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To recognize the impact of interfacial warmth exchange coefficient –A review

Rohit Pardhi and Prof. P. K. Sharma
Department of Mechanical Engineering, NIIST, Bhopal, (M.P.), India

Abstract

The warmth exchange at the metal shape interface and greatness of warmth exchange amid the beginning periods of hardening and the way warm streams over the form surface is rely upon the interfacial warmth exchange coefficient at metal shape interface and specifically influence the advancement of cementing and influences the castability of metal and nature of item. display work the impact of the distinction estimation of interfacial warmth exchange coefficient is considered for two diverse combination Aluminum amalgam (A356), Magnesium composite (MgAz91D) for the throwing of step circle utilizing PC recreation.

PC recreation of sand throwing is turned out to be more huge now daily. There so it has developed quickly with expanding modernity of PC equipment and programming. The PC reenactment of solidifying design in packaging much to widen our comprehension of throwing. Results are gotten under the accompanying heads for each other distinctive estimation of interfacial warmth exchange coefficient. Cementing time, Fraction of strong, Temperature, Shrinkage, Air capture, filling time.

Hardening time diminishes as the estimation of interfacial warmth exchange expanded for aluminum amalgam. The exemption of magnesium combination which setting aside greatest time for h=500 .Maximum temperature diminished with the expansion estimation of interfacial warmth exchange coefficient for a two composites. Metal composites are being cemented at the focal point of the form all the more quickly for all the combinations and for higher estimation of interfacial warmth exchange coefficient it is following same example. Division of strong has the best an incentive at the middle and moving without end it is diminishing for the all estimation of interfacial warmth exchange interfacial warmth exchange the amalgams taken. The likelihood of shrinkage and porosity is little for all unique estimation of interfacial warmth exchange coefficient for all the two combinations. Air entanglement is expanding with the higher estimation of interfacial warmth exchange coefficient.

The primary point of the proposition is to reenact the sand throwing process on PC and to recognize the impact of interfacial warmth exchange coefficient on the throwing of step plate made by different amalgams aluminum composite (A356), and magnesium combination (MgAz91D) as far as hardening time, temperature, part of strong and shrinkage/porosity, air-captured utilizing the diverse estimation of interfacial warmth exchange coefficient by PC reproduction.

Key words:- Heat transfer coefficient, aluminum alloy (A356), magnesium alloy (MgAz91D).

1.1 Introduction

Casting is a manufacturing process by which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process.Casting process simulation uses numerical methods to calculate cast component quality considering mold filling, solidification and cooling, and provides a quantitative prediction of casting mechanical properties, thermal stresses and distortion. Simulation accurately describes a cast component's quality up-front before production starts. The casting rigging can be designed with respect to the required component properties. This has benefits beyond a reduction in pre-production sampling, as the precise layout of the complete casting system also leads to energy, material, and tooling savings.

1.2 Computer simulation:

Present day improvements in PC innovation and PC programming have permitted recreation of exceptionally complex physical wonders, which was relatively unthinkable or restrictively costly even quite a long while back. One such territory is liquid stream including heat exchange and combined with stage change. The issue is extremely troublesome as it sounds, yet these days one can acquire great outcomes even on a PC inside a sensible timeframe. The assembling procedure that has a place with this gathering of issues is metal throwing. Before, metal throwing was a greater amount of a craftsmanship than the science; notwithstanding, these days PC programming is effectively connected to reproduce filling and hardening process. The precise aftereffect of reproduction permits enhanced throwing plan alongside the advancement of the gating and rise ring framework used to deliver a sound item.

Throwing forms are generally used to create metal parts in an extremely sparing manner, and to acquire confused shapes with next to zero machining. The make of a section includes a few stages, the first is simply the plan of the

part, and the determination of the material to be utilized. This data is passed to the techniques build, who will pick the throwing procedure, and after that plan the apparatus framework important to get the liquid metal into all locales of the part in order to create a sound throwing. Two noteworthy contemplations in the throwing configuration are the nature of the last item and the yield of the throwing, both of which intensely rely on the gear framework utilized. PC demonstrating gives one course to upgrade form configuration, enhancing both the yield and nature of the last item.
his procedure has become part of the design process in a number of industries such as the automobile and chemical industries, however in the manufacturing industry, casting design of mould components still relies on rules developed experimentally in the late fifties rules that ensure a casting with minimal defects and relatively very low yield.
Improving both quality and yield and thus decreasing energy consumption lead to opposing constraints that are best dealt with on a case-by-case basis rather than through the use of very general design guidelines. The feeding system of a steel casting was designed according to the feeding rules guided by computer simulation. Solidification modeling using FLUENT was integrated into the conventional design process to improve the feeder design.
Casting simulation has become a powerful tool to visualize mould filling, solidification and cooling, and to predict the location of internal defects such as shrinkage porosity, sand inclusions, and cold shuts. It can be used for troubleshooting existing castings, and for developing new castings without shop-floor trials. This paper describes the benefits of casting simulation (both tangible and intangible), bottlenecks (technical and resource related), and some best practices to overcome the bottlenecks. These are based on an annual survey of computer applications in foundries carried out during 2001-2006, which received feedback from about 150 casting engineers, and detailed discussions involving visits to over 100 foundries. While new developments such as automatic optimization of method design are coming up, a national initiative must ensure that the technology is available to even small and medium foundries in remote areas.
Simulation is the process of imitating a real phenomenon using a set of mathematical equations implemented in a computer program. Metal casting, which has been compared to natural phenomena such as sea wave splashing and volcanic flow, is subject to an almost infinite number of influences. A few major factors related to casting geometry, material, and process, are listed below.

1.3 Literature Survey

José Eduardo Spinelli, Amauri Garcia et al [2004] are applied Aluminium alloys with silicon as a major alloying element, consist a class of alloys, which provides the most significant part of all shaped castings manufactured. This is mainly due to the outstanding effect of silicon in the improvement of casting characteristics, combined with other physical properties such as mechanical properties and corrosion resistance. In general, an optimum range of silicon content can be assigned to casting processes. For slow cooling rate processes (sand, plaster, investment) the range is 5 to 7 wt%, for permanent molds 7 to 9% and for die castings 8 to 12%. Since most castings parts are produced considering no dominant heat flow direction during solidification, it seems to be adequate to examine both upward and downward growth directions in order to better understand foundry systems. The way the heat flows across the metal/mold interface strongly affects the evaluation of solidification, and plays a remarkable role in the structural integrity of castings. Gravity or pressure die casting, continuous casting and squeeze casting are some of the processes where product quality is more directly affected by the interfacial heat transfer conditions. Once information in this area is accurate, foundry men can effectively optimize the design of their chilling systems to produce sound castings. The present work focuses on the determination and evaluation of transient heat transfer coefficients from the experimental cooling curves during solidification of Al 5, 7 and 9 wt % Si alloys. The method used is based on comparisons between experimental data and theoretical temperature profiles furnished by a numerical solidification model, which applies finite volume techniques. In other words, the resulting data were compared with a solution for the inverse heat conduction problem. The necessary solidification thermodynamic input data were obtained by coupling the software ThermoCalc FORTRAN interface with the solidification model. A comparison between upward and downward transient metal/mold heat transfer coefficients is conducted.
Ivaldo l. Ferreira, Jose e. Spinelli et al [2008] is modeling of casting solidification can provide a method for improving casting yields. An accurate casting solidification model might be used to predict microstructure and to control the process based on thermal and operational parameters, and for this, it is necessary the previous knowledge of the transient metal/mold heat transfer coefficient, hi. Most investigations concerning the overall heat transfer coefficient between metal and mold have applied numerical methods for the solution of the inverse heat conduction problem (IHCP). In general, such studies consider a constant initial melt temperature in order to reckon the time-dependent hi. In the present work, solidification experiments have been carried with alloys of two metallic systems, and experimentally obtained temperatures were used by a numerical technique in order to determine transient

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metal/mold heat transfer coefficients, hi. It is shown that hi profiles can be affected significantly by the initial melt temperature distribution.

Gating system

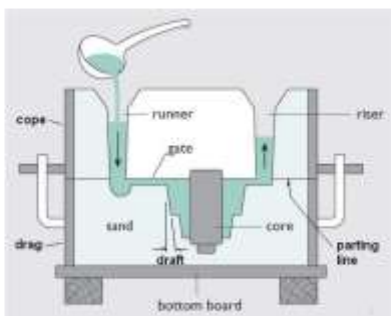
The gating and rise ring committee of the American foundry men's society has done much towards standardizing the nomenclatures in connection with the feeding of castings.

Therefore the definition evolved by these groups serves as useful reference for this purpose. Accordingly, the information given below is used practically verbatim as supplied by the gating and risering committee, Gray Iron Division. The elements of basic and very common gating are the down sprue through which metal enters the runner, and from which it turn passes through the ingate into the mold cavity. That part of their gating system which most restrict or regulates the rate of pouring is the primary choke, more often called simply the choke. At the top of the down sprue may be a pouring cup or pouring basin. To minimize their splash and turbulence and promote the entry of the clean metal only into the down sprue. To further prevent the entry of dirt or slag into the down sprue, the pouring basin may contain a skim core, a strainer, a delay screen or a sprue plug. To prevent erosion of the gating system when a large amount of metal is poured, a splash care may be placed in the bottom of the pouring basin, at the bottom of the down sprue, or whenever the flowing metal impinges with more than normal force.

Casting of heavy section or of high shrinkage alloys commonly requires a riser or reservoir where metal stays liquid while the casting is freezing. The riser thus provide the feed metal which flows from the riser to the casting to make up for the shrink which takes place in the casting metal as it changes from liquid to solid. Depending on the location, the riser is described as a Top riser or side riser and may be either an open riser or blind riser.

Since riser are designed to stay liquid while the casting is solidifies, riser height and riser dimensions as or those of the body of the riser itself. Riser distance and the shape riser base or additional important detail's that pertain only to side risers.

Gates and risers or often designed to take advantage of the principle of the controlled directional solidification which requires the freezing start furthest from the riser and proceed towards the riser. To accomplish this casting are riser gated with Meta the riser through a down sprue and runner, heating both the riser base and riser neck while flowing into the mold cavity.



Factors involved in gating design

The physical aspects of the gating systems have already been considered. How these gates are to be used to produce a sound casting is a question of gating design. Improper design of a gating system can cause one or more of the following defects in the casting.

1. Sand, slag, dross, or other impurities.
2. Rough surface.
3. Entrapped gases.
4. Excessively oxidized metal.
5. Localized shrinkage (pipe shrinkage, or macro-shrinkage).
6. Dispersed porosity, or micro-porosity.
7. Incomplete fusion of liquid metal where two streams meet (cold shuts).
8. Entrapped globules of pre-solidified metal (cold shots).
9. Unfilled mold (mis-runs).
10. Metal penetration into sand mold and/or core.

The gating system must therefore be designed to accomplish the following objectives as quoted from Wallace and Evans.

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1 Fill the mold rapidly, without tape or requiring excessively high pouring temperatures.
2. Reduce or prevent agitation or turbulence and formation of dross in the mold.
3. Prevent slag, scum, dross, and eroded sand from entering the casting by way of the gating system.
4. Prevent aspiration of air or mold gases into the metal stream.
5. Avoid erosion of molds and cores.
6. Aid in obtaining suitable thermal gradients to attain directional solidification and minimize the distortion in the casting.
7. Obtain a maximum casting yield and minimum grinding costs.
8. Provide for ease of pouring, utilizing available ladle and crane equipment.
9. Turbulence can be avoided by incorporating small changes in the design of gating system. The sharp changes in the flow should be avoided to smooth changes. The gating system must be designed in such a way that the system always runs full with the liquid metal. The most important things to remember in designing runners and gates are to avoid sharp corners. Any changes in direction or cross sectional area should make use of rounded corners.
10. To avoid the aspiration the tapered sprues are designed in the gating systems. A sprue tapered to a smaller size at its bottom will create a choke which will help keep the sprue full of molten metal.
    It is evident that not all these requirements are compatible, and compromises may have to be made to get as close as possible to the desired goal.

Finite element method
The solution approach is based either on eliminating the differential equation completely (steady state problems), or rendering the PDE into an approximating system of ordinary differential equations, which are then numerically integrated using standard techniques such as Euler's Method , Runge - kutta etc.
A variety of specializations under the umbrella of the mechanical engineering discipline (such as aeronautical, biomechanical, and automotive industries) commonly use integrated FEM in design and development of their products. Several modern FEM packages include specific components such as thermal, electromagnetic, fluid, and structural working environments. In a structural displacements and stresses) , and derives and examine additional quantities (such as specialized stresses and error indicators).
The advantages of FEA are numerous and important. A new design concept may be modeled to determine its real world behavior under various load environments, and may therefore be refined prior to the creation of drawings, when few dollars have been committed and changes are inexpensive. Once a detailed CAD model has been developed, FEA can analyze the design in detail, saving time and money by reducing the number of prototypes required. An existing product which is experiencing a field problem, or is simply being improved, can be analyzed to speed an engineering change and reduce its cost. In addition, FEA can be performed on increasingly affordable computer workstations and personal computers, and professional assistance is available.
It is also important to recognize the limitations of FEA. Commercial software packages and the required hardware, which have seen substantial price reductions, still require a significant investment. The method can reduce product testing, but cannot totally replace it. Probably most important, an inexperienced user can deliver incorrect answers, upon which expensive decisions will be based. FEA is a demanding tool, in that the analyst must be proficient not only in elasticity or fluids, but also in mathematics, computer science, and especially the finite element method itself.

1.7 Methodology & Analysis

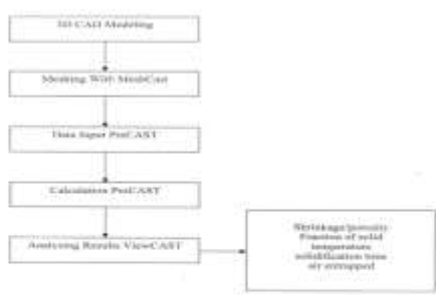

Figure: 1.5 Steps of simulation

1.9 PRECAST

Precast is done after the meshcast. In pre-cast all the boundary conditions such as material property for the sand and casting .velocity of molten metal, temperature of pouring metal, heat on the mold cavity etc applied on the nodes. Some other parameter such as flow parameter, step for calculation, gravity also applied in pre-cast. Metal properties, sand properties all are specify in pre cast.

Geometry: -

Units:-It sets the units system. **Restart: -** It opens a data file**. Mesh cast: -** It opens a .mesh file.

Create 2-D: -It opens a work space for 2-D modeling. **Symmetry: -**It allows us to declare type of symmetry.

Materials:-

Database: -It allows us to store material property to the data base**.**

Mold Property: - Mold **-** Sand, silica**.** Base: **-** Si

Composition: - 8%- Bentonite**,**5%**-**Water.

Density: - 1520Kg/m^3.

Conductivity: - Linear change with the temperature.

Specific heat: - Linear change with the temperature.

Casting: -ALSI7Mg03-A356 **Base:** -Al

Composition: -Si-8%, Mg-0.4%.

Solidus temperature: -556°C

Liquid us temperature: - 616°C

Conductivity: - Linear change with the temperature.

Assign: It opens a table for assigning material to mode, i.e. mold casting, core etc. from database. In the problem we are taking sand silica for the mold and AISI-1030 steel for the casting.

Stress: Database it alloys us to store material property related to stress to the database. Assign it opens a table for assigning stress related properties to material.

Micro:

Database: It allows us to store material property related to micro modeling to the database. **Assign**: It opens a table for assigning micro properties to material.

Interface: Database it allows us to store interface value to database. In the present work the different value of interfacial heat transfer coefficient is taken.

Create: It creates interface between sand mold and the casting. **Assign:** It assigns interface value.

Boundary: Database it allows us to store boundary conditions to database. The different boundary conditions are temperature, heat and velocity.it allows us to apply various boundary conditions.

Gravity- it defines gravity in direction and magnitude. Acceleration due to gravity is 9.81m/sec^2

Initial condition –

Constant: It provides the capability to specify an initial temperature for each material ID in the model. The initial temperature for the sand silica and the casting is 40°C.

Free surface: It provides the capability to specify the material volumes, which are initially empty. In the precast we also define the number of steps for the simulation. If number of steps is more then we get more accurate results.

1.10 Datacast -

Datacast is followed by precast. In datacast all units of boundary condition bring down in same unit. It reads the problem definition data created by precast, checks the problem definition for errors, converts all units into CGS unit and creates the binary files which will be read by the simulation modules, procast. If errors are encountered, they will be displayed on the workstation. This will also be written in the file.

Procast -It simulates the casting process, performs the finite element analysis & generates process results. This data may then be processed for viewing & analysis. The steps for the analysis must be specified in beginning.

Prostat -Prostat shows the percentage filling of molten metal and percentage solidification during each step of procast calculation.

View cast -It provides the post simulation capability to view X-Y plots, calculate derivative results & selectively extract data from the simulation results files & format this data for further processing, analysis or viewing.

Contour -Thermal: -It displays thermal related views, which are available like temperature, fraction solid, heat flux and solidification time etc.

Fluids: - It displays fluid related views, which are available like pressure, fluid velocity-magnitude etc.

Stress: - It displays stress related views, which are available like effective stress, maximum shear stress, average normal stress etc.

Micro: - It displays the micro modeling related views, which are available. **Vector:** - It enables us to select a vector plot of selected analysis result.

Steps:

Start: - It is the number of step from which result are to be viewed. **End:** - It is the number last step.

Frequency: - This is the interval with which result are to be viewed. **Reverse video:** -It changes the background color.

Automatic: - It set the contour band automatically.

Semi-Auto: - It sets the contour bands with reference to base value and interval (delta). **Manual:** - It sets the contours band by given value.

Free surface: - It shows the free surface of material. **Enclosure:** - It shows the inside of enclosure. **Animated Gif:** - It writes a gif file of the view.

Rotational Sym: - It actives rotational symmetry for viewing.

Mirror Sym1, Mirror Sym 2: - It actives mirror symmetry for viewing. **Materials:** -It enables us to see particular material.

View: -**Rotate:** - It rotates model.

XYZ Planes,

Any Plane: - It enables us to see different planes in the material. **Picture:** - It shows picture.

Postcast: It is the last operation in which all results such as casting solidification, Places of residual stress are taken.

Options:

X-Y Plot: - It provide capability to plot the temperature, fraction solid, pressure, velocity, stress, strain versus time result of simulation. We may select or specify the nodes to be displayed in the node.

1.11 Result & Discussion-

Analysis for aluminum alloy (A356)

With the help of simulation result obtained for aluminum alloy (A356) we can observe that.

Solidification time

As the value of interfacial heat transfer coefficient increase the solidification time decreases as it is 141sec for the value of h=400, 130 sec for h= 500 and 106 sec for h= 600 this is due to rapid heat transfer between the mold metal interface. However the for the higher value of h (500&600) the mis-run defect occur and mould is not filled by molten metal completely. As the heat transfer rate increases at metal mould interface temperature falls in less time and fluidity of molten metal decreases.

Temperature

From the temperature region pattern it is clear that the maximum temperature varies from 522°C for the h = 500, 519°C for h= 600 and 517°C for h=600. This is due to quick and more heat transfer at mold metal interface.

Fraction of solid

Fraction of solid content shows the fraction of solid present in the casting it is nearly 100% at the center of the mold and fraction decreases as we move away from centre. For the different value of interfacial heat transfer coefficient the pattern is same.

Shrinkage Porosity

Shrinkage and porosity is in the casting is less and a little higher at the vicinity of riser and sprue but for a small region of the casting.

Air Entrapped/Void

Air entrapped in the casting is increasing with increasing value of inter facial heat transfer coefficient for h= 400 the air is entrapped at the top of riser and sprue but for the higher value of h (400, 500) the air entrapped is increased it mainly due to partial filling of the mold cavity.

Filling time

Filling time generally decreased with increased value of interfacial heat transfer coefficient it 19 sec for h =400. 17 sec for h= 500 and 13 sec for h=600.

1.12 Simulation result for Magnesium alloy (MgAz91D)

With the help of simulation result obtained for Magnesium alloy (MgAz91D) we can observe that.

Solidification Time

As the value of interfacial heat transfer coefficient increase the maximum solidification time decreases as it is 118sec for the value of h =300 , 136 sec for h=400 and 99 sec for h=500 this is due to rapid heat transfer between the mold metal interface . However the for the higher value of h (400&500) the mis-run defect occur and mould is not filled by molten metal completely. As the heat transfer rate increases at metal mould interface temperature falls

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in less time and fluidity of molten metal decreases.

Fraction of Solid

Fraction of solid content shows the fraction of solid present in casting it is nearly 100% at the center of the mold and fraction decreases as we move away from centre .For the different value of inter facial heat transfer coefficient the pattern is same.

Temperature

From the temperature region pattern it is clear that the maximum temperature varies 522°C for the h = 300, 520°C for h= 400 and 517°C. For h=500.

Air Entrapped/void

Air entrapped in the casting is increasing with increasing value of inter facial heat transfer coefficient for h=300 the air is entrapped at the top of riser and sprue but for the higher value of h (400) the air entrapped is more than the both h=300& h=500.

Filling time

Filling time observed with increased value of interfacial heat transfer coefficient it 14 sec for h =300, 12 sec for h= 300 and 13 sec. for h=500.

Table 1.1 Result Aluminum alloy (A356)

Summary of simulation results

Interfacial heat transfer Coefficient	h = 400	h =500	h =600
Max.Solidification time	141 sec	133 sec	106 sec
Fraction of solid	Max. at center	Max. at center	Max at center
Max.temperature	522°C	520°C	518°C
Max.Filling time	19 sec	17 sec	13sec
Shrinkage/porosity	More region with less shrinkage	Less region with less shrinkage	Less region with less shrinkage
Air entrapped/Void	Less	More	max

Table 1.2 Result Magnesium alloy (MgAz91D)

Interfacial heat transfer Coefficient	h =400	h = 500	h =600
Max.Solidification time	118 sec	136 sec	99 sec
Fraction of solid	Max. at center	Max. at center	Max at center
Max.temperature	567°C	519°C	522°C

Max.Filling time	114 sec	12 sec	13 sec
Shrinkage /porosity	less region with less shrinkage	Less region with less shrinkage	Less region with less shrinkage
Air entrapped/Void	Less	Max.	Less

1.13 Conclusion-

Cementing time diminishes as the estimation of interfacial warmth exchange increments for aluminum combination. The special case of magnesium compounds. Which setting aside greatest time for h=500, Maximum temperature diminishes with the expanded estimation of interfacial warmth exchange coefficient for each of the two amalgams. Metal combinations are being set at the focal point of the form all the more quickly for all the compounds and for higher estimation of bury facial warmth exchange coefficient it is following same example. Portion of strong has the best an incentive at the middle and moving endlessly it is diminishes for the distinctive estimation of interfacial warmth exchange coefficient for all the compounds taken. The likelihood of shrinkage and porosity is little for various estimation of interfacial warmth exchange coefficient for all the two combinations. Air entangled is increments with the higher estimation of interfacial warmth exchange coefficient. Magnesium amalgam is demonstrating the most extreme air captured at interfacial. Filling time is diminishing with higher estimation of interfacial warmth exchange coefficient however the form isn't being filled totally by liquid metal because of mis-run imperfection. All the two combinations isn't in effect totally filled in the form it is frosty before the shape is filled totally for the higher estimation of interfacial warmth exchange coefficient Unfilled piece of the form is expanding with higher volume of interfacial warmth exchange coefficient for all their two compounds. By Computer reproduction comes about it is seen that the higher estimation of interfacial warmth exchange coefficient is unfortunate for cast capacity for all the combinations taken.

References

1) C.P. Hallam and W.D. Griffiths, "A model of interfacial Heat-Transfer Coefficient for the Aluminum GRAVITY Die Casting Process", Metallurgical and Materials Transactions B, Vol. 35B, August, 2004 .
2) T.S. Piwonka, K.A. Woodbury, J.M. Wiest, Mater. Des. 21 (2000) 365-372.
3) Degarmo, E. Paul, Black, J.T., Kohser, Ronald a. (2003), Materials and Processes in Manufacturing (9^{th} ed.), Wiley, ISBN 471-534.
4) Schleg, Frederick P, Kohloff, Frederick H, Sylvia, J.Gerin, American Foundry Society (23), American Foundry Society 10^{th} International Conference Semi-Solid Processing Of Alloys and Composites, EDS.g.Hirt, A. Rassili & A. Buhrig-Polaczek, Aachen Germany & Liege, Belgium, 2006,308-394