Iterative Method of Data Transfer From CAD to CAM Systems for the Profile of Stamping Dies

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ABSTRACT:

A proposal method for data transfer from CAD to CAM program has been investigated in the present work using iterative process for the stamping dies. The Bezier and B-spline equations forcurves and surfaces of n-degree had been derived as a matrix and formulated using MATLAB program, then a computer program had been constructed for the data transfer as a case study. The procedure of converting the profile of stamping dies from CAD program to CAM program without any geometrical distortion had been presented. The implementation of data transfer and the simulation using UGS(UniGraghics Solutions) program observed that the transformation of any complex profile shape from CAD to CAM program done without any distortion in final shape of the profile in CAM program. The present method matched the experimental result conformity and used in short time as compared with other methods.

Keywords: Stamping dies profile,CAD/CAM, Bezier, B-spline.

طريقة تكرارية لنقل البيانات من انظمة التصميم المعان بالحاسوب الى انظمة التصنيع المعان بالحاسوب لنماذج قوالب الطبع

الخلاصة:
تم تحقيق أسلوب مقترح لنقل البيانات من CAD إلى برنامج CAM في العمل الحالي باستخدام عملية تكرارية لقوالب الختم. معادلات بيزر وبي سبلاينللمنحنيات والأسطحمن الدرجة(n) تم اشتقاقها باستخدام برنامج MATLAB لبناء برنامج كمبيوتر لنقل البيانات كحالة دراسية. قدمت إجراءات تحويل نموذج قالب الختم من برنامج CAD لبرنامج CAM من دون أي تشويه في هندسية الشكل. بينت عملية نقل البيانات والمحاكاة باستخدام برنامج UGS بإمكانيه تحول أي نموذج شكليللأشكال المعقدة من برنامج CAD الى برنامج CAM دون أي تحريف في الشكل النهائي .الأسلوب الحالي يطابقالنتيجة التجريبية واستخدامها في وقت قصير بالمقارنة مع الطرق الأخرى.

INTRODUCTION:

The development of a new product is an iterative process, which includes: product design, analysis of performance, safety and reliability, product prototyping for experimental evaluation and design modification, where computer aided design is usually associated with interactive computer graphics, and the designer can conceptualize the object to designed more easily on the graphics screen and consider alternative designs or modify a particular design quickly to meet the necessary design requirements or changes[1,2].

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In pervious works the design of any profile using MATLAB program saves the extension of the design file as m-file or dxf-file, and then open it in CAM program such as SURFCAM or UGS programs to get the simulation of machining operation and get G-code [3 and 4]. This method can be succeed for simple surface, but it's useless if complex profile was designed and translated using this basic method. While other researchers write the control points of any complex surface in CAM program manually[5], and this primitive method also may be taking a long time. Where from MATLAB program it can be made a program to get G-code directly, and this method can be done for 2-axis, 3-axis at the maximum, while it's difficult to adapt this method to obtain G-code for machining in multi-axis because this need hard work and may be the results that got not compatible with CNC machine control system. Also there are many executive programs that can be convert the data from CAD program to CAM program, but if these programs used for complex surfaces, the result may be distorted the complex surface profile shape. So in the present research the matrix of n-degree of the Bezier and B-spline curves and surfaces will be derived and formulated. These matrices used with MATLAB to construct a solid model of proposed case studies, then constructed a program to data transfer from CAD to CAM without geometrical distortion, this program is able to generate any complex surfaces and exported to any CAD /CAM programs.

Some Related Works:

Dong Hongzh et al (2002) [6] discuss geometric modeling used in the dynamic stamping simulation of a die and discuss several modeling methods based on engineering drawings used often to construct 3D surface models of an auto body panel in CAD system then transfer into CAE system to perform stamping simulation using advanced CAD/CAE systems,(CATIA).**ShuhuaYue***et al* (2003)**[7]** established a CAD/CAE/CAM integrated system for die casting dies which has been applied successfully to the design and manufacture of die casting dies. Due to complex shape of die castings, the large scale of CAD/CAM software such as Pro/ENGINEER CAD/CAM software, the MAGMASOFT simulation software and a primary expert system for the design of the die casting process were adopted by researches to establish their work. A primary expert system package including a series of empirical calculation equations and data for the design of technological scheme and dies of die casting has been developed by the researchers. The use of this integrated system can shorten the cycle of die design and manufacture, and result in the production of high quality die castings in a shorter time. The lead-time of die castings was shortened greatly. **BorhenLouhichi***et al* (2005) **[8]**was oriented the integration of CAD/CAM/Analysis systems, and proposed algorithm which based on the BREP (a boundary representation) of CAD model features(geometrical and topological)and rebuilding the CAD model (BREP) starting from the CAE results (deformed mesh)according to FEA results, and using Beziers triangles to evaluate a surface from mesh. **Jinn-Jong Sheu***et al* (2006) **[9]** propose an automatic design method of a stamping die structure using a simplified column model . The solid die block under the die surface was divided into small rectangular columns. The surface pressure of the part after drawing was converted into the boundary conditions of the die structure design The topology optimization of the die structure was obtained by using the required pseudo density of the column model which is defined as a function of pressure and die surface slope, and the constraint of the buckle condition. The design results were compared with the ANSYS topology optimization to verify the proposed model. The similar topology results demonstrate that the proposed method is feasible. The design that adopted by Jinn shows the established simplified column model is capable of designing a reasonable die structure automatically. **A. Balakrishna***et al* (2006) **[10]** propose an interface program to communicate CAD/CAM/CAE systems to improve the product development processes. The interface program converts the STEP(The Standard for the Exchange of Product) model data file into an XML(Extensible Markup Language)file. The XML format is the lightweight web-based communication format. The researchers tested their interface program with a case study using ProE, CATIA, Solid Works, and Unigraphics packages individually and saved the drawings in the STEP format,

the interface program converts the STEP files into the XML tags and analyzes it using ANSYS package. The researchers was achieved the policy in the product development system, (Integration of the CAD/CAM/CAE systems), and management of the product information throughout the product life cycle to improve the product development processes. **Matin,** *et al* (2008) **[11]** present developed integrated CAD/CAE software for mold design. After creation of 3D CAD model of plastic product, numerical simulation of injection molding process was performed by the researchers on the module Pro/E, Pro/Plastic Advisor. Adopted program solution presents integrated system with unique applications to mold parameters computations, verifies injection molding parameters for final mold CAD modeling. **Bor-Tsuen Lin** *and* **Chun-ChihKuo**(2009) [**12]** introduce an integrated RE/RP/CAD/CAE/CAM system for constructing a magnesium-alloy AZ31 shell for the mobile phone and for developing related progressive dies. Reverse engineering (RE) was mainly used to reconstruct 3D geometric models from physical objects via data acquisition using a CMM (Coordinate Measuring Machine), an optical scanning system ATOS (Advanced Top metric Sensor) to measure and digitalize the product data d and CATIA, DYNAFORM, POWERMILL software to construct the 3D geometric model, forming simulation and design the tooling path respectively.

Mathematical representation of curves and surfaces:

Curves are often defined as the locus of a point moving with one degree of freedom, another definition describe a curve as the locus of a one parameter family a point. So that a curve may be represent as a collection of a points. Ways to mathematically describe curve for geometric modeling include intrinsic representation, non-parametric representation(explicit and implicit equations), and parametric representation. The latter category is expressed powerfully in Lagrange Hermit, Bezier, and B-Spline forms.

Initial drafting:

To obtain the imaginary initial draft, measuring the profile of two suggested case studies will be done using specific instruments. Then the drafting was done utilizing AUTOCAD program. From this drafting it can be obtain an initial control points of proposed case studies using ruled surfaces facilities.

The first case study represent the fuel cap of Hyundai cope 2001 car with dimensions (166*152 mm), which represented using Non Uniform B-Spline technique, as shown in Figure(1).

Figure (1) Fuel cap of Hyundai cope 2001 car

While, the second case study the wheel cap of car selected, as illustrated in Figure(2) this part have symmetric shape around the circle with diameter (150)mm, with multiplicity for five times, so that one section will be design, this section have all interested topology in final surface, then arraying it five times with angle (72^0) degree.

Figure (2) a car wheel cap

Mathematical representation:

In this stage of design, the program must be built using MATLAB environment to generate the database of geometry as a set of points in three Cartesian coordinate system, using the approximation techniques of 5th degree of Bezier equation and Non Uniform B-Spline equation for curve, (which are manually derivative and building a special program for that using MATLAB program). The parametric equation for curve of 5th degree polynomial is:

$$P(u) = \sum_{i=0}^{5} B_{i,5}(u)\, P_i$$

…(1)

The Bezier equation for curve of 5th degree with six control points is[13]:
$P(u)=(B_{0,5})*P_0+(B_{1,5})*P_1+(B_{2,5})*P_2+(B_{3,5})*P_3+(B_{4,5})*P_4+(B_{5,5})*P_5$
Where:

$$B_{i,n}(u) = \binom{n}{i}\, u^i (1-u)^{n-1}$$

…(2)

$$\binom{n}{i} = \frac{n!}{i!(n-i)!}$$

…(3)

The simplified with matrix form:

$$P(u) = \begin{bmatrix} u^5 & u^4 & u^3 & u^2 & u & 1 \end{bmatrix} \begin{bmatrix} -1 & 5 & -10 & 10 & -5 & 1 \\ 5 & -20 & 30 & -20 & 5 & 0 \\ -10 & 30 & -30 & 10 & 0 & 0 \\ 10 & -20 & 10 & 0 & 0 & 0 \\ -5 & 5 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} P_0 \\ P_1 \\ P_2 \\ P_3 \\ P_4 \\ P_5 \end{bmatrix}$$

The Non Uniform B-Spline equation for curve of 5th degree with six control points is[14,15]:
$P(u)=N_{i,5}(u)*P_i+ N_{i+1,5}(u)*P_{i+1} +N_{i+2,5}(u)*P_{i+2}+ N_{i+3,5}(u)*P_{i+3}+ N_{i+4,5}(u)*P_{i+4}$
Where:

$$Ni,k = \frac{(u - ti)}{t_{i+k-1} - ti} N_{i,k-1}(u) + \frac{(ti + k - u)}{t_{i+k} - t_{i+1}} N_{i+1,k-1}(u)$$

Where

K = Equation class

K − 1 = Equation degrees

ti = Knot values

T = Knot vector

The simplified with matrix form:

$$P(u) = 1/120 \, [u^5 \quad u^4 \quad u^3 \quad u^2 \quad u \quad 1] \begin{bmatrix} -1 & 5 & -10 & 10 & -5 & 1 \\ 5 & -20 & 30 & -20 & 5 & 0 \\ -10 & 20 & 0 & -20 & 10 & 0 \\ 10 & 20 & -60 & 20 & 10 & 0 \\ -5 & -50 & 0 & 50 & 0 & 0 \\ 1 & 26 & 66 & 26 & 1 & 0 \end{bmatrix} \begin{bmatrix} P_0 \\ P_1 \\ P_2 \\ P_3 \\ P_4 \\ P_5 \end{bmatrix}$$

The parametric form for Ruled surface is:

$$R(u, w) = P(u) + ((Q(u) - P(u)) * w$$

The building programs have acceptability to generate any applicable model using its control points only.

Exporting the generated set points:

The set of points that represent the shape of product which obtained from pervious stage will be export to CAD program, UGS program adopted in this work,usingan algorithm achieved in MATLAB environment, thisalgorithm is able to transfer the objects as a set of points to any other CAD/ CAM software without any distortion. Figures(3) and(4) shows this data points for first and second case study respectively.
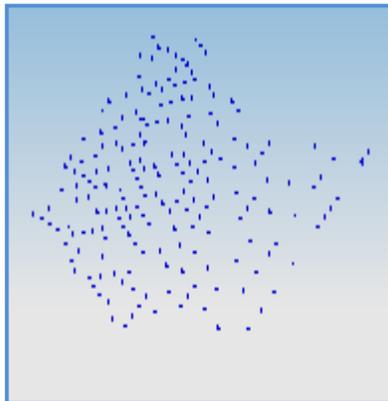

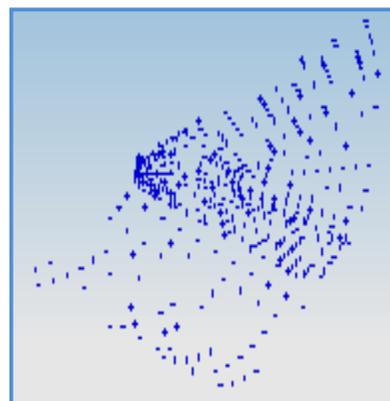**Figure (3).Exporting data points for the first case study to CAD program.**

Figure (4).Exporting data points for the second case study to CAD program.

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Generating final design:

According to a procedure achieved that shown in figure(5) using UGS program, the exporting set points are transferred to a set of curves as shown in Figures (6) and (7) then these set of curves are transferred to single surface as shown in Figures(8) and (9). Some modifications has been done in both first and second case studies involved array and fillet, to obtain the final shape of case studies as shown in Figures(10)and (11).
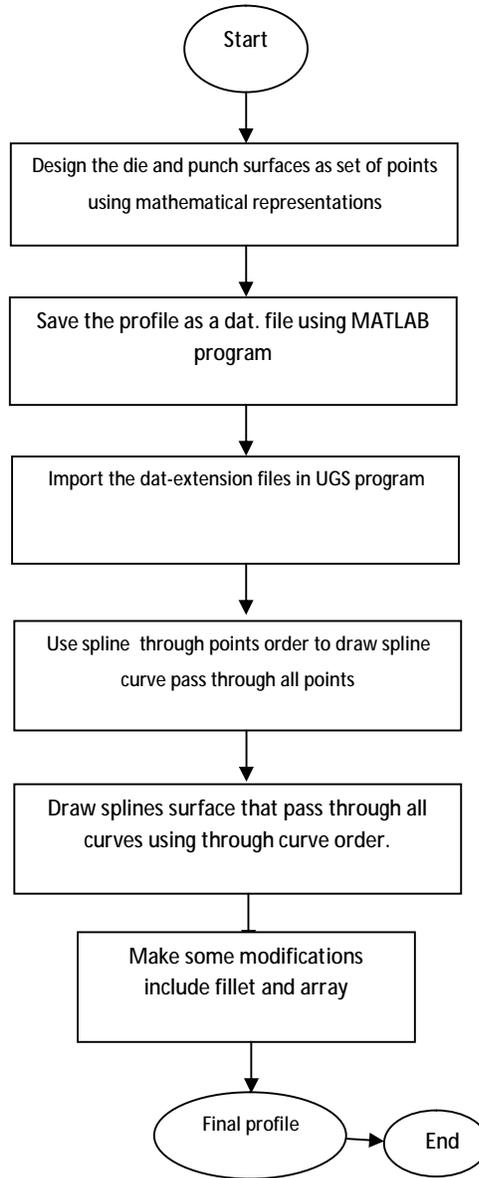
Figure (5) Flowchart of generating finalprofile using UGS program.

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CONCLUSIONS:

There are many programs and many method that can be used to translate the sculpture surface from CAD to CAM program but even these programs may be distort the surface after translated to CAM program, and the translation method may be need some modification process to get the original shape that was built in CAD program. In the present research a proposed method was implemented so as to translate any complex plot without any distortion using higher degree of Bezier and B-spline surface modeling. The present method matched the experimental result conformity, also, it can be implement this method using the program that is built in the present paper in short time if compared it to another method.
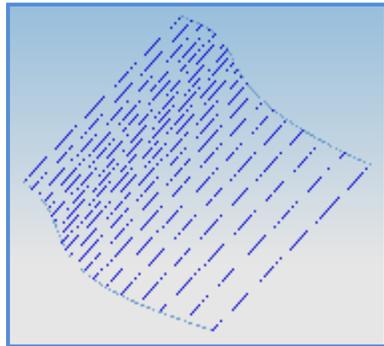

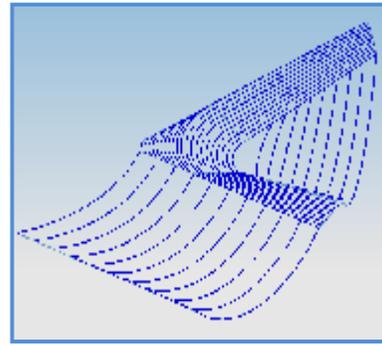**Figure (6) First case study as a
set of curves.**
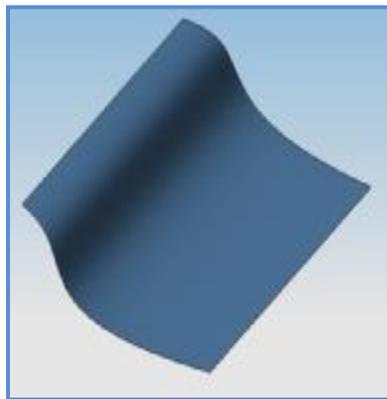

**Figure (7) Second case study as
a set of curves.**
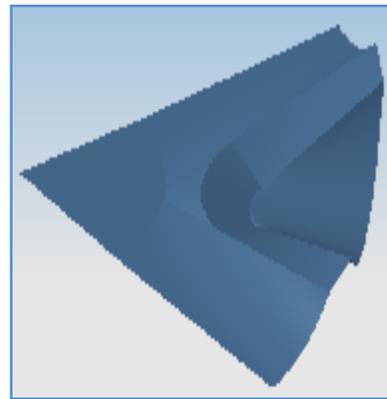

**Figure (8) First case study
as a surface.**

**Figure (9) Second case study
as a surface.**

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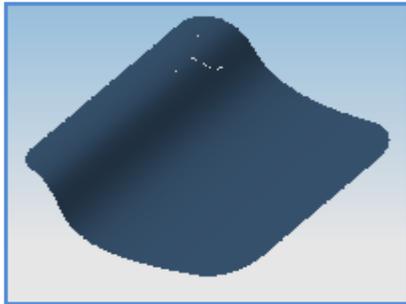CAD to CAM Systems for the Profile of
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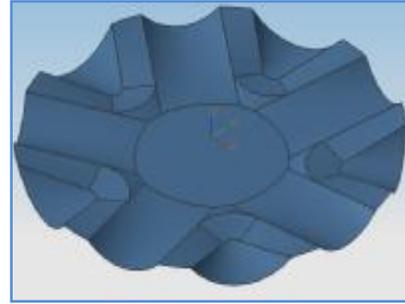**Figure (10)The modified first
case study.**

**Figure (11)The modified second
case study.**

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