appropriately contact other cars in low-speed collisions, vehicle bumpers must be positioned at standard heights above the ground and extend laterally to the corners.

٢. Stability – Vehicle bumpers must be sufficiently tall and broad to maintain contact with the bumpers of other cars even while the moving vehicle is being loaded, stopping, etc.

٣. Energy-absorption – Bumpers on vehicles should deflect low-speed accident energy without causing harm to other car components.[8]

١, ١٠, ٢, ١ Full-width Tests :

During collision, the center of the bumper barrier will be parallel to the centerline of the vehicle. The degree of lateral deviation that is permissible will be decided by each test houses due to the variations in automotive propulsion

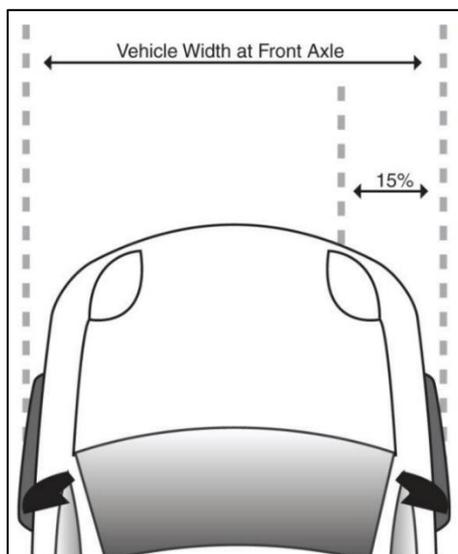
systems. The majority of the time, lateral variations up to and including 50 mm are acceptable. Impact will occur at a speed of 10.0 kph.



Fig. 7. Full width test

## ١,٥,٢,٢ Corner Test

Figure shows how the width of the vehicle, as estimated at the wheel wells (including frames and sheet metal protrusions) at the relevant axle—the front axle for the front corner tests—must exceed the lateral edge of the wall by 15% of the car's width after impact (1-8). A 5.0 kph impact speed is required.



**Fig. 9. 15 Percent Overlap Based on Vehicle Width at Front Axle Measured at Wheel Wells**

### ١,٥,٣ ISO

The ISO (International Organization for Standardization) is a non-governmental organization that creates and disseminates worldwide standards, some of which are used to evaluate how well car bumper's function., the EU (European Union) Directive on General Safety of Motor Vehicles, these standards include.

- ISO 6603-2: "Road vehicles -- Low-speed frontal impact test procedure -- Part 2: Passenger cars"
- ISO 6603-3: "Road vehicles -- Low-speed frontal impact test procedure -- Part 3: Light commercial vehicles"

These standards specify the procedures and requirements for testing the performance of vehicle bumpers, including requirements for the strength and attachment of bumper components, and the energy absorption and deflection of bumpers during a collision. These standards are intended to ensure that bumpers are able to effectively protect vehicles and their occupants in the event of a low-speed collision. [9]

### ١,٥,٤ EURO NCAP

The Euro NCAP (EUROPEAN NEW CAR ASSESSMENT PROGRAMME) is a program that is employed to assess how well new cars perform in terms of safety. It is administered by the European New Car Assessment Programme in Europe.

As part of the NCAP testing process, vehicles are subjected to several different crash tests, including a front impact test and a side impact test. These tests are designed to simulate the kinds of crashes that vehicles are likely to experience in real-world situations, and they are used to measure the performance of various safety systems, such as seat belts, airbags, and bumpers.

The NCAP program also includes to make evaluation for a new car test conducted at 56 kmph hit The front of the barrier is made up of a reinforced concrete block that is at least 3 meters wide and 1.5 meters high. The barrier must be at least 70 metric tons thick and weigh that much in weight. The front face must be level, vertical, and orthogonal to the run-up track's axis. [10]

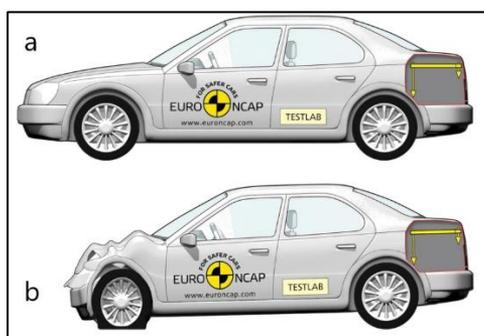


Fig. 10. Euro NCAP Front Test Protocol

١,٥,٥IIHS

Reducing the number of collisions is the mission of the Insurance Institute for Highway Safety (IIHS), a non-profit organization, injuries, and fatalities on the nation's roads. The IIHS conducts a variety of research and testing programs to evaluate the safety performance of vehicles, Reducing the amount of collisions is the mission of the Insurance Institute for Highway Safety (IIHS), a non-profit organization. One of the tests that the IIHS conducts as part of its vehicle rating program is the bumper test, which is designed to evaluate the performance of vehicle bumpers in low-speed collisions. The IIHS bumper test includes both a front and a rear impact test, and it measures the amount of damage sustained by the bumper and the underlying structure of the vehicle as a result of the collision. [11]

) ١,٥,٦ADR (

The Australian Design Rules (ADR). These standards specify requirements for the design, construction, and performance of vehicle bumpers, with the goal of ensuring that bumpers are able to effectively protect vehicles and their occupants in the event of a collision. [12]

١,٦conclusions: from the above there are many standards for manufacturing car bumper to improve the ability of energy absorbing through the collisions, all these efforts are to protect the passengers and driver.

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## Surface properties of glass ionomer cement after addition of Date seeds powder

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## Abstract

The aim of this study was to investigate the effect of adding date seeds powder to the glass ionomer cement on surface roughness, water sorption, and wettability. A conventional glass ionomer powder was mixed with date seed powders in different amounts. Mix 1, 3, and 5% (w/w) date seed powder with the glass ionomer powder by hand for 2 minutes. The samples were immersed in an artificial saliva solution during one-day, one-week, and one-month test periods. After 30 days, the surface roughness Ra values of the samples were found to be higher. After a month, water absorption decreased among the tested samples. In the wettability test, all of the samples were found to be hydrophilic and have a contact angle of less than 90 degrees. But all of the specimens are very close to being water-resistant.

**Keywords:** Glass ionomer cement, dates seed, Surface roughness, water sorption, wettability.

## Introduction

An increase in the demand for improved esthetics and the fluoride releasing ability of restorative materials has resulted in the development and widespread use of tooth colored restorative materials in pediatric dentistry.

One such material, a glass ionomer cement (GIC), has been advocated for use because of various reasons, including its physical–chemical bonding to the tooth structure, acceptable esthetic properties, biocompatibility, continuous fluoride release to the adjacent structures over a long period, inhibition of bacterial acid metabolism and activity, similar coefficients of thermal expansion to that of the tooth structure, and ease of clinical application [1-3]. However, conventional GICs also have a number of drawbacks, such as dehydration, initial moisture sensitivity, a prolonged setting reaction time, and a rough surface texture, which can negatively affect the mechanical properties of the restoration and lead to clinical failure [4, 5].

In order to fix these problems, different types of glass ionomer-based restorative materials and different types of glass ionomer-based material formulations have been made. These materials are easier to work with, last longer, and look better [6, 7]. Some of these are high-viscosity glass ionomers, resin-modified glass ionomer cements (RMGICs), and polyacid-modified composite resins (PMCRs). The newest innovations are based on nanotechnology and include high-viscosity GICs that set faster and have nanofluoroapatite/hydroxyapatite particles in them, as well as GICs that have been modified with resin [8, 9]. By adding nano-sized filler particles to glass ionomer-based materials, their mechanical properties, resistance to wear, color stability, and resistance to biomechanical degradation may be improved.

Although a few studies of nano-filled GICs have been performed, given the increasing use of GICs and recent trends toward increased consumption of acidic beverages, additional research is needed on the effects of these beverages on the surface texture of GICs. The clinical success of restorations depends on their long term durability in the oral environment. Thus, information is also needed on the performance of GICs as a restorative material.

Also, there are different kinds of surfaces in the mouth (enamel, restorative materials, and implants, orthodontic and prosthodontic appliances). When figuring out how wet the oral substrate is, the contact angle of saliva, artificial saliva, and different mouthwash solutions on enamel, glass ionomer cement, composite material, and other materials should be measured. The way wettability is interpreted can give information about how the surfaces of the mouth interact with liquids that

are commonly used [10, 11]. Therefore, the purpose of this study was to evaluate the effects of the addition of 1, 3 and 5 wt. % of Date seeds powder micro particles size into conventional GIC on the surface properties immersed in artificial saliva solution.

### Materials:

The seeds were washed with clean water and then left out in the open air for 24 hours to dry. The dried seeds were heated in an oven at 70°C for 24 hours to get rid of the water. After that, the seeds were crushed and milled for 5 hours using a high-speed multi-functional crusher (rotating speed 22000 r/min). Then, the material was filtered until the target micro-scale particle size (less than 50 micro) was reached, which was confirmed by x-ray diffraction.

A conventional glass-ionomer powder (Shanghai Rongxiang Dental Material Company Ltd, China) with a particle size of about  $>500 \mu\text{m}$  was blended with different proportions of date seeds powders. Powders were made by mixing 1, 3 and 5% (w/w) date seeds powder with the glass ionomer powder by hand for 1 min. The unblended powder was used as the control for all tests. The recommended powder/liquid (P/L) ratio of 20 g: 15 L by weight for glass ionomer cement was used in all of the prepared specimens. The samples were stored in artificial saliva based on the formulation described by Adsul et. al.[12], for one day, one week and one month. The materials used for preparing the artificial saliva are potassium chloride, sodium chloride, monopotassium phosphate, disodium phosphate, calcium chloride, sodium thiocyanate, ammonium chloride, urea, glucose, mucin and ascorbic acid. The artificial saliva was renewed daily. Figure 1 shows the samples immersed in the artificial saliva solution.



**Fig.1.** samples immersed in the artificial saliva

## Surface properties testing

### Surface roughness

A Hand-held Roughness Tester (TR200) manufactured by (TIME Group Inc.) was used. Figure 2 shows the surface roughness tester used in the study. The dimensions of the Disc - shaped specimens are (40 mm\* 10 mm). These models have proven their value in practical use for surface finish quality testing. An examination tube with a needle head (The recording needle in the cylinder and it has a tapering tip) and the surface of the material whose surface roughness is measured, and then the specific pressure is applied in that place and by moving this needle on the surface it turns within minutes into a digital reading in the device, which serves to work with it with one touch and contact with the device with the surface of the model to measure its surface roughness, provided that these materials are flat and subject to contact with the device.



Fig.2. Surface roughness test device

### Water sorption

Disc - shaped specimens were prepared at  $37 \pm 1^\circ\text{C}$  for 1 hr. ( $d = 20$  mm,  $h = 4$  mm). Samples were weighed before immersion. Then, the specimens were stored in artificial saliva at  $37 \pm 1^\circ\text{C}$  for 1, 7, and 30 days. After each period, the specimens were weighed using an electronic analytical balance (0.0001 mg precision). The measurements were repeated, and the baseline constant mass ( $m_0$ ) was recorded. All specimens were kept in artificial saliva, and they were weighed after 1, 7, and 30 days.

Before weighing, the samples were carefully dried on filter paper until there was no visible moisture left. They were then waved in the air for 15 seconds, weighed to 0.0001 mg 1 minute later, and then put back in their containers. The mass was written down as ( $m_1$ ). Using the same cycle as what was said above. After 30 days, the materials were measured to see how much water they could hold. The water absorption of the samples ( $W_{SP}$ ) in ( $\mu\text{g}/\text{mm}^3$ ) was determined based on the equation below:

$$W_{SP} = \frac{m_0 - m_1}{V}$$

### Wettability

The contact angle measuring method can be used to figure out how wet the surfaces of specimens are. Wetting is the ability of a liquid to stay in contact with a solid surface when it comes in contact with it. By measuring the contact angle, you can see how the liquid acts on a surface made of different materials. It is used to find out how water-resistant the composite surfaces are. The tests on the samples were done based on specification ASTM D - 7334. The disc-shaped specimens are 40 mm by 10 mm. A glass pipette is used to put a drop of water on the composite surface of the device. In all composites, the size of the water droplet stayed the same. Figure 3 shows the experimental setup that is used to measure the contact angle. It has an image processor, a moveable holder, a camera, optical lenses, and test sample holders.



**Fig.3.** Wettability test device

### Results and discussion

## Surface Roughness

Ra values for (1, 7, and 30 days) are presented in Table 1 All the tested materials showed significantly higher Ra values compared with the pure specimen after immersion in saliva.

**Table 1. Surface Roughness values (Ra) for samples**

Filler addition%	1 day Ra1	7 days Ra2	30 days Ra3
0%	0.998	1.861	2.407
1%	1.100	1.083	1.303
3%	1.922	2.906	3.140
5%	2.865	3.656	4.421

## Water sorption

Table 2 shows how much water the samples that were tested took in. Most of the water was taken up by all of the samples in the first 24 hours. The amount of water that each test material could hold for 24 hours and 30 days was very different. The least amount of water was taken up by samples after 1 month. As shown in Table 2, water sorption decreases for each addition after one month.

**Table 2. Water sorption values**

Filler addition%	Water sorption ( $\mu\text{g}/\text{mm}^3$ ) after 1 day	Water sorption ( $\mu\text{g}/\text{mm}^3$ ) after 7 days	Water sorption ( $\mu\text{g}/\text{mm}^3$ ) after 30 days
0%	0.0906	0.0953	0.0695
1%	0.2039	0.1716	0.1410
3%	0.1325	0.1227	0.0946
5%	0.3318	0.2785	0.2491

## Wettability

Contact angle measure analysis can be used to estimate the wettability or hydrophilicity of a GIC sample. A device for processing images was used to figure out the contact angle. Disc-shaped specimens with DS filler of (0%, 1%, 3% and 5%) addition, and the values obtained after 1 month of immersion in artificial saliva are shown in Table 3.

**Table 3.** Content Angles values

Filler percentage	Contact angle value (Degree) after 1 month
0%	75.18
1%	78.74
3%	81.22
5%	88.13

In general, surfaces that are rough have the highest contact angles and surfaces that are smooth have the lowest. A surface that is hydrophilic has a contact angle that is less than 90 degrees. Hydrophobicity is shown by a slope that is greater than 90 degrees. All of the made samples had contact angles that were less than 90 degrees, which showed that they were hydrophilic, but as the filler addition increased the contact angle shows a value close to 90 degrees (5% addition has a contact angle of (88.13%). Figure 4 shows images of contact angle measurements.

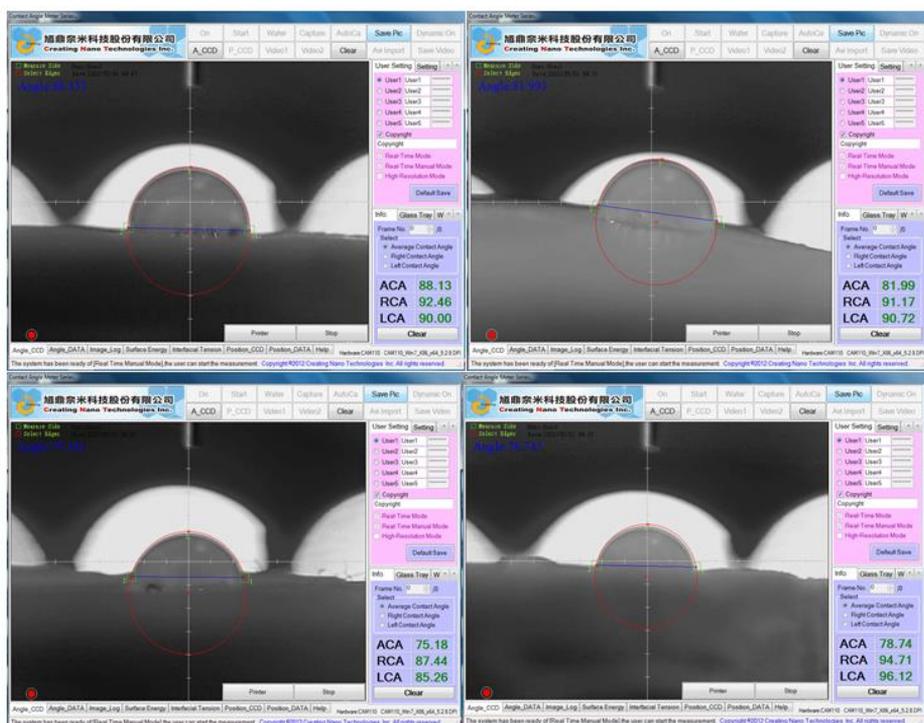


Fig.4. Wettability test values

## Conclusions

Based on the obtained results, it can be concluded that the surface properties of the glass ionomer cement were enhanced by the addition of the Date seed powder microparticles. These results were expected due to the date seed behavior as compared with the control group of the glass ionomer cement sample. It was found that samples have a higher Ra value after one month. Water sorption decreases for each addition after one month. As for the wettability test, it was found that all the specimens were hydrophilic and had a contact angle below 90 degrees. But all the specimens are close to having a hydrophobic nature.

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# Comparative study and evaluation of the compressive strength and mechanical wear resistance of colored geopolymer concrete based on fly ash as a binder

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**Abstract**— The purpose of this study is to conduct a comparative evaluation of the compressive strength and mechanical abrasion resistance of colored geopolymer concrete based on fly ash as a base material. Three percentages of 1%, 2% and 3% of three colored oxides were considered, which are red iron oxide, green chromium oxide and yellow iron hydroxide from fly ash. High plasticizer of the mixture to obtain workability in addition to a small

amount of water. The results of the study showed that the compressive strength and abrasion resistance had the best performance when the percentage of addition was 1% for the red and yellow colors and 2% for the green colour, which achieved the highest results and the best mechanical wear resistance aluminum oxide.

*Keywords— Geopolymer concrete, fly ash, pigments, mechanical properties and wear resistance.*

### INTRODUCTION

Davidovits used the term "geopolymer" in 1978 to designate a broad category of materials characterized by inorganic molecular networks [1]. Thermally active natural sources, such metakaolin, or industrial byproducts, like fly ash or slag, are the mineral sources of silicon (Si) and aluminium (Al) in geopolymer concrete. These two waste products can be dissolved in alkaline activating solutions, thereafter they are polymerized into molecular chains and transformed into a binder. According to Rangan, "the polymerization process involves a very quick chemical reaction of silicon and aluminium metals under alkaline circumstances, producing a three-dimensional polymeric chain and ring structure". Due to the outstanding properties of geopolymer concrete, such as its cohesiveness at room temperature, non-toxicity, impermeability, improved heat resistance, and resistance to all inorganic solvents, researchers have begun to examine employing it in structural components [2]. Fly ash was employed in place of Portland cement when Luhar and Khandelwal researched the behaviour of geopolymer concrete, the concrete was cured at 75°C for 24 hours, and the researchers discovered that the compressive strength could be increased while also reducing harmful emissions [3].

IT WAS POSSIBLE TO CREATE A VARIETY OF COLORED CONCRETE BY ADDING THIS COLORED POWDER TO GREY CONCRETE IN SOUTHERN CALIFORNIA, ACCORDING TO A PROPOSAL MADE BY F.D. CONTRACTORS, A DAVIS GROUP COMPANY, TO MANUFACTURE COLORED CONCRETE FOR THE FIRST TIME. INDUSTRIAL IRON OXIDE WAS DERIVED FROM CHEMICAL PROCESSING RESIDUES. IN 2004, COATINGS MADE OF SYNTHETIC  $Fe_2O_3$  WEIGHED 200 MILLION POUNDS [4]. COLORED GEOPOLYMER CONCRETE MAY BE EXTENSIVELY USED IN SOME CONSTRUCTION APPLICATIONS, SUCH AS INTERLOCKING PAVEMENT BRICKS, CURBSTONE AND CONCRETE PAVING BLOCKS. OTHER RESEARCHERS WHO HAVE STUDIED COLORED CONCRETE, SUCH AS AWADLY ET AL.[5], HAVE DISCUSSED THE IMPACT OF ADDING COLORED PIGMENTS ON THE VARIOUS PROPERTIES OF CONCRETE.

NUMEROUS RESEARCHERS HAVE INVESTIGATED THE USE OF FLY ASH AS A CEMENT SUBSTITUTE [6]. OUR WORK HAS INVESTIGATED THE COMPATIBILITY OF MIXING COLORED PIGMENTS WITH GEOPOLYMER CONCRETE. THIS STUDY'S OBJECTIVE IS TO EVALUATE THE COLORED GEOPOLYMER CONCRETE'S QUALITY USING COMPRESSIVE TEST AND MECHANICAL WEAR TEST. MATERIALS AND METHODS OF TESTS

## Materials and Tests

### 1) Fly ash

The term used to describe "fine inorganic and burned by-products", that are taken from the furnace to the flue gas particulate cleaning and collection system in coal-fired power stations. In this work, used fly ash according to the specifications of ASTM C 618 type C [7], the results of the chemical and physical tests for fly ash are displayed in TABLES I and II show the results of chemical and physical tests for fly ash according to the requirements of ASTM C 618 type C [13].

**TABLE I.** CHEMICAL COMPOSITION ANALYSES OF FLY ASH TYPE C BY XRF (% BY MASS).

Oxides	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	K <sub>2</sub> O
Content%	36.93	18.76	5.85	26.9	5.96	1.49
Oxides	SO <sub>3</sub>	TiO <sub>2</sub>	L.O.I	Na <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	/
Content%	0.94	0.73	1.78	0.31	0.35	/

**TABLE II.** FLY ASH PHYSICAL CHARACTERISTICS.

Characteristics	Surface area, cm <sup>2</sup> /g	Nature of material	Specific weight%	Color
Outcomes	6560	Powder	2.33	gray to light white

### 1) NaOH

*NaOH is commonly available in flaky form and is highly pure (>98%) when dissolved in distilled water as ASTM E291 [8]*

### 2) Sodium Silicate

*Na<sub>2</sub>SiO<sub>3</sub> utilized in this work is a common supply in the Iraqi market and was procured by the United Arab Emirates.*

### 3) Fine aggregate

Sand from the Ekhedir region is mostly used as fine aggregate. The results of the fine aggregate's chemical and physical test showed that it conforms to IQS No. 45/1984 specifications [9].

### 4) Coarse aggregate

*To create the mixtures for this work, traditional gravel from the Al-Nabai zone was used as the coarse aggregate. The examination's results demonstrate its compliance with IQS 45/1984 [9].*

### *Super-plasticizer (high range) admixture*

In accordance with ASTM C494[10], naphthalene formaldehyde sulfonate, super-plasticizer was employed to increase workability. The qualities of plasticizer are displayed in TABLE III..

**TABLE III.** PROPERTIES OF A PLASTICIZER

Technical properties	Basis	Color	pH	Density (kg/L)	Chloride content
Descriptions	Naphthalene formaldehyde sulfonate	Dark brownish	7–11	1.181 ± 0.01	Nil

### 2) Extra water

*Tap water, which is appropriate for concrete mix, was used as additional water for all colored geopolymer concrete mixtures.*

### 3) Pigments

In this work, 3 different types of pigments (powder) they were imported from China, red Fe<sub>2</sub>O<sub>3</sub>, green Cr<sub>2</sub>O<sub>3</sub>, and yellow FeOOH. Were used in varying amounts (0%, 1%, 2%, and 3% by weight of Fly ash) in the mixtures. The fineness value of the pigments was displayed in TABLE V.

**TABLE V.** Fineness (Surface Area) of Pigments

Pigment	Red Fe <sub>2</sub> O <sub>3</sub>	Yellow FeOOH	Green Cr <sub>2</sub> O <sub>3</sub>
Fineness (cm <sup>2</sup> /g)	6580	12720	8178

### *B) Geopolymer concrete mixtures with various colours*

Table VI a and VI b show the mix design of colored geopolymer concrete mixtures are displayed [11].

**TABLE VI a:** Colored Geopolymer Concrete Mixes\*

MIX.	FA Pigments kg	Alkaline liquids, Admixture kg	Sand Kg Na <sub>2</sub> SiO <sub>3</sub> /N aOH	Gravel kg Molari ty of	Extra water kg
Ms	15	5.316	22.185	45.075	1.425
Mr1%	14.85	5.316	22.185	45.075	1.425
Mr2%	14.7	5.316	22.185	45.075	1.425
Mr3%	14.55	5.316	22.185	45.075	1.425
Mg1%	14.85	5.316	22.185	45.075	1.425
Mg2%	14.7	5.316	22.185	45.075	1.425
Mg3%	14.55	5.316	22.185	45.075	1.425
My1%	14.85	5.316	22.185	45.075	1.425
My2%	14.7	5.316	22.185	45.075	1.425
My3%	14.55	5.316	22.185	45.075	1.425

\*Where Ms: Referance geopolymer concrete, Mr: Geopolymer concrete with red pigment, My: Geopolymer concrete with yellow pigment, and Mg: with green pigment.

TABLE VI b: Colored Geopolymer Concrete Mixes

				NaOH
Ms	0	0.585	2.5	14
Mr1%	0.15	0.585	2.5	14
Mr2%	0.3	0.585	2.5	14
Mr3%	0.45	0.585	2.5	14
Mg1%	0.15	0.585	2.5	14
Mg2%	0.3	0.585	2.5	14
Mg3%	0.45	0.585	2.5	14
My1%	0.15	0.585	2.5	14
My2%	0.3	0.585	2.5	14
My3%	0.45	0.585	2.5	14

## C) Prepare alkaline solutions

### 1) Preparing NaOH Solution

The weight of NaOH solid was predicted to be 404 g dissolved in 596 g of distilled water to reach a solution with a concentration of 14 moles based on ASTM E291 [8] and Hardjito and Rangan[11].

### 2) Preparation of alkaline liquids for mixtures

For the purpose of obtaining the alkaline solution, Na<sub>2</sub>SiO<sub>3</sub> and NaOH solution were combined in a ratio of 1:2.5 while taking into account the solution's earlier preparation (24 hours prior to the mixture's components) [12].

# A Review on decorative cement

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**Abstract:** In this research, a group of the most important researches related to the cement used for decorative purposes, which is colored cement, which is the main material in the production of colored concrete, was reviewed. It has been concluded that the use of inorganic pigments is better than natural pigment, the percentage of inorganic pigment powders must not exceed 2% wt. of cement, because the pigment's particle size is smaller than that of cement, it tends to decrease the workability of concrete and mortar. In some applications we need to improve workability, in these cases may be adding superplasticizer and the percentage of pigments in the liquid state cannot be determined because they depend on several variables.

Keywords: decorative cement, colored cement, colored concrete, pigment.

## **1-Introduction:**

Concrete in which colored cement is used as a binding material is called colored concrete [1]. Colored cement or decorative cement are prepared by adding coloring pigment to white Portland cement [2].

Decorative cement was first developed in the early 1950s. When iron oxide has been suggested, it was added to the gray concrete mix by Davis engineers in California using a waste product from chemical industry. The standard gray concrete could be dyed in a variety of earth colors by mixing in such colored powder. In the last six decades, cement coloring has expanded quickly; in the year 2004, no less than 204 million pounds of iron oxide were utilized to color cement-based products as a staple in North America alone [3].

## **2-Literature Review:**

- G. H. Rowe and S. M. Bruce have conducted research in 1992. The concrete block paving industry frequently uses the fundamental properties of 9 pigments (black two, Marigold, light brown, dark brown, yellow, and red

"three sorts"). Each pigment's characteristics of water consumption are obviously influenced by its shape and particle size. All pigment are much finer than cement and when added at a 2% dose rate (depending on the cement block), there is a significant decrease in operability compared with mixed control. The pigments identified as containing longitudinal particles with high surface area (marigold and yellow) show a relatively high demand for water, which reduces their workability when tested at a constant rate of percentage. Pigments made of spherical particles have a lower demand on water than long molecules. Softness in terms of the specific surface is the most useful guide to water demand in these pigments. Adding pigment with high water demand reduces the relative ease of this operability. If water is added to the mix to maintain operability, the subsequent increase in w/c ratio will reduce durability with potential reduction in performance parameters such as physical and chemical weathering and corrosion resistance [4].

- L. Hyun-soo et al. investigated how iron oxide pigments affected the characteristics regarding concrete interlocking blocks in 2003. They presented the details of the experimental results and pointed to the flourishing of the interlocking concrete blocks pigmented and found that the interlocking blocks mixed with iron oxide pigments gained a higher color strength than those found in brown iron oxide because iron oxide pigments are finer compared to the other. A unique correlation between the absorption ratio as well as the bending strength regarding pigmented blocks was discovered through additional study. They discovered that the pigment to cement proportion must not be more than 4% when using iron oxide pigments to create colorful concrete interlocking blocks [5].

- D. F. Lin and H. L. Luo investigated how the surface color regarding mortar samples made of sludge ash changed at various temperatures in 2007. Additionally, the impact of temperature on variations in the mortar surface's color was investigated. Three distinct sewage sludge ash percentages (10, 20, and 30%) as well as six various temperatures (25, 200, 400, 600, 800, and 1000 ° C) are used to compensate for certain cement percentages, which are after that adjusted. The findings show that the surface color change is significantly influenced by the addition of sludge ash to mortar. Ash additions lessen the intensity of blue, red, and green. The presented work demonstrates how the use of grayscale might be crucial for evaluating high-temperature fires [6].
- The impacts of adding 5 types of inorganic pigments (iron oxide red, iron oxide yellow, chromium oxide green, iron oxide black, and ultramarine blue) to architectural self-compacting concrete were researched by Sungur and Karaguler in 2007. The main results of experimental work are the red concrete has largest value of water absorption while the lowest value appears with green concrete, at 28 day compressive strength of blue, yellow and black pigment-doped mixture is reduction (18%, 11% and 8%) respectively while red and green are not noted reduction in compressive strength. The flexural values at 28 day have no much effect [7].
- The idea of creating colored structural concrete and colored floor tiles, bricks, and precast concrete products was investigated by B. Alkharabsheh and M. Reshedat in 2007. Zercon Sand, Red Zeolitic Tuff, Black Zeolitic Tuff, Red & Black Zeolitic Tuff, Lime "by product," and Bentonite with particle size of (45)  $\mu\text{m}$  have been utilized as processed natural and locally accessible raw materials, with the exception of red Zeolitic Tuff pigment

(45 and 500  $\mu\text{m}$ , to add to white cement. The experimental investigation has been concentrated on two separate goals: the color of concrete and the strength of concrete that was intended to be utilized as structural concrete. Thus, using the traditional testing methods for flexure, compression, direct tension, splitting, and direct shear, the features regarding the generated colored concrete were characterized. The results regarding each test will have specification limitations of (ASTM C-979), Additionally, the bonding between the colored paste and aggregates was examined in the microstructure regarding concrete created in this study with the use of XRD and SEM analysis [8].

- In 2008, G.Juan et al. examined the performance of colored white cement with blue pigment. Performance is illustrated by the metal changes that occur in the replacement of cement by 5, 10, 15 and 20%. Concrete and mortars were produced to be studied to 3, 7, 28 and 90 days of the curing. The pigment which is suitable for C3A of cement and water, and was found to allow large amounts of initial exchange (irregular and dispersed in the matrix) to be produced, because of its sulfur content. It means an increase in the mechanical strength of the cement blended with the ultramarine blue pigment by up to 45% to 90 days of curing [9].
- With the use of earthenware powder, M. Inoue et al. (2008) investigated the mechanical characteristics and assessed the color related to colored concrete. Thus, as the ratio regarding earthenware powder replacement rose, the strength of concrete and coloring effect also improved [10].
- In 2009, A. Lopez et al. has examined the advantages of using colored self-compacting concrete (C-SCC) mortar-based mixture design methodology. In the case when cement mortar is utilized, there is a possibility for

observing the impact of pigments on C-SCC viscosity as well as evaluating certain aspects like color homogeneity, color parameters, and surface finishing along with quickly and easily identifying mixtures, including rapid types of cements, mineral additives, chemical additives, and pigments [11].

- In the year 2012, Mohammed Ali Abdulrehman et al. concentrated on examining how the environment affected a few physical and mechanical characteristics regarding colored concrete; pigments are sold locally and are also imported from countries other than Iraq. Through testing specimens for modulus of rupture, compressive strength, and water absorption under varying situations including acidic medium, high temperatures, rain, the experimental study has addressed a few physical and mechanical aspects of concrete. Also, the researchers found that for all used colors (Yellow, Red and Black), it has been found that 2% of pigment give the best properties of colored concrete (compressive strength, modulus of rupture and absorption water), however, 1% of pigment in black colored concrete gives the best properties than other percentage of black colored concrete but this percentage makes the concrete appear with gray color and this color can be achieved without using any pigment, which is the normal color of Portland cement [12].
- With studying the pigments in liquid case with fly ash (the second alternative), V. Hospodarova et al. (2015) investigated a few of the mechanical and physical features regarding pigment compounds (in liquid case) in the first alternative. The water absorption, density, and compressive strength related to concrete compounds were a few of the significant materials' attributes that were examined. The results indicated that pigments can reduce the density, increase the water absorption by a slight increase of

1% and increase the strength in compressive up to 20%. Addition of fly ash to the mixture can reduce the density, increase the absorption of water slightly, as the compressive strength is slightly lower compared to the reference sample. The mixture, which contains fly ash and pigment is capable of attaining compressive strength at the comparative reference sample level (27.64 MPa). From the results obtained, the use of pigment in concrete does not have a negative impact on physical properties and strength regarding the concrete [13].

### **3-Conclusion:**

1. The use of inorganic pigments is better than natural pigment.
2. The percentage of inorganic pigment powders must be not exceed 2% wt. of cement.
3. The pigment's particle size is finer compared to the particle size of cement and that tends to reduce the workability of mortar and concrete.
4. In some applications we need improve workability, in this cases may be adding super plasticizer.
5. The percentage of pigments in the liquid state cannot be determined because they depend on several variables.

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# Review of Friction stir welding (FSW)

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## **Abstract:-**

A type of steel weld known as friction stir welding (FSW) is utilized. A utilized device which could be utilized for joining two works without them. Dissolve the workpiece. Friction between the workpiece and the tool causes thermal to be produced. Solubility isn't eased by this heat; just metal is. For joining its goal, the tool glides over the surface that is softening. Welding range expands as needed on a daily basis. The investigation of the FSW method, microscopic features, mechanical characteristics, and heat soldering function are the basis for this research. Treatment of joints, experiment design, Joints of aluminum and their alloys.

**Keywords:** Solid type welding, Welding properties, Non-consumable tool, Mechanical properties, FSW process analysis, Post weld heat treatment of the joints, Microstructural properties, Design of experiments, Corrosion of the joints.

## **1- Introduction:-**

The primary goal of the literature review is demonstrating how previous works in friction drives the welding regarding aluminum alloys. This literature review was written with the intention of assisting other researchers who require detailed information about a prior welding operation. Researchers at the Welding Institute (TWI) in Cambridge, U.K., have created the welding kind of steel called heat FSW for joining panels. Utilize combinations for imposing the task on back panel for stopping the lateral. Combinations are used to impose the back panel and stop the lateral. [1]

A pin from which the tool is stretched causes the shoulder to spin many hundred rounds per minute. The pin is driven into the work-piece to the point where it

touches shoulder surface. The friction is created between them as a result of their shoulder contact.

In a space between two faces, the tool moves. The weld cools and then joins as the tool moves. Using conventional welding techniques, like fusion welding, was done after the tool was removed. The primary disadvantage of fusion welding is the full change in microscopic structure and loss of mechanical characteristics that occurs following welding. Due to the FSW's solid welding condition, the problem may be entirely avoided. Additionally, FSW has a few benefits in the case when put to comparison with conventional welding techniques.

- 1- FSW is produced without the use of fillers.
- 2- There is no need for shielding gas with FSW.
- 3- No arc or smoke is produced.
- 4- Less distortion and pressure are applied to FSW Basic Materials by FSW.

There is no need for the skilled professionals. [2]

The solid welding type prevents cracking and porosity from forming. Depending on microstructure, FSW welded area is divided into 4 regions: the stress zone, heat-affected zone (HAZ), thermal mechanically affected zone (TMAZ), and unaffected zone (SZ). A area in which microstructure is not altered is referred to as an unaffected area. Heat does not alter the features of mechanical objects. Comparable to fusion welding, HAZ is the area in which heat can impact both mechanical qualities and microstructure. The area where mechanical characteristics are impacted by the heat has been known as mechanically damaged zone. The original grain boundaries are placed in the noise zone. [3]

## 2- Literature survey

Welding Institute (TWI) Thomas et al. (1991) examined the problem with fusion welding of an aluminum alloy because FSW prevents the production of surface oxides in base material. In order to join metal, FSW employs a consumable tool that generates heat due to base material friction [1]

Through changing the fixed location regarding the materials, Lee et al. (2003) conducted a research depending on joint characteristics for different cast A356 and wrought AA6061. The longitudinal tensile tests revealed that in the case when placed on the side of retreating, AA6061 has a stronger stir zone compared to A356. [4] Peel et al. (2003) changed welding conditions, like rotational speed, tool design, and translational speed, to use AA5083 aluminum alloy for FSW. The results of mechanical analysis and residual pressure tests on the four pieces of AA5083 aluminum showed that heat input, rather than tool deformation, affects the parameters of welding. [5] Cavalierre *etal.* (2006) have investigated FSW tensile as well as the fatigue behavior regarding alloys 7075 and 2024. In the tensile test, it has been discovered that 2024 fails because of lesser hardness, while 7075 fails because to shorter fatigue life. [6] Steuwer *etal.* (2006) have found that AA5083-AA6082 process parameters have an effect on the residual stress. Also, found that, particularly in the case of AA5083, the welding speed in welding tools is of higher quality compared to the spin speed regarding the remaining pressure. [7] According to Lee et al. (2008), under various welding parameters, the interface geometry related to AA5052-H112 and AA6061-T6 has an effect on the joint's tensile performance. It was discovered that lower welding speeds and faster spin velocities reduced the fracture load. [8]

Through selecting three rotations as well as welding speeds, Sayer *etal.* (2008) examined the impact of process parameters for FSW on mechanical characteristics, microstructure, and low fatigue behavior regarding the cycle of aluminum alloy

plates of AA6063. Throughout tensile test, it was discovered that the majority of samples broke between HAZ and TMAZ. It has been found that base metal accounts for 70% of welding properties. Additionally, low cycle fatigue life of the welded specimens has decreased by 40%. [9] Sunggon et al. (2008) changed the process parameters, like the rotation and welding rates, to examine the tensile behavior related to the FSW of AA6061-T651. The friction elongation ratio in AA6061-T651 material reduces with the increase in the spin speed or slower speed of the welding, according to tensile test. The effect of process parameters also affects the maximum as well as yield tensile strength. [10] According to Lohwasser (2009), FSW can accommodate the pin driven flow and shoulder flow, 2 different types of material flows. The firm bonding of materials is impacted by the creation of oxide layers. With the use of the tool shoulder in FSW prevents the production of this oxide layer. The working temperature regarding FSW is approximately 0.60 – 0.90 times the temperature of the melting.[11]

In their 2009 study of mechanical behavior on joints made of dissimilar alloys AA6061-T4 and AA5182-H111, Leitao et al. have examined that tensile strength of joints for AA5182-H111 completely dependent on grain size. According to studies examined A413 and A319, the welded joint loses ductility. [12] Through varying the speed regarding the passage from 50mm/min to 175mm/min, Sakthivel *etal.* (2009) examined the effects of various speeds of welding with regard to FSW on the mechanical and metal features of the alloys. Because of a lack of thermal input, it was discovered throughout tensile testing that the maximum tensile strength decreased as movement speed increased. On the other speed, higher heat generation happens when welding happens more slowly. [13] According to Dhilip et al. (2010), the specifications regarding the materials to be joined as well as the process parameters, material placement, and tool positioning all affect the welding related to dissimilar metals in FSW. [14]

Sundaram et al. (2010) used five different pin profiles to assess the FSW for AA2024-T6 and AA5083-H321. By examining the flat cylindrical pin, triangular pin, and cylindrical threaded profile, it could be seen that a cylinder with taper tool pin diameter is one of key factors influencing tensile strength. They also discovered that a defect-free weld is possible at speeds between 300 and 700 rpm, 15 to 35 mm per minute, and 4 to 8 kN of axial force. [15] The tensile properties regarding the dissimilar welds AA5083 and AA2219 were altered in FSW by Koilraj et al. (2012) with the use of 5 tool profiles, like transversal speed, rotational speed, and D/d ratio, in which D represent the shoulder's diameter and d represent the tool pin's diameter, which are parameters that have been taken into consideration for this study.[16]

### 3- Parameters of FSW

With regard to welding and process control, independent process variables are crucial. Axial force of the fall, ignition angle, turning tool rotational speed, welding speed, and tool engineering are process variables. The aforementioned factors have a significant effect on the rate of thermal generation, the process's need for mechanical energy, the temperature distribution within the work material, the distribution of loads within the work material, and the evolution of welding material. As depicted in the figure, there are 3 different types of the tools for the FSW: adjustable, fixed, and RFID with the same. One piece with a probe and a shoulder is compatible with fixed scan tool (Fig. 2a). Because of the length of fixed probe, this welding tool might just work with a fixed thickness. The probe should be totally replaced if it is severely damaged or broken. The shoulders regarding the tool are made to be thermally relevant to the friction piece of the workpiece's surface area, and the creation of angles is required to standardize welding and prevent hot metal from contacting the lower shoulder's surface. The rotary tool's rotation speed, the workpiece's degree of ductility or plasticity when

working with material interface, applied axial load, and design tool all have a significant tool on the torque produced by the welding process.[17]

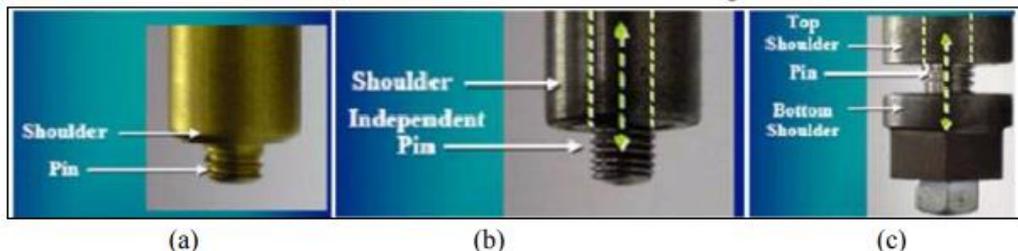


Figure 2: Different Tool configuration,

It was investigated how welding and rotation speeds affected the mechanical characteristics as well as the microstructure of pristine tool (BT-FSW) Mg AZ31. The findings demonstrated that the TMAZ was made up of equal granules, in contrast to the distorted, controlled, and rectangular grains discovered in TMAZs for pulley abrasion, the alloy of inverted frictional alloys, and friction aluminum. S.Yu.Tarasov et al. [18] (2014) From the standpoint of the study regarding the tribal layer and its interaction with the instrument's metal, the propagation corrosion process in the FSW 1.2344 X40CrMoV5-1 tool for steel was studied. By breaking along the distinct grain boundaries under shear stress that was created on tool's surface during FSW, it is suggested that FSW fragments can be deformed and separated from FSW. Juan Chen and others [19] (2015) Convex and precipitated (DFSW) tools were used in conjunction to study double-sided FSW (DFSW) for bonding magnesium alloys. The concave-DFSW acoustic joints. Under the right circumstances, it was feasible, and the joints had a distinctive structure for the stirring area that was different from the traditional FSW with a single-sided tool rotation. By speeding up the concave instrument's rotation, the average grain size in the stirring area was reduced. This finding implies that friction and plastic deformation both contribute to thermal generation during FSW. Convex tool fabric

in the stirring area created a composite mineral flow that offers preferred tensile behavior.

K. Kumaria et al. [20] (2015), in FSW method, a double tool is created to conduct a study between a double tool and a single tool. The dual device aids in producing high thermal levels that cause the treated area to exhibit high plastic deformation. The effectiveness of seamless welding depends on the interaction between welding speed and spin speed as well as rotation speed alone. A higher hardness value is produced via fast welding and rotation. In this combination, the joints of the defect are also noted. Additionally, a pleading failure is explained by SEM results that show microscopic holes of varied shapes and sizes.

### **Summary:-**

1. FSW is a highly reliable and successful solid-state bonding process.
2. FSW has a number of advantages over the conventional metal bonding process.
3. FSW has a very broad range of applications in fields including automobiles, shipbuilding, and space.
4. The field can be further studied Double pass sold FSW tool and also metal study for FSW Metal.
5. The gap between two consecutive FSW tools and its tool on the quality of the welding could also be examined.

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# Review on heat transfer performance in porous media

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## Abstract

In the presented study, a review has been studied the history of heat transfer through porous materials. Four sides have been the focus of this review: materials, porosity, heat transfer and applications. The paper contains listed many references. It is provides an overview of previous research on knowledge sharing. Many papers reviewed here is relate to experimental works, including numerical, analytical for heat transfer systems. In addition of equipment's design, heat transfer has a major role at applications for natural systems also.

**Keywords:** Porous media, Heat transfer, Forced convection

## 1. Introduction

The purpose of a literature review is to carry the reader the information and ideas have been presented for a porous media, and what are the point of power and weak. The literature review give the researcher to be brought to this time limit related to the state of research in this region and make familiar with any different idea and viewpoints on the porous media.

## 2. Previous studies on heat transfer through porous media

*Hilal, K. H. et al. (2014)*, the authors conducted an experimental study of forced convection heat transfer for air in a rectangular porous duct. The pad is made of a (zig-zag) metallic wire mesh insert with 2 distinctive porosity values ( $\epsilon$ ) (0.97) and (0.99). Reynolds numbers (7,682; 12,497; and 17,323) and constant heat flux have been agreed upon for experiments. The findings indicate that as Reynolds and heat flux increased, the number of Nusselt grew, but when pad porosity increased, the number of Nusselt reduced. It has been discovered that [(Nonporous - Nuclear) / weight of pad] equals (84.34) and (40.49) for ( $\epsilon= 0.99$  and  $\epsilon= 0.97$ )

correspondingly, which has been found suitable for improving heat transfer between the pad weight placed into clear duct. Enhancing heat transfer through a porous rectangular duct while decreasing the original duct's weight and size [1]

**Brijendra, S. B. & S. K. Choudhary (2017)**, metal foam heat exchanger was used to demonstrate the thermal performance, which includes pressure drop and heat transfer by porous material. With regard to thermal applications, they create the production technology for lightweight materials. In both scholarly and industrial study, heat transfer through porous materials plays a significant role. The experimental data has been calculated for various performance parameters such as effectiveness, factor of friction, number of Reynolds and number of Nusselt. A compared for another porous medium of heat exchangers like (magnesium, nickel, copper and carbon) with aluminum foam in heat exchanger was made for heat transfer performance [2].

**Hilal, K. H. (2012)**, in this study, pressure drop as well as forced convection heat transfer over a packed duct that measures 12.50 by 12.50 by 100cm have been investigated. The pad was constructed using 48 units of the metallic wrapping coils (0.98 porosity). It has been discovered that when heat flux, Reynold number, and the surface of duct surfaces exposed to the rise of the heat flux, so do Nusselt numbers. In the case when heating the packed duct's bottom and top surfaces as well as its entire surface. The packed duct should have a Nusselt number that is (1.20, 1.19) times greater than empty ducts. The temperature of the side and top surfaces of the duct rises as the Reynolds number and heat flux fall. Temperature differences between the side and top surfaces increases while just the top surface is being heated and decreases to its lowest value when all duct surfaces are being heated. In addition, local heat transfer coefficient increases with rising Reynolds number, heat flux, and number of duct surfaces exposed to continuous

heat flux, and decreases along the duct's axial direction. As Reynolds number increases, the pressure loss across the packed duct increases. [3]

**Habeeb, L. J., Mashkour, & et al. (2012)**, In 3D laminar steady flows, an experimental analysis of heat transfer for both forced and free convection was provided. A glass cubic duct with the size 30x30x30 cm that is filled by saturated porous medium. The porous media with a homogeneous diameter (11.7mm) is utilized with plastic balls. The experimental work includes investigation of the influence of porous media on the forced convection at various heat flux values and for various (Re, PM) ranges of the Reynolds number ( $17.45 \leq Re, PM \leq 22.13$ ) for every heat flux. With regard to mean Nusselt number ranges ( $41.52 \leq Nu \leq 82.85$ ), the air enters from down and departs from the top in this experimentation. Findings demonstrate that average Nusselt number rises with rising Reynolds Number and reduces with rising heat flux. [4]

**Vu, J. (2017)**, in order to increase the precision of porous continuum models, this study has used computational modeling regarding porous medium for convective heat transfer. Convective heat transfer caused by forced flow via highly conductive porous blocks was predicted using CFD models. With regard to pore-level predictions, multiple domains were produced throughout a porosity range as well as pore diameter typical regarding graphitic foams using idealized geometric model for spherical-void-phase porous materials. The findings have been put to comparison with pore-level findings and show that it is necessary to modify solid phase conductivity of the porous material in order to take the solid structure complexity into account. [5]

**Tahseen A.T. (2007)** many types of porous media are gravel and glass sphere respectively was used. The testes are carried out for two values of pressure gradient

( $\Delta p$ ) along the channel. The pressure gradient is (1.7kpa) and (2.65kpa) with changing of the amount of heat flux for each pressure gradient. The dimensionless distribution of temperature were decreases as the increase of the dimensionless length of the channel where, the value of a gravel less than for a glass sphere. the local number of Nusselt is decrease with the increase of Peclet number in both types and the value for glass sphere greater than that for gravel. The study shows that the number of Nusselt on the length of channel decreases with the increase of the dimensionless channel length both types of porous media for various values of the applied heat flux. This is because of the fluid bulk temperature is increase with the forward flow to the channel end. [6]

**Hussain, I. Y., & Yaseen, A. A. (2013)**, a forced convection heat transfer has been presented theoretically and experimentally from a flat plate which heated with set up in porous medium at a constant value regarding the heat flux. in experimental work, the impact of heat flux and Reynolds number on local Nusselt number and temperature profile was investigated. The heat flux values were between 1,000 and 5,000W/m<sup>2</sup>, and the Reynolds numbers were (24,118; 44,545; 739,832; and 82,208). An experimental part is being simulated by an ANSYS Fluent program. The experimental element uses the numerical component, which includes initial values as well as the boundary conditions for both velocities and heat flux. In addition, the local temperature at the wall gradually rises with flow direction and falls with Reynolds number as heat flux increases. When moving away from a heated wall in a vertical direction, fluid temperature decreases in porous medium. The investigation came to the conclusion that there was an increase in local Nusselt number along with an increase in the Reynolds and heat flux. [7]

**Quintard, M. (2015)** prepared a model of heat transfer in the porous medium demand to description multiple scale for structures of porous medium. The more

problem of heat transfer in porous medium has been indicated. For different behaviors, the different models were appearing on a whole scale, depending on interaction between different times and various lengths that describe this problem. Different models are examined and outlined of their relations. In addition, a more difficult heat transfer problems in porous medium were indicated, coupling with heat sources effect, boiling, radiation, mass diffusion, etc. [8]

*Rashidian, S., &Tavakoli, M. R. (2017)*, used a passive method in porous materials for the fluid flow for increasing the transfer of heat in heat exchangers. the thermal conductivity as well as effective thermal capacity regarding the flow are improved by the existence of porous medium along its path. Heat transfer through radiation will be accelerated by porous medium matrix, particularly for the flow related to two phases (gas-water). Material as well as its structure in the path of flow have been examined for both experimental tests and numerical simulations employing porous media with different percentages of porosity. The medium regarding porous in the stream's path has been proven to increase thermal conductivity and effective thermal capacity of the stream. In the case when using a porous solid state, the heat transfer velocity in systems using gas flow is increasing.[9]

*Barman, P. C. et al. (2016)*, various flow transport problems involve the phenomenon of heat transfer via a porous medium, which is significant. It has the benefit that the mass and energy equations relating to various flow and mass transport phenomena in the porous medium are all typically based upon the same medium regarding mass and energy conservation principles. It is evident that as Reynolds number as well as the porous layer thickness increased, so does the rate regarding the transfer of the heat in the flow direction. The wall thickness and temperature are constant for non-Newtonian fluid. In various Nanotechnology

applications, it is found that heat transfer across a porous medium is helpful. There is a reduction into the difference of pressure due to increasing in parameter of porous medium which causes a reduction in fluid mass which reduces the fluid velocities. The method of finite difference is used to calculate the natural convection with unsteady state and mixed convection for vertical flat plate with isothermal condition with non-Newtonian fluid saturated porous media, which are simulate as a power law fluid. [10]

**Elewi, M. A. (2012)** In saturated porous media for cross flow in cylinder the forced convection heat transfer was studied theoretically and experimentally. The equations of conservation of energy and momentum were derivation using Darcy flow model. A finite difference method was used to solved two equations at constant cylinder surface temperature, with Peclet numbers ranging in ( $1 < Pe < 10$ ). Experimental work collected of cylinder of copper material of (13 mm dia.) which heated using an electrical source. This cylinder has been embedded in the glass spheres (12 mm dia.) which placed in wind tunnel of low velocity. The results detected the increasing in heat transfer with Peclet number increasing theoretically and the experimentally. [11]

**Siva M. M. R., Venkatesh, & et al. (2016)**, examined experimentally the transfer of the heat in the porous medium under forced convection for flow of water. at various porosity, area and position have been conducted with 36 sets of experiments for heat transfer. at the outlet and inlet cross sections, the bulk temperature as well as pressure are monitored. It is possible to acquire local Nusselt and pressure drop numbers. Steel balls utilized as a porous medium Finding how Nusselt number varies with area, porosity, and position is the primary goal of the experiment. When put to comparison with a clear flow case without porous materials, it was found that

the maximum heat transfer increasing took place with the least amount of pressure drop when the core had a diameter of 55mm and a porosity of (0.44), which was 4.6 times greater. According to the calculation, this particular combination of porous insert design, area, and porosity had lowest  $\Delta P/Nu$  value. [12]

*Pastore, N. et al. (2018)*, analyzed the subject through thermal transfer experiments and their interpretation on a laboratory scale. For a column which thermally isolated and filled with the porous medium an experimental study was studied at forced convective heat transfer. The porous medium behavior with multi sizes of grain and surfaces was noticed. For condition of 1-dimensional heat transport local non-thermal equilibrium phenomena, an analytical solution have been compared with experimental data. the experimental work's local non-thermal equilibrium demonstrates how the dynamics regarding heat transport are impacted by the porous media's non-homogeneity. Heat transfer has an impact on heat transfer and thermal removal between liquid and solid phases, which in turn limits the capacity regarding porous media for storing or dissipating heat. [13]

*Haji-Sheikh, A., & Vafai, K. (2008)* the subject of this studied the transform the heat fluid passing through a duct with porous medium. A different cross sectional geometries in channels have been submitted **with temperature solutions derivation**. firstly, Graetz problem investigated for channels of parallel plate and tubes of circular sections. Brinkman's model solution used for two ducts. based on weighted residuals method, the results compared another numerical previous study. The weighted residuals method used for flow as well as heat transfer in passages of elliptical shapes. At different aspect ratios of elliptical passages section, the fluid flowing fluid have the heat transfer computation.[14]

### **3.conclusions:**

The research presented by each researcher can be categorized as follows:

1. Studying the effect of the difference in pressure (Pressure drop) inside the duct on heat transfer coefficient through porous media.
2. Studying the effects of porous media and porosity on Prandtl number (Pr), Peclet number (Pe), Biot number (Bi) and Grashof number (Gr).
3. Studying porous media effect, permeability and porosity on Darcy number (Da).
4. Many researchers find an experimental relationship between Reynold Number (Re) and Nusselt Number (Nu).
5. Study and test others porous media of a similar metal type and similar dimensions but with different porosity.
6. Changing the dimensions regarding the duct effects on the heat transfer through porous media.

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