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STRUCTURES ON INTUITIONIST FUZZY R - IDEAL

[1]G.Rethnarexlin, [2*]G.Subbiah and [3]V.Nagarajan

1 Research scholar, Reg.No: 18123152092017,Department of Mathematics, S.T.Hindu College, Nagercoil-629 002,Tamil Nadu, India.

2 *Associate Professor in Mathematics, Sri K.G.S. Arts College, Srivaikuntam-628 619, Tamil Nadu, India.

3 Assistant Professor in Mathematics, S.T.Hindu College, Nagercoil-629 002,Tamil Nadu, India.

* Corresponding author: E-mail Id: subbiahkgs@gmail.com

Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli-627 012, Tamil Nadu, India.

ABSTRACT :

In this paper, we introduce the notion of direct product of intuitionist fuzzy R – ideal of BCK – algebras and related properties are investigated. Characterizations of direct product intuitionist fuzzy R – ideals of BCK – algebras are given.

Key words: R-ideal, Fuzzy R-ideal, intuitionistic fuzzy ideal, intuitionistic Fuzzy R-ideal

1.Introduction: The notion of fuzzy sets in a set theory was introduced by Zadeh[27], and since then this concept has been applied to various algebraic structures. The idea of intuitionist fuzzy sets was first introduced by Atanassov [7,8], as a generalization of the notion of fuzzy set.Abdullah et al. [1 − 3,6], provided some interesting results on direct product of fuzzy ideals in different algebraic structures. The product of fuzzy subgroups was introduced in [20,26]. Imai and Iseki introduced two classes of algebras,BCK-algebras [12,13]. BCI-algebras are generalizations of BCK-algebras which were studied by many researchers [4,10,11,14,18,19]. A.Shehri[5], Jun et al. [15 − 17], Saeid et al. [21 − 23] and Satyanarayana et al. [24,25], applied the concept of fuzzy set to BCK-algebras, Zhan and Tan [28],introduced the concept of fuzzy R-ideals in BCK-algebras.In this paper, we introduce the notion of direct product of intuitionist fuzzy R-ideals in BCK-algebras and some related properties are investigated. Characterizations of direct product of

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intuitionist fuzzy R-ideal of BCK-algebras are given.And also we introduce the notion of upper s-level cut of μ_{AXB} and lower t-level cut ofλ_{AXB} . Also we proved, for an intuitionistfuzzy set of BCK-algebras A X B =<μ_{AXB} , λ_{AXB}> of $X_1 \times X_2$, then A X B =<μ_{AXB} , l_{AXB}> is an intuitionist fuzzy R-ideals of BCK-algebras $X_1 \times X_2$ if and only if for any s ,t $\epsilon[0,1]$ upper and lower level sets are R-ideals of BCK-algebra X_1X X_2.

2. Preliminaries

Algebra (X,*, 0) of type (2,0) is called a BCI-algebra if satisfies the following conditions:

(i) ∀ x, y, z ∈ X, ((x * y) * (x*z) * (z * y)) = 0,

(ii) ∀ x, y∈ X, (x *(x * y)) * y = 0,

(iii) ∀ x, y∈ X, x * x = 0,

(iv) ∀ x, y∈ X, x * y = 0, y * x = 0 ⟹x = y,

$We can define a partial$order '≤' on X by x ≤ y if and only if x * y = 0.

AnyBCI-algebra X has the following properties:

(T1) ∀ x ∈ X, x * 0 = x,

(T2) ∀ x, Y, Z ∈ X, (x * y) * z = (x * z) * y,

(T3) ∀ x, Y, Z ∈ X, x ≤ y⇒ x * z ≤ y * z, z *y ≤ z * x.

Definition 2.1A nonempty subset A of a BCI-algebra X is called an **ideal** of X if it

satisfies:

(II) 0 ∈ A, (I2) ∀ x, y∈ X, y∈ Ax * y ∈ A ⟹ x ∈ A,

Definition 2.2 A nonempty subset A of a BCI-algebra X is called **a- ideal** of X if it satisfies:

(II) and (I3) ∀ x, y∈ X, (∀ z ∈A)((x*z)*(0*y) ∈ A ⟹y * x ∈ A)

Definition 2.3 A nonempty subset I of a BCI-algebra X is called **R- ideal** of X, if

1.0 * I, 2. (x * z) (z * y) ∈ I and y ∈ I ⟹ x ∈ I

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Definition 2.4 A fuzzy subset μ in a BCK- algebra X is called a fuzzy R- ideal of X, if

1. $\mu(0) \geq \mu(x)$

2. $\mu(x) \geq \min\{\mu((x * z) * (y * z)), \mu(y)\}$, $\forall$ x, y, z $\in$ X.

Definition 2.5 Ideal I of a BCI-algebra (X, *, 0) is called Closed if 0 * x ∈ I, for all x ∈ I

Definition 2.6 Let A and B be two fuzzy ideal of BCI algebra X. The fuzzy set A$\cap B$

With membership function $\mu_{A\cap B}$is defined by$\mu_{A\cap B}(x) = \min\{\mu_A(x), \mu_B(x)\}$, ∀ x ∈ X

Definition 2.7 Let A and B be two fuzzy ideal of BCI algebra X. The fuzzy set A$\cup B$.

With membership function $\mu_{A\cup B}$is defined by $\mu_{A\cup B}(x) = \max\{\mu_A(x), \mu_B(x)\}$, ∀ x ∈ X.

Definition 2.8 Let A and B be two fuzzy ideal of BCI algebra Xwith membership function μ_A *and* μ_B respectively. A is contained in B if $\mu_A(x) \leq \mu_B(x)$, ∀x ∈X .

Definition 2.9 Let A be a fuzzy ideal of BCI algebra X. The fuzzy set A^m with membership function ${\mu_A}^m$ is defined by ${\mu_A}^m(x) = (\mu_A(x))^m$, ∀x ∈X .

Definition 2.10 Let m be a fuzzy set in X. The complement of μ is denoted by μ and is defined as μ (x) = 1- μ (x), ∀x ∈ X.

Definition 2.11 Let A = (X,μ_A , λ_A) be an intuitionist fuzzy set in X. Then

(i) $\bar{A}$ = (X,μ_A , $\mu_{\bar{A}}$) and (ii) A = (X,$\lambda_{\bar{A}}$, λ_A).

Definition 2.12 An intuitionist fuzzy set A in non-empty set X is an object having the form

A = $\{(x, \mu_A(x), \lambda_A(x)) : x \in X\}$,where the function μ_A : X → [0,1] and λ_A : X → [0,1] denoted the degree of membership (namely $\mu_A(x)$) and the degree of non-Membership (namely $\lambda_A(x)$) of each element x ∈ X to the set A respectively, and $0 \leq \mu_A(x) + \lambda_A(x) \leq 1$ for all x ∈ X

Definition 2.13 An IFS A= <X,μ_A , λ_A> in a BCI-algebra X is called an intuitionist fuzzy Sub-algebra of X if it satisfies: ∀x, y∈ X.

1. $\mu_A(x * y) \geq \min\{\mu_A(x), \mu_A(y)\}$, ∀x, y∈ X.

2. $\lambda_A(x * y) \leq \max\{\lambda_A(x), \lambda_A(y)\}$

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Definition 2.14 An intuitionist fuzzy set A = (X,μ_A , λ_A) in X is called an intuitionist fuzzy ideal of X, if it satisfies the following axioms:

(IF1) $\mu_A(0) \geq \mu_A(x)$ and $\lambda_A(0) \leq \lambda_A(x)$,

(IF2) $\mu_A(x) \geq \min\{ \mu_A(x * y), \mu_A(y)\}$,

(IF3) $\lambda_A(x) \leq \max\{\lambda_A(x * y), \lambda_A(y)\}$, ∀x, y∈ X.

Definition 2.15 An intuitionist fuzzy set A = (X,μ_A , λ_A) in X is called an intuitionist fuzzy ideal of X, if it satisfies (IF2), (IF3) and the following :

(IF4) $\mu_A(0 * x) \geq \mu_A(x)$ and $\lambda_A(0*x) \leq \lambda_A(x)$, ∀x ∈ X

Definition 2.16 An IFS A = <X,μ_A , λ_A> in X is called an intuitionist fuzzy R-ideal of X.If it satisfies (2.12) and (∀x, y, z∈ X).

1. $\mu_A(x) \geq \min\{ \mu_A((x * z) * (z * y)), \mu_A(y)\}$

2. $\lambda_A(x) \leq \max\{\lambda_A((x * z) * (z * y)) , \lambda_A(y)\}$

3. Direct Product of Intuitionistic Fuzzy R-ideals

Definition 3.1 Let A = < μ_A , λ_A> and B = < μ_B , λ_B> be two intuitionist fuzzy sets in BCK-algebras X_1 and X_2 respectively.Then direct product of intuitionist fuzzy sets A and B is denoted by A× B =<$\mu_{A\times B}$, $\lambda_{A\times B}$>, and defined as $\mu_{A\times B}(x,y) = \min\{ \mu_A(x), \mu_B(y)\}$ and $\lambda_{A\times B}(x,y) = \max\{\lambda_A(x), \lambda_B(y)\}$,for all $(x,y) \in X_1 \times X_2$.

Definition 3.2 An IFS A× B =<$\mu_{A\times B}$, $\lambda_{A\times B}$>, of $X_1 \times X_2$ is called an intuitionist fuzzy sub-algebra of $X_1 \times X_2$ if

(DIF1) $\mu_{A\times B}((x_1y_1)*(x_2y_2)) \geq \min\{\mu_{A\times B}(x_1y_1), \mu_{A\times B}(x_2y_2)\}$

(DIF2) $\lambda_{A\times B}((x_1y_1)*(x_2y_2)) \leq \max\{\lambda_{A\times B}(x_1y_1), \lambda_{A\times B}(x_2y_2)\}$

For all (x_1y_1),$(x_2y_2) \in X_1 \times X_2$

Definition 3.3 An IFS A× B =<$\mu_{A\times B}$, $\lambda_{A\times B}$>, of $X_1 \times X_2$ is called an intuitionistic fuzzy R-ideal of $X_1 \times X_2$ if

(DIF3) $\mu_{A\times B}((0,0)) \geq \mu_{A\times B}(x,y)$and $\lambda_{A\times B}(0,0) \leq \lambda_{A\times B}(x,y)$

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(DIF4) $\mu_{A\times B}((x_1y_1))\geq\min\{\mu_{A\times B}(((x_1y_1)*(x_3y_3))*((x_2y_2)*(x_3y_3))),\mu_{A\times B}((x_2y_2)\}$

(DIF5)$\lambda_{A\times B}((x_1y_1))\leq\max\{\lambda_{A\times B},(((x_1y_1)*(x_3y_3))*((x_2y_2)*(x_3y_3))),\lambda_{A\times B}(x_2y_2)\}$,

For all (x_1y_1),(x_2y_2) , $(x_3y_3)\in X_1\times X_2$.

Definition 3.4 An IFS A× B =<$\mu_{A\times B}$, $\lambda_{A\times B}$>, of $X_1\times X_2$ is called an intuitionist fuzzy closed R-ideal of $X_1\times X_2$ if it satisfies (DIF3),(DIF4),and (DIF5) and the following

(DIF6) $\mu_{A\times B}((0,0)*(x,y))\geq\mu_{A\times B}(x,y) and \lambda_{A\times B}((0,0)*(x,y))\leq\lambda_{A\times B}(x,y)$

Theorem3.5: Let A = <μ_A,λ_A>and B = <μ_B,λ_B> be two intuitionist fuzzy sub-algebra of BCK-algebras$X_1 and X_2$ respectively.Then A× B =<$\mu_{A\times B}$, $\lambda_{A\times B}$> is an intuitionist fuzzy sub-algebra of BCK-algebras$X_1\times X_2$.

Proof: For any (x_1y_1), $(x_2y_2)\in X_1\times X_2$ .Then

$\mu_{A\times B}((x_1y_1)*(x_2y_2))=\mu_{A\times B}(x_1*x_2, y_1*y_2)$

$=\min\{\mu_A(x_1*x_2),\mu_B(y_1*y_2)\}$

$\geq\min\{\min\{\mu_A(x_1),\mu_A(x_2)\},\min\{\mu_B(y_1),\mu_B(y_2)\}\}$

$=\min\{\min\{\mu_A(x_1),\mu_A(y_1)\},\min\{\mu_B(x_2),\mu_B(y_2)\}\}$

$\geq\min\{\mu_{A\times B}(x_1,y_1),\mu_{A\times B}(x_2,y_2)\}$

And $\lambda_{A\times B}((x_1y_1)*(x_2y_2))=\lambda_{A\times B}(x_1*x_2, y_1*y_2)$

$=\max\{\lambda_A(x_1*x_2),\lambda_B(y_1*y_2)\}$

$\leq\max\{\max\{\lambda_A(x_1),\lambda_A(x_2)\},\max\{\lambda_B(y_1),\lambda_B(y_2)\}\}$

$=\max\{\max\{\lambda_A(x_1),\lambda_b(y_1)\},\max\{\lambda_A(x_2),\lambda_B(y_2)\}\}$

$\leq\max\{\lambda_{A\times B}(x_1,y_1),\lambda_{A\times B}(x_2,y_2)\}$

Hence for all (x_1,y_1), $(x_2,y_2)\in X_1\times X_2$, A× B =<$\mu_{A\times B}$, $\lambda_{A\times B}$> is an intuitionist fuzzy sub-algebra of BCK-algebras $X_1\times X_2$.

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Theorem 3.6: Let A = <μ_A,λ_A>and B = <μ_B,λ_B> be two intuitionist fuzzy H-ideals of BCK-algebras $X_1 and X_2$ respectively.Then A× B =<$\mu_{A\times B}$, $\lambda_{A\times B}$> is an intuitionist fuzzy R-ideal of BCK-algebra as$X_1 \times X_2$.

Proof: For any $(x, y) \in X_1 \times X_2$

$\mu_{A\times B}$ (0,0) = min $\{\mu_A(0), \mu_B(0)\} \geq$ min $\{\mu_A(x), \mu_B(y)\} = \mu_{A\times B}(x, y)$.

And $\lambda_{A\times B}$ (0,0) = max $\{\lambda_A(0), \lambda_B(0)\} \leq$ max $\{\lambda_A(x), \lambda_B(y)\} = \lambda_{A\times B}(x, y)$.

Now for any $(x_1 y_1)$,$(x_2 y_2)$, $x_3 y_3 \in X_1 \times X_2$.

$\mu_{A\times B}((x_{1,} y_1)) = \min\{\mu_A(x_{1,}), \mu_B(y_1)\}$

$\geq \min\{\min\{\mu_A((x_1 * x_3) * (x_2 * x_3)), \mu_A(x_{2,})\}, \min\{\mu_B((y_1 * y_3) * (y_2 * y_3)), \mu_B(y_2)\}\}$

$= \min\{\min\{\mu_A((x_1 * x_3) * (x_2 * x_3)), \mu_B((y_1 * y_3) * (y_2 * y_3))\}, \min\{\mu_A(x_{2,}), \mu_B(y_2)\}$

$= \min\{\mu_{A\times B}((x_{1,} * x_3)*(x_2 * x_3)), ((y_1 * y_3) * (y_2 * y_3))\}, \mu_{A\times B}(x_{2,}, y_2)\}\}$

$\geq \min\{\mu_{A\times B}(((x_{1,} y_1)*(x_3, y_3)*((x_2, y_2)*(x_3 y_3))), \mu_{A\times B}(x_2, y_2)\}$

And $\lambda_{A\times B}((x_{1,} y_1)) = \max\{\lambda_A(x_1), \lambda_B(y_1)$

$\leq \max\{\max\{\lambda_A((x_1 * x_3) * (x_2 * x_3)), \lambda_A(x_{2,})\}, \max\{\lambda_B((y_1 * y_3) * (y_2 * y_3)), \lambda_B(y_2)\}\}$

$= \max\{\max\{\lambda_A((x_1 * x_3)*(x_2 * x_3)), \lambda_B((y_1 * y_3)*(y_2 * y_3))\}, \max\{\lambda_A(x_{2,}), \lambda_B(y_2)\}\}$

$= \max\{\lambda_{A\times B}((x_{1,} * x_3)*(x_2 * x_3)), ((y_1 * y_3) * (y_2 * y_3))\}, \lambda_{A\times B}(x_{2,}, y_2)\}\}$

$\leq \max\{\lambda_{A\times B}(((x_{1,} y_1)*(x_3, y_3)*((x_2, y_2)*(x_3 y_3))), \lambda_{A\times B}(x_2, y_2)\}$

Hence for all $x_1 y_1)$,$(x_2 y_2)$, $(x_3 y_{3)} \in X_1 \times X_2$, A× B =<$\mu_{A\times B}$, $\lambda_{A\times B}$> is an intuitionist fuzzy R-ideal of BCK-algebr $X_1 \times X_2$.

Theorem 3.7: Let A = <μ_A,λ_A> and B = <μ_B,λ_B> be two intuitionist fuzzy closed R-ideals of BCK-algebras $X_1 and X_2$ respectively. Then A× B =<$\mu_{A\times B}$,$\lambda_{A\times B}$> is an intuitionist fuzzy closed R-ideal of BCK-algebra $X_1 \times X_2$.

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Proof: Let A = <μ_A,λ_A> and B = <μ_B,λ_B> be two intuitionist fuzzy closed R-ideals of BCK-algebras $X_1 and X_2$ respectively. Using Theorem 3.6,A× B =<$\mu_{A\times B}$, $\lambda_{A\times B}$> is an intuitionist fuzzy closed R-ideal of BCK-algebra $X_1 \times X_2$, then

$\mu_{A\times B}((0,0)*(x,y)) = \mu_{A\times B}((0*x, 0*y)) = \min\{\mu_A(0*x),\mu_B(0*y)\}$

$\geq \min\{\mu_A(x), \mu_B(y)\} = \mu_{A\times B}(x,y)$.

And $\lambda_{A\times B}((0,0)*(x,y)) = \lambda_{A\times B}((0*x, 0*y)) = \max\{\lambda_A(0*x),\lambda_B(0*y)\}$

$\leq \max\{\lambda_A(x), \lambda_B(y)\} = \lambda_{A\times B}(x,y)$.

Hence A× B =<$\mu_{A\times B}$, $\lambda_{A\times B}$> is an intuitionist fuzzy closed R-ideal of BCK-algebra

$X_1 \times X_2$.

Lemma 3.8: If A× B =<$\mu_{A\times B}$, $\lambda_{A\times B}$> is an intuitionist fuzzy closed R-ideal of BCK-algebra $X_1 \times X_2$. Then we have (a,b) $\leq (x,y) \Rightarrow \mu_{A\times B}(x,y) \leq \mu_{A\times B}$ (a,b) and

$\lambda_{A\times B}(x,y) \geq \lambda_{A\times B}$ (a,b), $\forall$ (a,b),$(x,y) \in X_1 \times X_2$

Proof:

Let (a,b),$(x,y) \in X_1 \times X_2$,

Such that (a,b) $\leq (x,y) \Rightarrow$ (a,b)*(x,y) = (0,0).

Consider $\mu_{A\times B}(x,y) = \mu_{A\times B}((x,y))$

$\geq \min\{\mu_{A\times B}(((x,y)*(0,0))*((0,0)*((a,b))),\mu_{A\times B}(a,b)\}$

$= \min\{\mu_{A\times B}((x,y)*((a,b)),\mu_{A\times B}(a,b)\} = \mu_{A\times B}(a,b)$.

And $\lambda_{A\times B}(x,y) = \lambda_{A\times B}((x,y))$

$\leq \max\{\lambda_{A\times B}(((x,y)*(0,0))*((0,0)*((a,b))),\lambda_{A\times B}(a,b)\}$

$= \max\{\lambda_{A\times B}((x,y)*(a,b)),\lambda_{A\times B}(a,b)\} = \lambda_{A\times B}(a,b)$.

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Theorem 3.9: Let A = <μ_A,λ_A> and B = <μ_B,λ_B> be two intuitionistic fuzzy closed R-ideals of BCK-algebras X_1 and X_2 resectively. Then (A×B) = <$\mu_{A\times B}$,$\bar{\mu}_{AxB}$> is an intuitionistic fuzzy R-ideal of BCK-algebra $X_1\times X_2$ Where $\bar{\mu}_{AxB} = 1-\mu_{A\times B}$,

Proof:

Since by theorem 3.6 A×B = <$\mu_{A\times B}$,$\lambda_{A\times B}$> is an intuitionistic fuzzy R-ideal of BCK-algebra $X_1\times X_2$ Then $\mu_{A\times B}(0,0) \geq \mu_{A\times B}(x,y)$

$1-\mu_{A\times B}(0,0) \leq 1-\mu_{A\times B}(x,y)\mu_{A\times B}(0,0)\leq \bar{\mu}_{A\times B}(x,y)$,

Now for any $(x_1,y_1),(x_2,y_2),(x_3,y_3) \in X_1\times X_2$ we have

$\mu_{A\times B}((x_1,y_1))\geq\min\{\mu_{A\times B}(((x_1,y_1)*(x_3,y_3))*((x_2,y_2)*(x_3,y_3))),\mu_{A\times B}(x_2,y_2)\}$

$1-\mu_{A\times B}((x_1,y_1))\leq 1-\min\{\mu_{A\times B}(((x_1,y_1)*(x_3,y_3))*((x_2,y_2)*(x_3,y_3))),\mu_{A\times B}(x_2,y_2)\}$

$= \max\{1-\mu_{A\times B}(((x_1,y_1)*(x_3,y_3))*((x_2,y_2)*(x_3,y_3))),1-\mu_{A\times B}(x_2,y_2)\}$

$\bar{\mu}_{AxB}((x_1,y_1))\leq\max\{((\bar{\mu}_{AxB}(x_1,y_1)*(x_3,y_3))*((x_2,y_2)*(x_3,y_3))),\bar{\mu}_{AxB}(x_2,y_2)\}$

Hence (A× B) =<$\mu_{A\times B}$,$\bar{\mu}_{AxB}$> is an intuitionistic fuzzy R-ideal of BCK-algera $X_1\times X_2$

Theorem 3.10: Let A = <μ_A,λ_A> and B = <μ_B,λ_B> be two intuitionistic fuzzy R-ideals of BCK-algebras X_1 and X_2 respectively. Then A×B = <> is an intutionistic fuzzy R-ideals of BCK-algebras $X_1\times X_2$.

Proof:

Since by theorem 3.6 A×B = <$\mu_{A\times B}$,$\lambda_{A\times B}$> is an intuitionistic fuzzy R-ideal of BCK-algebra $X_1\times X_2$

$\lambda_{A\times B}(0,0) \leq \lambda_{A\times B}(x,y)$

$1-\lambda_{A\times B}(0,0) \geq 1-\lambda_{A\times B}(x,y)\bar{\lambda}_{AxB}(0,0)\geq \bar{\lambda}_{AxB}(x,y)$,

Now for any $(x_1,y_1),(x_2,y_2),(x_3,y_3) \in X_1\times X_2$ we have

$\lambda_{A\times B}((x_1,y_1))\leq max\{\lambda_{A\times B}(((x_1,y_1)*(x_3,y_3))*((x_2,y_2)*(x_3,y_3))),\lambda_{A\times B}(x_2,y_2)\}$

$1-\lambda_{A\times B}((x_1,y_1))\geq 1-max\{\lambda_{A\times B}(((x_1,y_1)*(x_3,y_3))*((x_2,y_2)*(x_3,y_3))),\lambda_{A\times B}(x_2,y_2)\}$

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$\geq$ min $\{1 - \lambda_{A\times B}(((x_1,y_1)*(x_3,y_3))*((x_2,y_2)*(x_3,y_3))), 1 - \lambda_{A\times B}(x_2,y_2)\}$

$\bar{\lambda}_{\mathrm{AxB}}((x_1,y_1)*) \geq$ min $\{((\bar{\lambda}_{\mathrm{AxB}}(x_1,y_1)*(x_3,y_3))*((x_2,y_2)*(x_3,y_3))),\bar{\lambda}_{\mathrm{AxB}}(x_2,y_2)\}$

Hence A×B = <> is an intutionistic fuzzy R-ideals of BCK-algebras $X_1\times X_2$

Theorem 3.11: Let A = < μ_A,λ_A> and B = <μ_B,λ_B> be twointuitionistic fuzzy closed R-ideals of BCK-algebras X_1 and X_2respectively. Then (A×B) = <$\mu_{A\times B}, \lambda_{\mathrm{AxB}}$> is an intutionistic fuzzy R-ideals of BCK-algebras $X_1\times X_2$. If and only if (A×B) = <$\mu_{A\times B},\bar{\mu}_{\mathrm{AxB}}$> and are intutionistic fuzzy R-ideals of BCK-algebras $X_1\times X_2$

Proof:

The proof follows from theorem 3.9 and Theorem3.10

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