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INTELLIGENT DESIGN OF ROTOR PROFILES FOR EFFICIENT PERFORMANCE OF TWIN-SCREW SUPERCHARGERS

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1 Introduction

Engine power rating represents an important selling point in the automotive industry, but the use of big engines to develop the small power needed for day-to-day motoring conditions is an expensive and inefficient practice. The answer to this issue has been the addition of power-boosting devices to small engines. Following it will be investigated in greater detail the twin-screw supercharger design as part of an engineering solution that makes this supercharger type particularly efficient in high supercharging. An adaptive model-based intelligent design of helical rotor profiles is developed from the 3D parametric model of the supercharger conjugated rotors and integrated with commercial CAD software into an original 3D CAD module. The original 3D CAD module with built-in intelligent design features will be used for design of supercharger rotors or as design tool to investigate the relationships and effects of different rotor profiles on supercharger performance for a particular engine system. It could be regarded as a significant engineering design input to manufacturing of such components.

2 Development of a high performance compressor for automotive use

In automotive highly competitive markets in recent years there has been a need for products designed to increasingly demanding criteria of high efficiency while satisfying requirements of improved fuel consumption, exhaust gas control, environmental protection and various driving demands of the users.
Engine power rating represents an important selling point in the automotive industry. Using bigger engines has traditionally fulfilled the need for more engine power. During the majority of actual driving conditions the engine is required to generate a small fraction of its rated peak power. The use of big engines to develop the small power needed for day-to-day motoring conditions is an expensive and inefficient practice. The high level of air pollutants produced by the automobile engines has further exasperated this issue. The pollutant production is, among other factors, proportional to the size of the engine and its operating conditions. Engine's fuel consumption and emission levels are mainly optimized around the high power operating range of the engine. The fact is that when high power engines spend most of the time producing lower levels of power the results are even higher levels of pollution. Thus the automotive industry

requires a small engine that can deliver the peaking high power performance of large engines yet still be economical and environmentally friendly at the nominal operating conditions of day-to-day driving. The answer to this issue has been the addition of different types of power-boosting devices to small engines.
The main idea behind power boosting comes from the basics and restrictions of internal combustion (IC) engines. The power generated from an IC engine is proportional to the amount of fuel that can be burned properly and completely in the engine's cylinders. The oxygen required for this combustion process is provided by the air the engine "breaths" from the atmosphere. IC engines are fixed volume devices meaning they are designed to draw in a constant volume of air. But the amount of fuel that can be burned properly in the engine is a function of the mass of the oxygen that enters the cylinder. Thus it is required to have a higher mass flow rate for the given fixed volumetric flow rate that the engine is designed for. The way to do this is by forcing denser air into the engine's cylinders. Increasing the air density is achieved primarily by compressing the atmospheric air before it is fed into the engine's cylinders. This can be achieved in many ways but the most common methods are turbocharging and supercharging.
The development of the ultra-supercharged engine with a completely new combustion cycle derived from Miller Cycle required a new supercharger capable to achieve higher boost pressure, high-efficiency and good response.
The turbocharger as an exhaust gas driven supercharger could not meet requirements of good response in conditions of decreased exhaust emissions at low engine speed. A conventional Roots type supercharger cannot achieve high-pressure and high-efficiency. The twin-screw type supercharger with design adapted for automotive use, with good response and high performance in high-pressure ratios ranges, was developed to match an ultra-supercharged engine.

This paper investigates in greater detail the twin-screw supercharger design and in particular the design relationships and effects of rotor profile designs on supercharger performance.
As part of an engineering solution that makes this supercharger type particularly efficient in high supercharging, the intelligent design of supercharger rotor profiles developed is adaptive, model-based and could be regarded as a significant engineering design input to manufacturing.
More specifically, the paper will present the three-dimensional parametric model of conjugated helical rotors and its application for intelligent design of high performance twin-screw superchargers.

The twin-screw supercharger has been developed from the Lysholm industrial compressor in order to achieve high compression ratios and volumetric efficiency at low engine speed, compact installation and good response. It is a positive displacement compressor with the working cavity enclosed by the housing and the helical surfaces of the rotors. The volume of the working cavity varies periodically from zero to its maximum and back to zero through revolving of rotors and mating of adjacent spaces between concave grooves of one rotor and convex threads of the other rotor. Following this periodic variation the supercharger completes a cycle of suction, compression and discharge with characteristics related to rotors profiles and speed.
The volume and efficiency of the air flow through the supercharger depend on the geometric parameters of the helical rotors, the profile and size of the inlet and outlet ports and on the occurrence of leakage. Rotor profiles pack the compression cavities therefore to ensure adequate pressure between the cavities the convex profile is essential on the trailing flank of the rotor lobes and similarly a concave profile is required on the trailing side of the mating rotor grooves. The profiles could be symmetric or asymmetric with a major geometric difference between generic profile types consisting in that the symmetric profiles have the same geometric contours on both

compression and suction flanks of lobes respectively grooves; asymmetric profiles although made of symmetric profile segments are defined so that the suction flanks combine curve segments enclosing a pocket of air while the compression side is made of curves in tighter mesh. For both profile types specific correlation between parameters of supercharger rotors ensures rotor meshing with minimum clearance between rotors helical edges. Known as gasket edges or sealing lines these edges located on individual rotors between adjacent profiles segments have the length defined by geometric parameters of supercharger rotors: lobes respectively groove profiles, rotors diameters and length, rotor helix angle, etc. The sealing line length and clearances between mating flanks define clearance areas that are leak passages as well. Increased and decreased sealing line length in correlation with the leak passages influence the inner-lobe leak and the leak between the rotor periphery and the housing.
Leakage analysis in twin-screw superchargers has indicated that the mating rotors profile geometry producing functional clearances between rotors and between rotors and casing, generate typical leakage paths (shown in Figure1). Through these paths the leakage from an enclosed cavity to the suction room with the cavity still connected to the suction room has direct influence on the supercharger volumetric efficiency, while the leakage from an enclosed cavity to the next enclosed cavity has no direct influence on the volumetric efficiency. Leaks through all the leakage paths influence the supercharger performance, although each leakage path has a distinct contribution to that. With the performance of existing twin-screw superchargers dependent upon clearance sealing, any percent of leakage reduction is important for the proportional increase of the supercharger volumetric and thermal efficiency. Research shows that the performance of this type of supercharger depends on the rotor profile design, rotors lobe combination, and other influencing factors but how exactly differences between rotor profiles geometry or between symmetric and asymmetric rotor profiles influence specific relations between superchargers geometric parameters and the supercharger efficiency especially at high speed range and high compression ratios still remains to be investigated. Therefore in order to optimize supercharger designs it is essential that the effects of different rotor profiles on supercharger performance be understood in greater depth. Currently the rotor profile design is based on proprietary information from traditional licensors or manufacturers. There has been limited access to such information to date. Although there are unusually large numbers of patents dealing with rotor profiles they do not give sufficient details to the extent of making them reproducible for different applications, specific engines or performance parameters, especially regarding the rotor profile design. Application centered studies do not discuss details of rotors inner geometry and there is no universal rotor profile which can guarantee optimum performance in all cases.

This research interest is the modeling of helical rotors and the related geometry of their conjugated profiles for high pressure and high efficiency superchargers used in automotive engines. The research interest is heightened in part by the lack of unitary theory to accurately predict the gas leakage in correlation to variation of the intrinsic inter-lobe clearances or of the clearances between the rotors and other components of the supercharger housing. Currently there is a need for well defined design criteria based on a supercharger model to enable accurate identification and control of clearance values in transverse and axial direction.

This paper will present an original approach that has been used to create a specialized CAD module based on the 3D parametric model developed for design optimization of rotor profiles in twin-screw superchargers. The 3D model includes the description of longitudinal meshing of helical rotors with accurate definition of the meshing line of conjugate profiles, so that the meshing line length can be used as an indicator for comparative evaluation of different rotor profiles. Integration of the CAD module with commercial CAD software provides a design tool for rapid visualization of design changes and quantification of specific optimization criteria for the supercharger rotors.

3 System approach to design of Lysholm type supercharger rotors

Motor engines equipped with high response superchargers have been introduced to the market in the form of Miller cycle gasoline engines with Lysholm type compressors. The performance of a Lysholm type supercharger in terms of volumetric efficiency and total adiabatic efficiency depends upon rotors geometry. The dependence of Lysholm type supercharger performance upon the rotors parameters is suggested by generic relationships for the volumetric efficiency (η_v) as function of discharge air volume (V_d) and theoretical air volume (V_{th}) or the internal leak volume (V_{int}) and the theoretical air volume:

$$\eta_v = V_d / V_{th} = 1 - V_{int} / V_{th} \tag{1}$$

A similar relationship indicates the dependence of the total adiabatic efficiency (η_{total}) upon the discharge air volume (V_d), the adiabatic head (W_{ad}), the indicated power (HP_i), the mechanical loss ($W_{m/l}$) and the windage loss ($W_{w/l}$):

$$\eta_{total} = V_d \times W_{ad} / (HP_i + W_{m/l} + W_{w/l}) \tag{2}$$

These equations express relationships relevant for design of Lysholm type supercharger rotors in terms of performance criteria such as high pressure ratios and high supercharger efficiency correlated with the rotors geometric parameters, clearances and leaks (Figure 1).

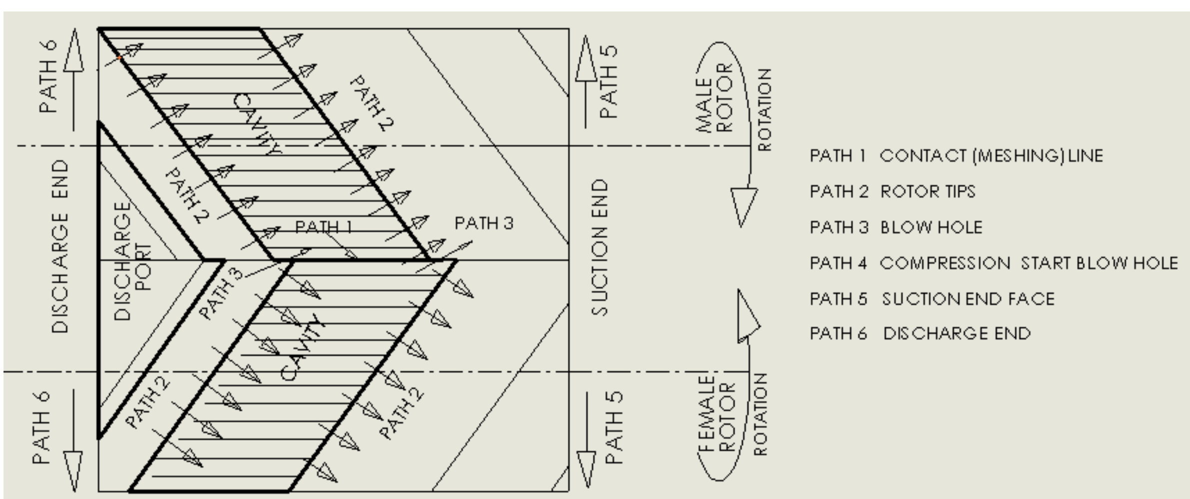

Figure 1. Representation of the leakage paths in a twin-screw supercharger

The internal leak occurs through the pressure differential between adjacent rotors tooth spaces and through four clearance areas characteristic for internal leak passage of supercharger rotors: inter-lobe sealing path, end sealing path, top sealing path and the blow hole and therefore is proportional with the rotors sealing line length and is dependent on geometric parameters including rotor profiles, rotor length and helix angle. Typically by reducing the internal leak is increased the supercharger volumetric efficiency which leads to increase of total adiabatic efficiency; but at the same time the theoretical air volume depending on the volume defined between rotors conjugated cavities varies with the size and geometry of the rotors and with the supercharger speed. For the automotive mechanical supercharger driven by the engine the restricted space and the need to maintain the discharge air ratio favor small sizes for the mating rotors and the rotor lobe combination becomes an important factor for the air volume supplied and speed. Specific for each functional cycle of twin-screw superchargers is the generation of joined conjugated compression-discharge cavities and the change of pressure linked structurally through a relationship with the helical rotors rotation angle per cycle (the rotors wrap angle). Wrap angles induce increase or decrease of seal line length and is important for the inter-lobe leak passage and the tip leak passage (leak between top of lobes and housing). However sizes of the wrap angle above a specific range (280°-330°) cause decrease of theoretical air volume due to compression beginning before the suction completed. As a result of these dependencies adequate clearances must be designed in correlation with the length of contact line of the rotors, the volume of clearance and related geometric parameters of the rotors that ensure pre-defined compression characteristics.

4 The 3D parametric model of supercharger helical rotors

The proposed three-dimensional CAD module operates on a new design technique. Rather than creating libraries of existing rotor profiles or storing large collections of profile curves in CAD data bases, the proposed CAD module is based on a three-dimensional parametric model of supercharger conjugated helical rotors, which allows integration of this method into commercial CAD software for visualization.

4.1 Theoretical background

The underpinning mathematical model of the twin-screw supercharger derives from the physical model of the axial displacement compressor with two helical conjugated rotors having constant axial pitch (h) and conjugated helical grooves. The helical surfaces of the rotors are generated through helical motion along z-axis by planar curves defined on the transverse plane of each rotor as transverse profile of the rotor. Current axial advance of a point on the driving respectively driven helical rotor transverse profile is:

$$z_i = \frac{h_i}{2\pi} \cdot \tau_i = p_i \cdot \tau_i , (i = 1, 2) \tag{3}$$

where h_i (i = 1, 2) the constant axial pitch of driving respectively driven helical rotor; τ_i (i = 1, 2) is the rotation angle around axis Oz of the generating curve of the driving respectively driven rotor; z_i (i = 1, 2) is the elevation of a current point of the transverse profile of the rotors; p_i (1 = 1, 2) is the helical constant. Between two helical rotors set up on a centre distance $A = r_1 + r_2$ in the transverse plane (Figure 2) a transmission ratio i is obtained:

$$i = \frac{r_2}{r_1} = \text{const.} \tag{4}$$

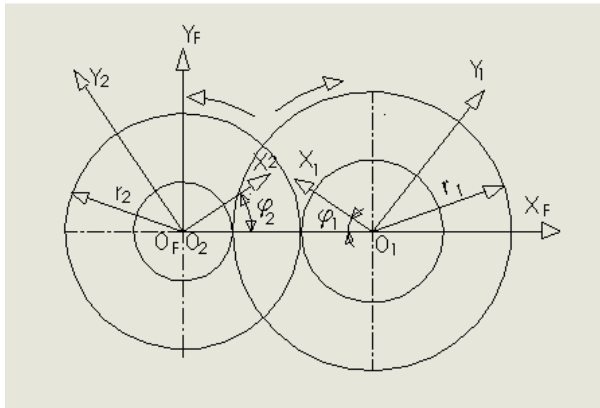

Figure 2. Coordinate systems of the helical rotors in transverse plane

After rotation by angles φ_1 respectively φ_2, the correlation between φ_2 and φ_1 is expressed as:

$$\varphi_2 = i \cdot \varphi_1 \tag{5}$$

In 3D space the conjugated helical rotors are defined by the vector functions $\mathbf{r}_i$ (u_i) ($i = 1, 2$), of a current point P situated on the helical surfaces of the rotors meshing flanks, with u_i ($i = 1, 2$) functions of scalar independent variables u_i (t) and u_2 (t). By rotation of the generated curves of the rotors around axis Oz_i ($i = 1, 2$), P advances axially with z_i ($i = 1, 2$) current axial advance of the driving respectively driven helical rotor, so that the projection of the instantaneous rotation angle of P on the transverse plane of the rotors is τ_i ($i = 1, 2$) (Fig.3).

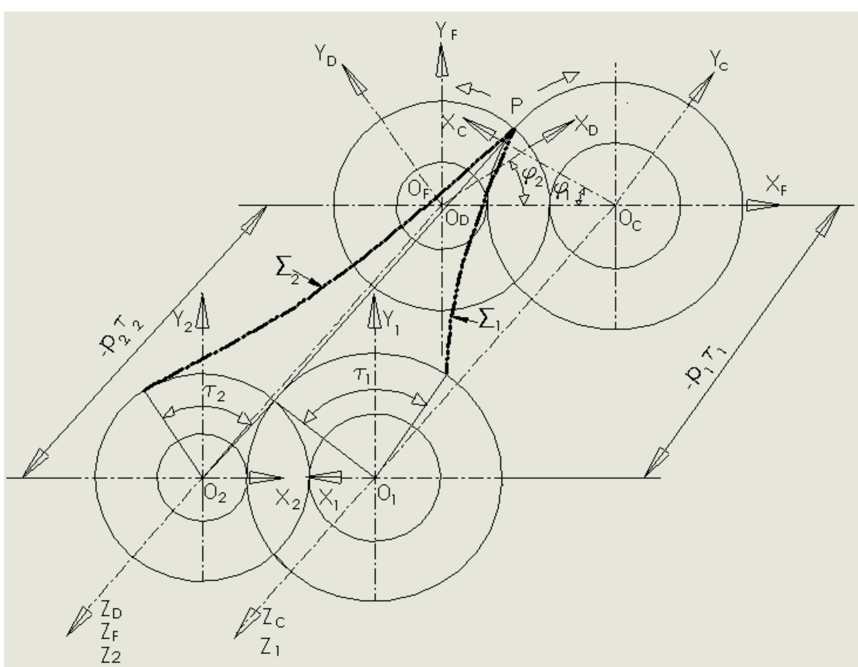

Figure 3. Coordinate systems for generation of 3D parametric models of conjugated helical rotors

The helical movement of the generating curves of the rotors maintains for the rotors equal axial advance:

$$p_1 \cdot \tau_1 = p_2 \cdot \tau_2 \tag{6}$$

and a constant transmission ratio i:

$$i = \frac{m_2}{m_1} \tag{7}$$

where m_i ($i = 1, 2$) is the number of lobes on driving helical rotor respectively the number of grooves on driven helical rotors and p_i ($i = 1, 2$) is the characteristic constant of each rotor ($p_i = h_i / 2\pi$) ($i = 1, 2$).
The first rule of meshing can express the relation between conjugated helical rotors as:

$$\frac{\tau_1}{\tau_2} = \frac{m_2}{m_1} \tag{8}$$

4.2 Three-dimensional parametric model of supercharger helical rotors

The supercharger conjugated helical rotors rotate about parallel axes in opposite directions with constant angular speed on known centre distance A with transmission ratio i in the mobile coordinate systems S_1 (x_1, y_1, z_1) and S_2 (x_2, y_2, z_2) that are rigidly attached to the rotors origins O_1 and O_2 in transverse plane. There is a third fixed coordinate system (frame) S_F (x_F, y_F, z_F) represented with the centre O_F coinciding with O_2. Such rotors are modeled in 3D from the known transverse profile of one of the rotors and the coordinate transform matrix that simulates the generating helical movement. Consider the conjugated transverse helical rotor profiles expressed as planar curves represented by the following equations in the mobile systems of coordinates S_i ($X_iO_iY_i$) ($i = 1, 2$):

$$\mathbf{r}_i = \mathbf{r}_i(u_i) = [\, X(u_i) \quad Y(u_i) \quad 0 \quad 1 \,]^T \quad (i = 1, 2) \tag{9}$$

If the transverse rotor profile $\mathbf{r}_2 = \mathbf{r}_2(u_2)$ is known, the profile of the mating rotor $\mathbf{r}_1 = \mathbf{r}_1(u_1)$ can be derived in transverse plane using the theory of planar gearing. Radius-vector $\mathbf{r}_2 = \mathbf{r}_2(u_2)$ of the rotors current contact point is completely defined and can be expressed in vector form in $X_2O_2Y_2$:

$$\mathbf{r}_2 = \mathbf{r}_2(u_2) = X(u_2)\,\mathbf{i} + Y(u_2)\,\mathbf{j} \tag{10}$$

Radius-vector $\mathbf{r}_1 = \mathbf{r}_1(u_1)$ of the current contact point of conjugated helical rotors, expressed in $X_1O_1Y_1$:

$$\mathbf{r}_1 = \mathbf{r}_1(u_1) = X(u_1)\,\mathbf{i} + Y(u_1)\,\mathbf{j} \tag{11}$$

can be found from dependencies that occur between $\mathbf{r}_1$ and $\mathbf{r}_2$.
In order to find $\mathbf{r}_1(u_1)$ from $\mathbf{r}_2(u_2)$, coordinate transformations are applied to the radius-vector $\mathbf{r}_2(u_2)$ to transform it from the coordinate system $X_2\,O_2\,Y_2$, into the coordinate system $X_1\,O_1\,Y_1$.

Transformations applicable to $\mathbf{r}_2 (u_2)$ include:

1. Rotation of $\mathbf{r}_2 (u_2)$ by angle (φ_2) in $X_2\ O_2\ Y_2$ around the origin O_2 and pointing in the positive direction of $X_F\ O_F\ Y_F$ to bring $\mathbf{r}_2 (u_2)$ in the frame $X_F\ O_F\ Y_F$, with the rotation matrix $\mathbf{R}_{F2} (-\varphi_2)$.

2. Translation of $\mathbf{r}_{F2} (u_{F2})$ by $A = r_1 + r_2$ in the frame $X_F\ O_F\ Y_F$ to move the radius-vector $\mathbf{r}_{F2} (u_{F2})$ along the positive direction of axis $O_F\ X_F$ and bring its origin in O_1, with the translation matrix $\mathbf{T}_{F2} (A)$.
Matrix $\mathbf{R}_{F2} (-\varphi_2)$ and matrix $\mathbf{T}_{F2} (A)$ operate the transformation on $\mathbf{r}_{F2} (u_{F2})$ in $X_F\ O_F\ Y_F$:

$$\mathbf{r}_{F2} (u_{F2}) = \mathbf{T}_{F2} (A) \,.\, \mathbf{R}_{F2} (-\varphi_2) \,.\, \mathbf{r}_2 (u_2). \tag{15}$$

Alternatively a transformation matrix $\mathbf{M}_{F2}$ can be applied directly to $\mathbf{r}_2 (u_2)$:

$$\mathbf{r}_{F2} (u_{F2}) = \mathbf{M}_{F2} \,.\, \mathbf{r}_2 (u_2). \tag{16}$$

3. Rotation of $\mathbf{r}_{F2} (u_{F2})$ by angle $(\pi - \varphi_1)$ in $X_1O_1Y_1$, completes the transformation of $\mathbf{r}_2 (u_2)$ in $X_1O_1Y_1$ with the rotation matrix $\mathbf{R}_{1F} (\pi - \varphi_1)$, marked $\mathbf{M}_{1F}$ for consistency of notations. Through concatenation of matrix $\mathbf{M}_{1F}$ with matrix $\mathbf{M}_{F2}$, the transformations of $\mathbf{r}_2 (u_2)$ can be expressed as:

$$\mathbf{r}_1 (u_1) = \mathbf{M}_{1F} \,.\, \mathbf{M}_{F2} \,.\, \mathbf{r}_2 (u_2) \tag{17}$$

where:

$$\mathbf{M}_{F2} = \mathbf{T}_{F2} (A) \,.\, \mathbf{R}_{F2} (-\varphi_2) = \begin{bmatrix} 1 & 0 & 0 & A \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} . \begin{bmatrix} \cos(-\varphi_2) & -\sin(-\varphi_2) & 0 & 0 \\ \sin(-\varphi_2) & \cos(-\varphi_2) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{18}$$

An example for A = 65 can be expressed:

$$\mathbf{M}_{F2} = \begin{bmatrix} \cos\varphi_2 & \sin\varphi_2 & 0 & 65 \\ -\sin\varphi_2 & \cos\varphi_2 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad \mathbf{M}_{1F} = \begin{bmatrix} -\cos\varphi_1 & -\sin\varphi_1 & 0 & 0 \\ \sin\varphi_1 & -\cos\varphi_1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{19}$$

$$\mathbf{M}_{1F} \,.\, \mathbf{M}_{F2} = \begin{bmatrix} \cos(\varphi_1 + \varphi_2) & \sin(\varphi_1 + \varphi_2) & 0 & 65.\cos\varphi_1 \\ -\sin(\varphi_1 + \varphi_2.) & \cos(\varphi_{.1} + \varphi_2) & 0 & -65.\sin\varphi_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}. \tag{20}$$

With corresponding substitutions in equation $\mathbf{r}_1(u_1) = \mathbf{M}_{1F} \,.\, \mathbf{M}_{F2} \,.\, \mathbf{r}_2 (u_2)$; $\mathbf{r}_1(u_1)$ can be obtained from equation:

$$\begin{bmatrix} X(u_1) \\ Y(u_1) \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} \cos(\varphi_1+\varphi_2) & \sin(\varphi_1+\varphi_2) & 0 & 65.\cos\varphi_1 \\ -\sin(\varphi_1+\varphi_2.) & \cos(\varphi_{.1}+\varphi_2) & 0 & -65.\sin\varphi_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} X(u_2) \\ Y(u_2) \\ 0 \\ 1 \end{bmatrix} \tag{21}$$

The equation of meshing between conjugated rotors can now be solved together with $\mathbf{r}_2\,(u_2)$ and the result will be a family of envelopes including the transverse rotor profile $\mathbf{r}_1(u_1)$.
The helical surfaces $\mathbf{\Sigma}_1$ and $\mathbf{\Sigma}_2$ of conjugated helical rotors (Figure 3) are defined in $S_i\,(x_i, y_i, z_i)$ $(i = 1, 2)$ and can be expressed with their current point position vector $\mathbf{R}_i$ $(i = 1, 2)$ using a set of equations as follows:

$$\mathbf{R}_1 = \mathbf{M}_{1C}\,(\tau_1)\,.\,\mathbf{r}_1\,(u_1) \tag{22}$$

$$\mathbf{R}_2 = \mathbf{M}_{2D}\,(\tau_2)\,.\,\mathbf{r}_1\,(u_2) \tag{23}$$

where $\mathbf{M}_{1C}$ and $\mathbf{M}_{2D}$ are the coordinate transform matrices for generation of helical movement.

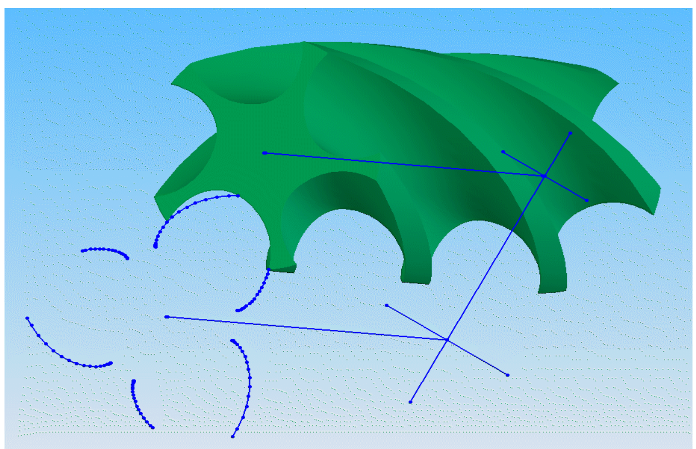

Figure 4. 3D model of conjugated helical rotors generated from the 3D parametric model

5 Architecture of the CAD module for design of supercharger rotors

The CAD module for design of supercharger rotor profiles has been developed with software reuse techniques through integration of VBA macros created in Microsoft Excel with SolidWorks, commercial 3D object oriented modeler based on customized Microsoft Foundation Classes (MFC) licensed by Microsoft to this product. The result is a CAD design tool that can access the functionality of SolidWorks applications and control them from within other object oriented applications of Windows platform, such that it can create VBA macro modules in Excel then run the VBA modules directly from the Feature Manager Design Tree in SolidWorks. This approach is original in that it customizes existing Windows applications bridged to work together into a local situation: Visual Basic for Applications (VBA) provides only the basic control structures, math, string functions and variable manipulation capabilities (Figure 5), taking its real power from the applications that support it, Microsoft Excel for its powerful math functionality and SolidWorks for geometry processing (Figure 6 and Figure 7).

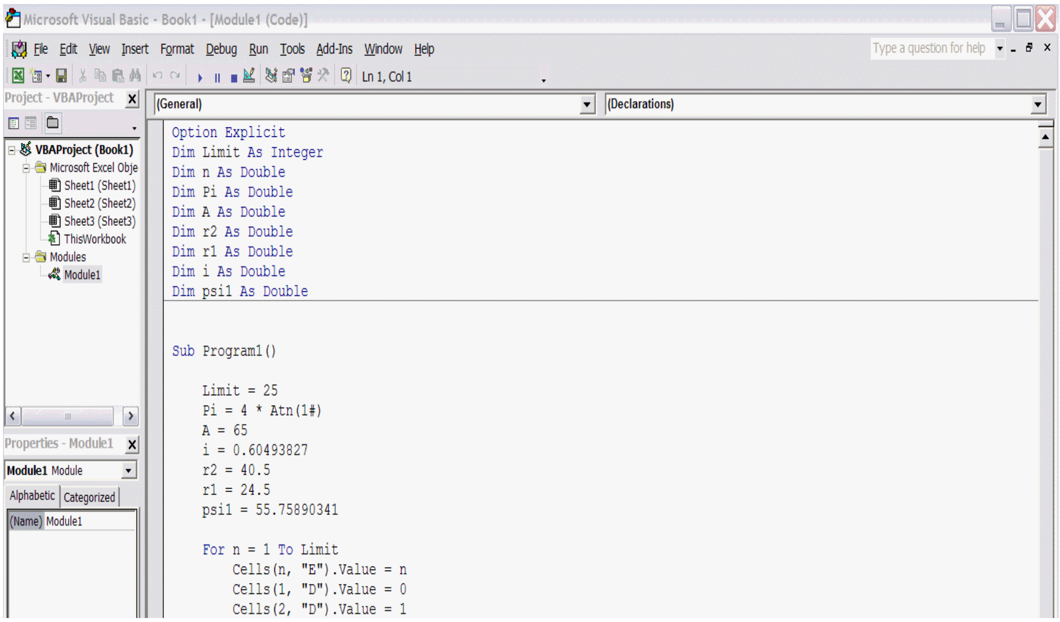

Figure 5. VBA program for calculation of rotors profiles from the parametric model within the CAD module

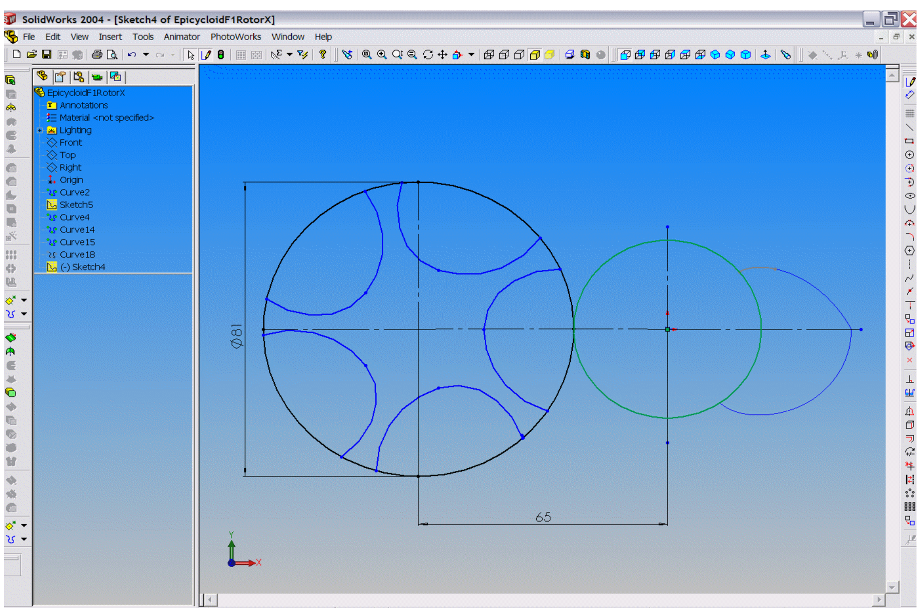

Figure 6. Parametric model of conjugated helical rotor profiles generated with the CAD module

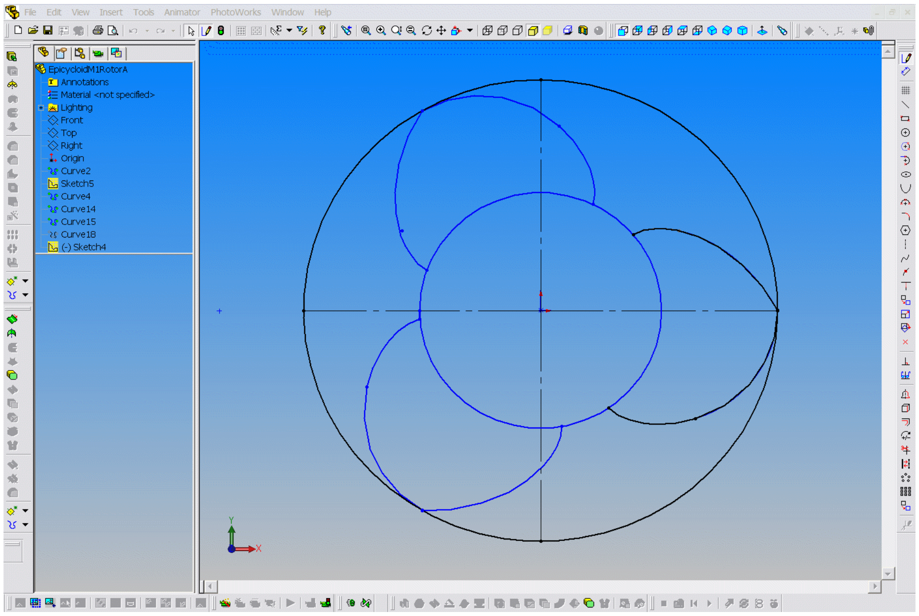

Figure 7. Validation of parametric model of rotor profile generated with the CAD module

There are various ways to customize the proposed CAD module to satisfy different programming environments.
Table 1 provides a comparative example of choices available for customization of the proposed CAD module input type.

Table 1. Parametric System Input Options for the integrated CAD module

Type of Input	Visual LISP	**VBA**	ActiveX Client
Command Input	Good choice	**Good**	Good
Graphic Selection	Good choice	**Good**	Good
Dialog Box	Okay	**Best choice**	Good
Active Server	Okay	**Best choice**	Good
Excel Spreadsheet	Okay	**Best choice**	Good
Access Database	Okay	**Best choice**	Good
Text Data File	Good	**Good**	Good

The operation of the CAD module is based on that the 3D parametric model of supercharger conjugated rotors described in section 3.2 has allowed integration of this method into commercial CAD software (SolidWorks) for rapid visualization. This has allowed selection of a wider range of geometric curves for rapid testing of different curve combination that updates the parametric model. The process is repeated until the optimum solution is obtained or until the maximum number of iterations is reached in relation to set optimization criteria.
Preliminary 2D conjugated profile combinations can be validated and prototyped in Matlab before analysis within a VBA module of the proposed CAD module (Figure 8).

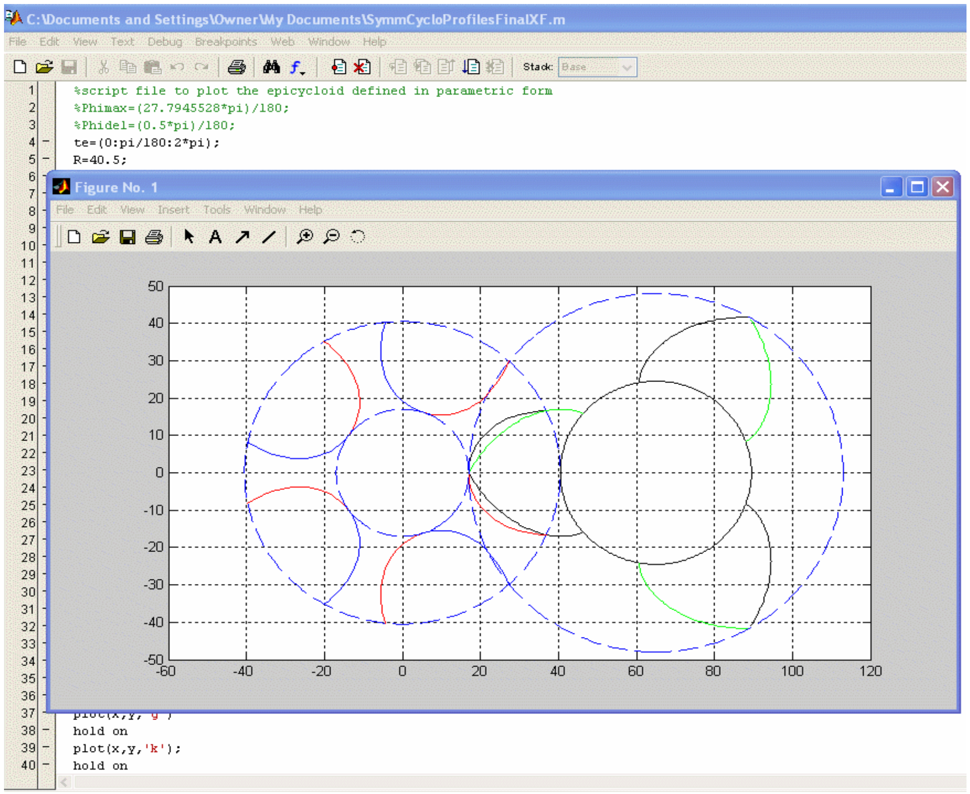

Figure 8. Validation of two-dimensional helical rotor parametric conjugated profiles with Matlab

6 Conclusion

The presented CAD module for design of supercharger rotors has been developed using a new design technique. Rather than creating extended libraries of existing rotor profiles or storing large collections of profile curves in CAD data bases, the proposed CAD module is based on a three-dimensional parametric model of supercharger conjugated helical rotors, which allows integration of this method into commercial CAD software for visualization. More specifically this method allows selection of a wider range of geometric curves through rapid testing of different curve combinations and updating a current design model by relating the rotors geometry to clearances in key points of the model. The process is repeated until the set design criteria is met or until the maximum number of iterations is reached. This method is expected to reduce the design cycle and manufacturing costs currently involved. The algorithm used with the presented CAD module allows optimization of the rotors inter-lobe clearances taking the minimum normal functional clearance along the sealing lines of the supercharger rotors. Using the 3D parametric model of the supercharger rotors the sealing lines can be presented within a system of iso-clearance paths. Design models developed using the proposed CAD module can be transferred to Computational Fluid Dynamics (CFD) software via an appropriate interface for flow analysis in connection with supercharger rotors geometry and clearances.

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